COST Action TD1105 *EuNetAir*

European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability

BOOKLET

FINAL MEETING - SIXTH SCIENTIFIC MEETING

WORKING GROUPS AND MANAGEMENT COMMITTEE

ON

NEW SENSING TECHNOLOGIES FOR AIR QUALITY MONITORING

hosted at J. Heyrovský Institute of Physical Chemistry

organized by Academy of Sciences of the Czech Republic

Prague, Czech Republic, 5 - 7 October 2016

COST EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

The Czech Academy of Sciences

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COST Action TD1105

European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability - EuNetAir

FINAL MEETING - SIXTH SCIENTIFIC MEETING

Working Groups and Management Committee

organized by Academy of Sciences of the Czech Republic
J. Heyrovský Institute of Physical Chemistry
Prague, Czech Republic, 5 - 7 October 2016

hosted at J. Heyrovský Institute of Physical Chemistry - Conference Hall
Dolejškova 3, 182 23 Prague, Czech Republic

Meeting AGENDA	
5 Oct. 2016 - Wednesday	
09:00 - 18:00	***REGISTRATION***
09:30 - 10:00	**WELCOME SESSION**
10:00 - 11:00	**PLENARY SESSION 1: Invited Talks**
11:00 - 11:30	*Coffee-Break*
11:30 - 13:00	**PLENARY SESSION 2: Invited Talks**
13:00 - 14:30	*Lunch*
14:30 - 16:00	**WG1 Session**
16:00 - 16:30	*Coffee-Break*
16:30 - 18:30	**WG2 Session**
18:30	*Gathering of Day*
20:30 - 23:00	*Social Dinner*
6 Oct. 2016 - Thursday	
09:00 - 18:00	***REGISTRATION***
09.00 - 11.00	**WG3 Session**
11:00 - 11:30	*Coffee-Break*
11:30 - 13:00	**WG4 Session**
13:00 - 14:00	*Lunch*
14:00 - 15:30	**POSTER SESSION**
15:00 - 15:30	*Coffee-Break during Poster Session*
15:30 - 18:00	**SIG1-SIG4 Session**
18:00 - 18:30	**Inputs on Follow-up of EuNetAir**
18:30	**CONCLUSIONS**
20:30	*Free Dinner*
7 Oct. 2016 - Friday	
09.00 - 11.00	**Action WGs/SIGs GENERAL ASSEMBLY**
11:00 - 11:30	*Coffee-Break*
11:30 - 13:00	**9th MANAGEMENT COMMITTEE MEETING**
13:00 - 14:30	*Lunch*
14:30	***Meeting Closing***

COST is supported by the EU Framework Programme
ESF provides the COST Office through a European Commission contract

Background and goals

About COST Action TD1105 *EuNetAir*

COST Action TD 1105 EuNetAir, a Concerted Action on *New Sensing Technologies for Air-Pollution Control and Environmental Sustainability*, is a running Networking funded in the framework *European Cooperation in the field of Scientific and Technical Research* (COST) during 2012-2016.
The main objective of the Concerted Action is to develop new sensing technologies for Air Quality Control at integrated and multidisciplinary scale by coordinated research on nanomaterials, sensor-systems, air-quality modelling and standardised methods for supporting environmental sustainability with a special focus on Small and Medium Enterprises.
This international Networking, coordinated by ENEA (Italy), includes over 120 big institutions from 31 COST Countries (EU-zone: *Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Luxembourg, The Former Yugoslav Republic of Macedonia, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom*) and 7 International Partners Countries (extra-Europe: *Australia, Canada, China, Morocco, Russia, Ukraine, USA*) to create a S&T critical mass in the environmental issues.

About the *Sixth Scientific Meeting* at Czech Academy of Sciences, Prague, 5 - 7 Oct. 2016

The 9th MC Meeting jointly with WG1-4 Meeting will be held at Academy of Sciences of Czech Republic, in Prague, under local chairing and organization of Prof. Zdenek Zelinger (Action MC Member), J. Heyrovský Institute of Physical Chemistry; Dr. Vera Kurkova (Action MC Member) and Dr. Roman Neruda (Action MC Substitute), Institute of Computer Science, organized with a Plenary Session, Inter-WGs Sessions including a General Assembly of the WGs and Special Interest Groups (SIGs), a Roundtable, and finally, the MC Meeting. The Plenary Sessions will mainly focus on ***New Sensing Technologies for Air-Pollution Monitoring*** in a multidisciplinary approach including International Experts and Coordinators of the running FP7 and H2020 research projects.
Participation from research, university, industry, environmental agencies, stakeholders, policy-makers and institutional managers is widely planned with large outreach and dissemination activities, at high expected impact (31 Parties involved in the Action on June 2016). Fruitful discussions between Action TD1105 participants, experts, speakers and international organizations delegates (e.g., WHO Europe, JRC, EEA, EPA, EC DG) are strongly expected. At the Open ***Sixth Scientific Meeting*** of the COST Action TD1105 *EuNetAir*, a strong impact on focusing of the critical outdoor and indoor environmental issues would be mutual benefit.

More Information

Dr. Michele Penza
MC Chair/Proposer of COST Action TD1105 EuNetAir
ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development
Department for Sustainability - Head of Laboratory Functional Materials & Technologies for Sustainable Applications
PO BOX 51 Br-4, I-72100 Brindisi, ITALY. Email: michele.penza@enea.it Action webpages: www.cost.eunetair.it

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COST is supported by the EU Framework Programme
European Science Foundation — ESF provides the COST Office through a European Commission contract

FINAL MEETING - SIXTH SCIENTIFIC MEETING
Working Groups and Management Committee

New Sensing Technologies for Air Quality Monitoring

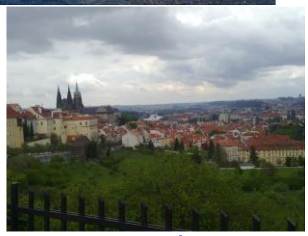
Prague, Czech Republic, 5 - 7 October 2016

hosted at J. Heyrovský Institute of Physical Chemistry - Conference Hall
Dolejškova 3, 182 23 Prague, Czech Republic



***Venue:* J. Heyrovský Institute of Physical Chemistry**

Prague view



Prague view

Action Meeting Programme Committee

Michele Penza, ENEA, Brindisi, Italy
Zdenek Zelinger, Czech Academy of Sciences, Prague, CZ
Vera Kurkova, Czech Academy of Sciences, Prague, CZ
Roman Neruda, Czech Academy of Sciences, Prague, CZ
Ivan Nedkov, Bulgarian Academy of Sciences, Sofia, Bulgaria
Dimiter Syrakov, Bulgarian Academy of Sciences, Sofia, Bulgaria
Milena Jovasevic-Stojanovic, VINCA, Belgrade, Serbia
Anton Kock, MCL, Leoben, Austria
Anita Lloyd Spetz, Linköping University, Sweden
Andreas Schuetze, Saarland University, Germany
Ingrid Bryntse, SenseAir AB, Sweden
Zafer Ziya Ozturk, GEBZE Technical University, Turkey
Carlos Borrego, IDAD, University of Aveiro, Portugal
Iveta Steinberga, University of Latvia, Riga, Latvia
Ole Hertel, Aarhus University, Denmark
Juan Ramon Morante, IREC, Spain
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Corinna Hahn, Eurice GmbH, Saarbrucken, Germany
Juliane Rossbach, Eurice GmbH, Saarbrucken, Germany
Annamaria Demarinis Loiotile, University of Bari, Italy
Michal Dostal, Czech Academy of Sciences, Prague, CZ
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Pavel Janda, Czech Academy of Sciences, Prague, CZ
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COST Action TD1105 EuNetAir Steering Committee

Michele Penza, ENEA, Brindisi, Italy - *Action Chair*
Anita Lloyd Spetz, Linköping University, Sweden - *Action Vice-Chair*
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Eduard Llobet, Universitat Roviri I Virgili, Tarragona, Spain
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Albert Romano-Rodriguez, Universitat de Barcelona (UB), Spain
Carlos Borrego, IDAD, University of Aveiro, Portugal
Annamaria Demarinis Loiotile, University of Bari, Italy – *Secretary*

URL: **www.cost.eunetair.it**

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Wednesday, 5 October 2016

COST Action TD1105 Working Groups and Special Interest Groups MEETING

Conference Hall: J. Heyrovský Institute of Physical Chemistry - ASCR

8:30 - 18:00	**Registration**
09:30 - 10:00	**Welcome Address Session** *Chairpersons: Zdenek Zelinger, Action MC Member, J. Heyrovsky Institute of Physical Chemistry - ASCR, Prague, Czech Republic* *Vera Kurkova, Action MC Member, Institute of Computer Sciences - ASCR, Prague, Czech Republic*
09:30 - 09:40	**Welcome: CZ COST National Coordinator - Ministry of Education** *Josef Janda*, CZ CNC - Ministry of Education Youth and Sports of the Czech Republic, Prague, Czech Republic
09:40 - 09:50	**Welcome: Academy of Sciences of the Czech Republic** *Zdenek Samec*, Director of the Heyrovsky Institute of Physical Chemistry - ASCR, Academy of Sciences of the Czech Republic, Prague, Czech Republic
09:50 - 10:00	**Welcome: COST Action TD1105** *Michele Penza*, Action Chair, ENEA, Brindisi, Italy
10:00 - 11:00	**Plenary Session 1: Air Quality Sensor Applications - *EuNetAir Celebration*** *Chairpersons: Zdenek Zelinger, Action MC Member, J. Heyrovsky Institute of Physical Chemistry - ASCR, Prague, Czech Republic* *Vera Kurkova, Action MC Member, Institute of Computer Sciences - ASCR, Prague, Czech Republic*
10:00 - 10:30	**COST Action TD1105: European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability - EuNetAir** *Michele Penza*, Action Chair, ENEA, Italy
10:30 - 11:00	**Gas and Particle Sensors in the Framework of EuNetAir** *Anita Lloyd Spetz*, Action Vice-Chair, Linkoping University (Sweden) and University of Oulu (FI)
11:00 - 11:30	**Coffee Break**
11:30 - 13:00	**Plenary Session 2: Environment Quality Applications** *Chairman: Michele Penza, Action Chair - ENEA, Italy*
11:30 - 12:00	**The SENSIndoor FP7 Project: Main Results, Lessons Learned and Outlook** *Andreas Schuetze*, Action MC Member, Saarland University, Saarbrucken, Germany
12:00 - 12:30	**The CITI-SENSE FP7 Project: From Sensor Technology to Citizen Engagement** *Nuria Castell*, Action MC Member, NILU - Norwegian Institute for Air Research, Kjeller, Norway
12:30 - 13:00	**Assessment of Air Pollution Impacts on Human Health using AirQ+** *Pierpaolo Mudu,* Technical Officer of the WHO European Centre for Environment and Health, Bonn, Germany
13:00 - 14:30	**Lunch offered by COST Action organization**
All Time Long 3-Day Meeting	**Questions & Answers at Registration Desk by COST Action TD1105 Grant Holder Manager: Online Travel Reimbursement Request & Strong Feature Authentication** *Juliane Rossbach,* Grant Holder Manager, Eurice GmbH, Saarbrucken/Berlin, Germany

Wednesday, 5 October 2016

Action TD1105 Working Groups Meetings

WG1 Session. Location: Conference Hall

14:30 - 16:00	**WG1: Sensor Materials and Nanotechnology** *Chairman: Jyrki Lappalainen, Action WG1 Vice-Chair - Oulu University, Oulu, Finland*
14:30 - 15:00	**Emerging Sensing Materials for Air Quality Monitoring** *Marcel Bouvet*, Action MC Member, Institut de Chimie Moléculaire de l'Université de Bourgogne, CNRS UMR 6302, Université de Bourgogne Franche-Comté, Dijon, France
15:00 - 15:15	**Recent Developments of Complex Nanostructured Metal Oxide Entities for Chemical Sensors** *Jyrki Lappalainen, Joni Huotari, Jarkko Puustinen*, Action MC Member, Faculty of Information Technology and Electrical Engineering, University of Oulu, Oulu, Finland
15:15 - 15:30	**Gas Sensors based on CuO-TiO_2 Heterostructures** *Zafer Z. Ozturk, O. Alev, E. Sennik, O. Sisman*, Gebze Technical University, Kocaeli, Turkey
15:30 - 15:45	**Solid Nanoporous Sensor for the Colorimetric Detection of Phenol** *C. Theron, et al., Thu-Hoa Tran-Thi*, NIMBE, CEA-CNRS, Gif-sur-Yvette Cedex, France
15:45 - 16:00	**Photoluminescence based Gas Sensing with Rare-Earth Doped Oxide Nanopowders and Thin Films** *Raivo Jaaniso, Tea Avarmaa, Leonid Dolgov, Marko Eltermann, Valter Kiisk, Margus Kodu and Sven Lange*, Action MC Member, Institute of Physics, University of Tartu, Estonia
16:00 - 16:30	**Coffee Break**

WG2 Session. Location: Conference Hall

16:30 - 18:30	**WG2: Sensors, Devices and Systems for AQC** *Chairman: Andreas Schuetze, Action WG2 Chair - Saarland University, Saarbrücken, Germany*
16:30 - 17:00	**Disposable Sensors and Instruments for Air Quality Monitoring** *Danick Briand*, Action MC Member, EPFL, Neuchatel, Switzerland
17:00 - 17:15	**Multilayer Graphene Cantilever for Laser Photoacoustic Detection** *Zdenek Zelinger*; Action MC Member, J. Heyrovský Institute of Physical Chemistry, Academy of Sciences of the Czech Republic, Prague, Czech Republic
17:15 - 17:30	**A New Concept of Environmental Camera through Volatile Organic Compounds Sensing** *Thomas Walewyns, Nicolas Andrè, Laurent Francis*, Université Catholique de Louvain, Electrical Engineering Department, Louvain-la-Neuve, Belgium
17:30 - 17:45	**Dosimeter-Type Sensor for sub-ppm NO_x Detection** *Daniela Schoenauer-Kamin, I. Marr, Ralf Moos* Laboratory of Functional Materials, MC Substitute, University of Bayreuth, Bayreuth, Germany
17:45 - 18:00	**Theoretical Modeling of QCM-D and SH-SAW Sensors in Environmental Applications** *Marina Voinova*[1,2], *Anton Wikstrom*[2], [1]Chalmers University of Technology, Gothenburg, Sweden [2]National Technical University, Kharkiv, Ukraine
18:00 - 18:15	**Implementation of Complex Gas Sensor Systems - Ideas for a Structural Model** *Wolfhard Reimringer, T. Rachel, T. Conrad* 3S - Sensors, Signal Processing, Systems GmbH, Saarbrücken, Germany
18:15 - 18:30	**Vulnerability of Classifiers to Adversarial Examples** *Roman Neruda, Petra Vidnerova, Vera Kurkova*, MC Member/Substitute, Institute of Computer Science, Academy of Sciences of the Czech Republic, Prague, Czech Republic

18:30	**Gathering of Day**

20:30 - 23:00	**Social Dinner at the Restaurant *Ladví*** Binarova 1661, Prague 8 (walking distance from Conference Venue) (*www.restauraceladvi.cz/*)

Thursday, 6 October 2016

Action TD1105 Working Groups and Special Interest Groups Meetings

Conference Hall: *Academy of Sciences of the Czech Republic*

09:00 - 18:00	**Registration**

WG3 Session. Location: Conference Hall

09:00 - 11:00	**WG3: Environmental Measurements and Air-Pollution Modelling** *Chairman: Ole Hertel*, Action WG3 Leader & MC Member, Aarhus University, Roskilde, Denmark
09:00 - 09:20	**Air Quality at Your Street - Public Assessable Digital Maps of Air Pollution from Traffic in Denmark** *Ole Hertel, Steen Solvang Jensen, Matthias Ketzel, Jørgen Brandt, Thomas Becker, Morten Fuglsang, Marlene Plejdrup, Morten Winther, and Thomas Ellermann*, Action WG3 Leader & MC Member, Aarhus University, Roskilde, Denmark
09:20 - 09:40	**New Version of the Bulgarian Early Warning System in Case of Nuclear Accident over Europe** *Dimiter Syrakov, Maria Prodanova, Kiril Slavov, Emilia Georgieva*; Action MC Member, National Institute of Meteorology and Hydrology - Bulgarian Academy of Sciences, Sofia, Bulgaria
09:40 - 10:00	**Summary of Activities during COST Action TD1105 Related to Air Phyto-Remediation Performed by Warsaw University of Life Sciences, Poland** *Stanislaw W. Gawronski,* MC Member, Warsaw University of Life Science, Warsaw, Poland
10:00 - 10:15	**Air Quality Issues in Hungary** *Krisztina Labancz*, Action MC Member, Hungarian Meteorological Service, Budapest, Hungary
10:15 - 10:30	**Application of Atomic Force Microscopy and Electrochemistry in Characterization of Marine Aerosols** *Sanja Stevanović[1], Ana Cvitešić[2], Marija Marguš[2], Vladislava Jovanović[1], Nikola Batina[3], Irena Ciglenečki[1]*, Action MC Member; [1]ICTM, Department of Electrochemistry, University of Belgrade, Belgrade, Serbia [2]Division for Marine and Environmental Research, Ruđer Bošković Institue, Zagreb, Croatia [3]Departamento de Química, Universidad Autónoma Metropolitana-Iztapalapa, México
10:30 - 10:45	**4 Year Experience of Application Low-Cost Sensors in Belgrade in the Framework of CITI-SENSE Project** *Milena Jovasevic-Stojanovic[1], Dusan Topalovic[1], Milos Davidovic[1], Ivan Lazovic[1], Marija Zivkovic[1], Zoran Ristovski[2], Alena Bartonova[3]*, [1]Action MC Member, VINCA Institute, Belgrade, Serbia; [2]Queensland University of Technology, Brisbane, Australia; [3]NILU, Kjeller, Norway
10:45 - 11:00	**Air Quality Modelling in Latvia: Recent Updating** *Iveta Steinberga*, Action MC Member, University of Latvia, Riga, Latvia
11:00 - 11:30	**Coffee Break**

WG4 Session. Location: Conference Hall

11:30 - 13:00	**WG4: Protocols and Standardisation Methods** *Chairman: Kostas Karatzas*, MC Member, Aristotle University, Thessaloniki, Greece
11:30 - 11:50	**Life after EuNetAir** *Kostas Karatzas*, Environmental Informatics Research Group, Department of Mechanical Engineering, Aristotle University, Thessaloniki, Greece

11:50 - 12:10	**Mapping Urban Air Quality using Low-Cost Sensors: Opportunities and Challenges** *Philipp Schneider,* MC Member*,* NILU - Norwegian Institute for Air Research, Kjeller, Norway
12:10 - 12:30	**Conclusions from One Year Operating a Low-Cost Sensor Network in Zurich** *Michael Mueller,* WG Member, EMPA, Zurich, Switzerland
12:30 - 12:45	**Particulate Matter Smart Sensors Validation In Real-World Conditions** *Mariacruz Minguillon*, WG Member, CSIC-IDAEA, Barcelona, Spain
12:45 - 13:00	**Towards Intelligent Air Quality Monitoring Networks: How Machine Learning Improve the Accuracy of Air Quality Multisensors Systems** *Saverio De Vito,* MC Substitute, ENEA, CR Portici, Italy

13:00 - 14.00 **Lunch offered by COST Action organization**

Thursday, 6 October 2016

Action TD1105 Poster Session

Gallery of **Conference Hall**

14:00 - 15:30	***Poster Session:*** ***New Technologies and Methods for Environmental Monitoring*** *Chairperson: Andreas Schuetze, Action WG2 Leader, Saarland University, Saarbrucken, Germany*

Posters (max sizes: 80 cm width x 110 height) will be exhibited on Panels. The Poster Presenter, preferably Early Stage Researcher, is required to stay near poster for discussion with interested people.

P01

Intracavity Acetylene Detection with Fiber Loop Ring down Spectroscopy

Alim Yolalmaz[1], Farhad Hanifepour[2], Mehmet Fatih Danışman[1,3], and Okan Esentürk[3]
[1] Micro and Nanotechnology Department,Graduate School of Natural and Applied Science, Middle East Technical University (METU), Ankara, Turkey; Action MC Member;
[2] Department of Advanced Technologies, Institute of Science and Technology, Gazi University,Turkey;
[3]Chemistry Department, Faculty of Arts and Sciences, METU, Turkey

P02

Specific Filters for the Trapping of Specific Air Pollutants

T-H.Tran-Thi[1], A.Borta[1], L.Caillat[1], K.Aguir[2], M.Othmans[2], M.Bendahan[2], V.Vrignaud[3], S. Margeridon-Thermet[3], G. Le Chevallier[1], C.Rivron[1], C.Théron[1], C.Tran[1], L.Mugherli[1], F.Hammel[3],
[1]Department NIMBE, CEA-CNRS, Université Paris-Saclay, CEA-Saclay, Gif-sur-Yvette, France;
[2]Aix-Marseille Université, CNRS, IM2NP, Faculté des Sciences, Marseille, France;
[3]ETHERA, 628 rue Charles de Gaulle, Crolles, France

P03

Atmospheric Deposition of Trace Elements on Carbonate Material of Historic Buildings in two Urban Sites

Palma Orlović-Leko[1], Kristijan Vidović[2], Irena Ciglenečki[3],*
[1]University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering, Zagreb, Croatia;
[2]Center for Marine and Environmental Research, Ruđer Bošković Institue, Zagreb, Croatia,
[3]Institute of Chemistry, Ljubljana Slovenia

P04

DAV³E - A Comprehensive Toolbox for Multisensor Data Fusion not only for Gas Sensors

Manuel Bastuck, Tobias Baur, Tizian Schneider, Andreas Schütze
Laboratory for Measurement Technology, Department of Mechatronics, Saarland University, Saarbruecken, Germany

P05

Gas Sensitive SiC-FET Sensors for Indoor Air Quality Control

Donatella Puglisi[1,], Manuel Bastuck[1,2], Mike Andersson[1,3], Joni Huotari[3], Jyrki Lappalainen[3], Andreas Schütze[2], Anita Lloyd Spetz[1,3]*
[1] Linköping University, Linköping, Sweden;
[2] Saarland University, Saarbrücken, Germany;
[3] University of Oulu, Oulu, Finland

P06

Impedance Spectroscopy of Molecular Material - Based Heterojunctions for a Better Discrimination Between Ammonia and Water

M. Bouvet[1], T. Sauerwald[2], M. Schüler[2], J.-M. Suisse[1], A. Wannebroucq[1], P. Gaudillat[1], A. Kumar[1], A. Schütze[2]**
[1]Institut de Chimie Moléculaire de l'Université de Bourgogne, CNRS UMR 6302, Université de Bourgogne Franche-Comté, Dijon, France; [2]Laboratory for Measurement Technology, Department of Mechatronics, Saarland University, Saarbruecken, Germany

P07	**Molecular Semiconductors - Doped Insulator (MSDI) Heterojunctions as New Conductometric Devices for Chemosensing** *A. Wannebroucq, J.-M. Suisse, <u>M. Bouvet</u>* Institut de Chimie Moléculaire de l'Université de Bourgogne, CNRS UMR 6302, Université de Bourgogne Franche-Comté, Dijon, France
P08	**The Implementation of the Health Impact Assessment (HIA) in Val D'Agri (Italy) and the Direct Involvement of Citizens in Monitoring Activities** *<u>Annamaria Demarinis Loiotile</u>, Gianluigi De Gennaro, Stefania Petraccone,* University of Bari, Department of Biology, Core-Group Member, Bari, Italy
P09	**Thin Film Sensors based on 10% ZrO_2 - 90% TiO_2 Material for the Detection of Oxygen: Effect of Crystallization Conditions** *A.V.G. Sevastianov[1], A.S. Mokrushin[1], E.P. Simonenko[1], V.S. Popov[1], N.P. Simonenko[1], <u>A.A. Vasiliev</u>[2,3], N.T. Kuznetsov[1]* [1] N.S. Kurnakov Institute of General and Inorganic Chemistry of RAS, Moscow, Russia [2] National Research Center Kurchatov Institute, Kurchatov sq., 1, Moscow, Russia [3] OSTEC Enterprise, Moscow, Russia
P10	**A Comparison of Spectrometric Methods and Methods based on Electrochemical Principles** *Branislav Hric[1], <u>Jan Suchánek</u>[1,2], Ivana Bartlová[1], Michal Dostal[1,2], Pavel Kubát[2], Svatopluk Civiš[2], Vaclav Nevrlý[1], Petr Bitala[1], Vaclav Valek[1], Zdeněk Zelinger[2]* [1] VŠB-Technical University of Ostrava, Faculty of Safety Engineering, Ostrava, Czech Republic; [2] J. Heyrovský Institute of Physical Chemistry, v.v.i., Academy of Sciences of the Czech Republic, Prague, Czech Republic
P11	**Gas Detection by Quartz Enhanced Photoacoustic Spectroscopy** *<u>Michal Dostál</u>[1,2], Jan Suchánek[1,2], Václav Válek[2], Václav Nevrlý[2], Petr Bitala[2], Simona Slivková[2], Pavel Kubát[1], Pavel Janda[1], Svatopluk Civiš[1], Zdeněk Zelinger[1];* [1]J. Heyrovský Institute of Physical Chemistry AS CR, Prague, Czech Republic; [2]Faculty of Safety Engineering, VŠB - Technical University of Ostrava, Ostrava, Czech Republic
P12	**Measurement of $PM_{2.5}$ Concentrations in Indoor Air using Low-Cost Sensors and Arduino Platforms** *<u>Visa Tasić</u>[1], Milena Jovašević-Stojanović[2], Dusan Topalović[2], Milos Davidović[2]* [1]Mining and Metallurgy Institute Bor, Bor, Serbia [2]University of Belgrade, Vinča Institute of Nuclear Sciences, Belgrade, Serbia
P13	**Novel Graphene Cantilevers Employed in Photoacoustic Spectroscopy for Multicomponent Analysis of Acetic Acid** *<u>Jan Suchanek</u>[1,2], Michal Dostal[1,2], Pavel Janda[1], Pavel Kubat[1], Svatopluk Civis[1], Martin Ferus[1], Antonín Křížek[1], Tereza Kaiserová[1], Jana Hrnčířová[1], Vaclav Nevrlý[2], Petr Bitala[2], Vaclav Valek[2], Zdenek Zelinger[1]* [1]J. Heyrovsky Institute of Physical Chemistry of the CAS, v. v. i., Prague, Czech Republic; [2]VŠB - Technical University of Ostrava, Faculty of Safety Engineering, Ostrava, Czech Republic
P14	**SiC-FET based NO_x Sensor for Automotive Applications** *Peter Möller[1], Mike Andersson[1], Anita Lloyd Spetz[1,2], Jarkko Puustinen[2], Jyrki Lappalainen[2], Jens Eriksson[1];* [1]Linköping University, Linköping, Sweden; [2]University of Oulu, Finland
P15	**The Dynamics of Viscoelastic Layered Systems Studied by Surface Acoustic Wave (SAW) Sensors Operated in a Liquid Phase** *<u>Anton Wikstrom</u>[2], Marina Voinova[1,2]*, [1]Chalmers University of Technology, Gothenburg, Sweden [2]National Technical University, Kharkiv, Ukraine

15:00 - 15:30 Coffee-Break during POSTER Session

Thursday, 6 October 2016

Action TD1105 SIG1-4 Session

15:30 - 18:00	**SIG1: Network of spin-offs** **SIG2: Smart Sensors for Urban Air Monitoring in Cities** **SIG3:Guidelines for Best Coupling Air Pollutants and Transducer** **SIG4:Expert Comments for the Revision of the Air Quality Directive (AQD)** *Chairman: Anita Lloyd Spetz*, Action Vice-Chair, Linkoping University (Sweden) and University of Oulu (Finland)
15:30 - 16:00	**H2020 Opportunities of Funding in the Air Quality Monitoring and Related Topics** *Corinna Hahn*, Grant Holder & Action MC Member, Eurice GmbH, Saarbrucken, Germany
16:00 - 16:20	**Air Quality Networks: Lessons Learned, Current Status and Future Opportunities** *John Saffell*, Action MC Member, Alphasense Ltd, Essex, UK
16:20 - 16:40	**New Trends and Challenges of Air Pollution Monitoring using Low-Cost Sensors: What IDAD Learned?** *Carlos Borrego*, IDAD and University of Aveiro, Action MC Member, Aveiro, Portugal
16:40 - 17:00	**Organic/Inorganic Hybrid Materials for the Development of Acoustic Wave Chemical Sensors Dedicated to BTEX Detection** *Jerome Brunet, A.L. Ndiaye, A. Kumar, A. Pauly, C. Varenne*, Action MC Member, Université Blaise Pascal/CNRS, Clermont-Ferrand, Aubiere, France
17:00 - 17:20	**High Performance SiC-FET Gas Sensors for Highly Sensitive Detection of Hazardous Indoor Air Pollutants** *Donatella Puglisi[1], Mike Andersson[1,3], Jens Eriksson[1], Manuel Bastuck[1,2], Christian Bur[1,2], Joni Huotari[3], Jyrki Lappalainen[3], Andreas Schütze[2], Anita Lloyd Spetz[1,3]* [1]Linköping University, Linköping, Sweden; [2]Saarland University, Saarbrücken, Germany; [3]University of Oulu, Oulu, Finland
17:20 - 17:40	**Low Temperature-Low Power Gas Sensors based on Germanium Nanowires** *J. Samà[1], S. Barth[2], G. Domènech-Gil[1], M. Seifner[2], I. Gracia[3], C. Calaza[3], P. Pellegrino[1] and Albert Romano-Rodríguez[1]*, Action MC Substitute, [1]Universitat de Barcelona, Barcelona, Spain; [2]Technical University of Vienna; [3]Consejo Superior de Investigaciones Científicas (CSIC), Institut de Microelectrònica de Barcelona-Centro Nacional de Microelectrónica, 08193 Bellaterra, Spain
17:40 - 18:00	**A Flexible Platform for Extremely Sensitive Gas Sensing: 2D Materials on Silicon Carbide** *Jens Eriksson[1], J. Bahonjic[1], D. Puglisi[1], R. Yakimova[1,2], A. Lloyd Spetz[1]* [1] Department of Physics, Chemistry, and Biology, Linköping University, Sweden [2] Graphensic AB, Linköping, Sweden
18:00 - 18:30	**FOLLOW-UP of the COST Action TD1105** *Chairman: Michele Penza, Action Chair, ENEA, Brindisi, Italy*
	Which Future Initiatives after *EuNetAir*
18:00 - 18:10	**Updating on Report *Innovation on Environmental Sensor Technologies*** *Marco Alvisi,* Action SIG1 Leader, ENEA, Brindisi, Italy
18:10 - 18:20	**Editorial Initiatives of *EuNetAir*** *Michele Penza,* Action Chair, ENEA, Brindisi, Italy
18:20 - 18:30	**Discussion: Comments and Inputs from Participants and Stakeholders**
18:30	**Closure of the WGs Meeting**
20:30	**Dinner Freely by Participants**

Friday, 7 October 2016

Action TD1105 Working Groups and Special Interest Groups Meetings

09:00 - 11:00	**Action WGs-SIGs GENERAL ASSEMBLY** *Chairman: Michele Penza, Action Chair* *Italian National Agency for New Technologies, Energy and Sustainable Economic Development - ENEA, Brindisi, Italy*
	Specific Presentations from Key Speakers, WGs and SIGs Leaders
09:00 - 09:20	**Low-Power Heating for Conductometric Gas NanoSensors: Self-Heating Effects** *O. Monereo, C. Fàbrega, O. Casals, J. Samà, F. Hernandez-Ramírez, A. Cirera, A. Romano-Rodríguez, Juan Daniel Prades*, ERC Starting Grant & Action WG Member, Universitat de Barcelona, Barcelona, Spain ERC Starting Grant (no. 336917): *Nanodevice Engineering for a Better Chemical Gas Sensing Technology - BetterSense*
09:20 - 09:40	**High Spatial Resolution Air Quality Mapping using Data from an Opportunistic Mobile Monitoring Campaign** *Joris Van den Bossche[1, 2], Bart Elen[1], Jan Peters[1], Dick Botteldooren[3], Bernard De Baets[2], Jan Theunis[1]*, STSMs Coordinator and Action MC Member, [1]VITO, Health Unit, Mol, Belgium; [2]Ghent University, KERMIT Research Unit Knowledge-based Systems, Belgium; [3]Ghent University, INTEC Acoustics, Belgium
09:40 - 09:50	**Summary of Research and Innovation Needs from WG1:** ***Sensor Materials and Nanotechnology*** *Jyrki Lappalainen,* Action WG1 Vice-Chair - Oulu University, Oulu, Finland
09:50 - 10:00	**Summary of Research and Innovation Needs from WG2:** ***Sensors, Devices and Systems for AQC*** *Andreas Schuetze*, Action WG2 Chair, Saarland University, Saarbrucken, Germany
10:00 - 10:10	**Summary of Research and Innovation Needs from WG3:** ***Environmental Measurements and Air-Pollution Modelling*** *Ole Hertel*, Action WG3 Leader & MC Member, Aarhus University, Roskilde, Denmark
10:10 - 10:20	**Summary of Research and Innovation Needs from WG4:** ***Protocols and Standardisation Methods*** *Kostas Karatzas*, MC Member, Aristotle University, Thessaloniki, Greece
10:20 - 10:30	**Summary of Research and Innovation Needs from SIG1:** ***Network of Spin-offs*** *Marco Alvisi,* Action SIG1 Leader, ENEA, Brindisi, Italy
10:30 - 10:40	**Summary of Research and Innovation Needs from SIG2:** ***Smart Sensors for Urban Air Monitoring in Cities*** *Christoph Hueglin,* Action SIG2 Leader, EMPA, Zurich, Switzerland
10:40 - 10:50	**Summary of Research and Innovation Needs from SIG3:** ***Guidelines for Best Coupling Air Pollutant - Transducer*** *Eduard Llobet,* Action SIG3 Leader, Universitat Roviri I Virgili, Tarragona, Spain substituted by *Marcel Bouvet*, Action MC Member, Institut de Chimie Moléculaire de l'Université de Bourgogne, CNRS UMR 6302, Université de Bourgogne Franche-Comté, Dijon, France
10:50 - 11:00	**Summary of Research and Innovation Needs from SIG4:** ***Expert Comments for the Revision of the Air Quality EU Directive*** *Carlos Borrego,* Action SIG4 Leader, IDAD, Aveiro, Portugal
11:00 - 11.30	**Coffee Break**

Friday, 7 October 2016

Action TD1105 MANAGEMENT COMMITTEE Meeting

Conference Hall

11:30 - 13:00	**Action TD1105 9th MANAGEMENT COMMITTEE MEETING** *Chairman: Michele Penza, Action Chair* *Italian National Agency for New Technologies, Energy and Sustainable Economic Development - ENEA, Brindisi, Italy*

11:30 : 13:00 **9th Management Committee Meeting**
Michele Penza, Action Chair, ENEA, Brindisi, Italy

- **DISCUSSION** (see MCM AGENDA): *EuNetAir Meeting Participants and Stakeholders*
- **Coffee-Break** (timely scheduled)

13:00
- **End of the 9th MCM of the COST Action TD1105 - EuNetAir**

13:00 - 14:30
- **Lunch offered by the Conference Organization**

14:30
- **Meeting Closing**

Draft Agenda
9th Management Committee Meeting
COST Action TD1105

European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability

FINAL MEETING - SIXTH SCIENTIFIC MEETING
Working Groups and Management Committee

New Sensing Technologies for Air Quality Monitoring

Prague, Czech Republic, 5 - 7 October 2016

hosted at J. Heyrovský Institute of Physical Chemistry - Conference Hall
Dolejškova 3, 182 23 Prague, Czech Republic

Management Committee Meeting, 7 October 2016, 11:30 - 13:00

To be completed by the meeting secretary and circulated to the MC and the COST Association (Science and Administrative Officer)

1. Welcome to participants
2. Adoption of agenda
3. Approval of minutes and matters arising of last meeting
4. Update from the Action Chair
   a. Status of Action, including participating countries
   b. Action budget status
   c. STSM status and new applications
5. Promotion of gender balance and of Early Stage Researchers (ESR)
6. Update from the Grant Holder
7. Update from the COST Office
8. Update from the DC Rapporteur
9. Annual Progress Conference (preparation and/or feedback from DC)
10. Follow-up of MoU objectives
    a. Progress report of working groups
11. Scientific planning
    a. Scientific strategy
    b. Action Budget Planning
    c. Long-term planning (including anticipated locations and dates of future activities)
    d. Dissemination planning (Publications and outreach activities)
12. Requests for new members
13. Non-COST applications to the Actions
14. AOB
15. Location and date of next meeting
16. Summary of MC decisions
17. Closing

COST
EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY

9th MC Meeting Venue/Location of COST Action TD1105 EuNetAir

FINAL MEETING - SIXTH SCIENTIFIC MEETING

Working Groups and Management Committee

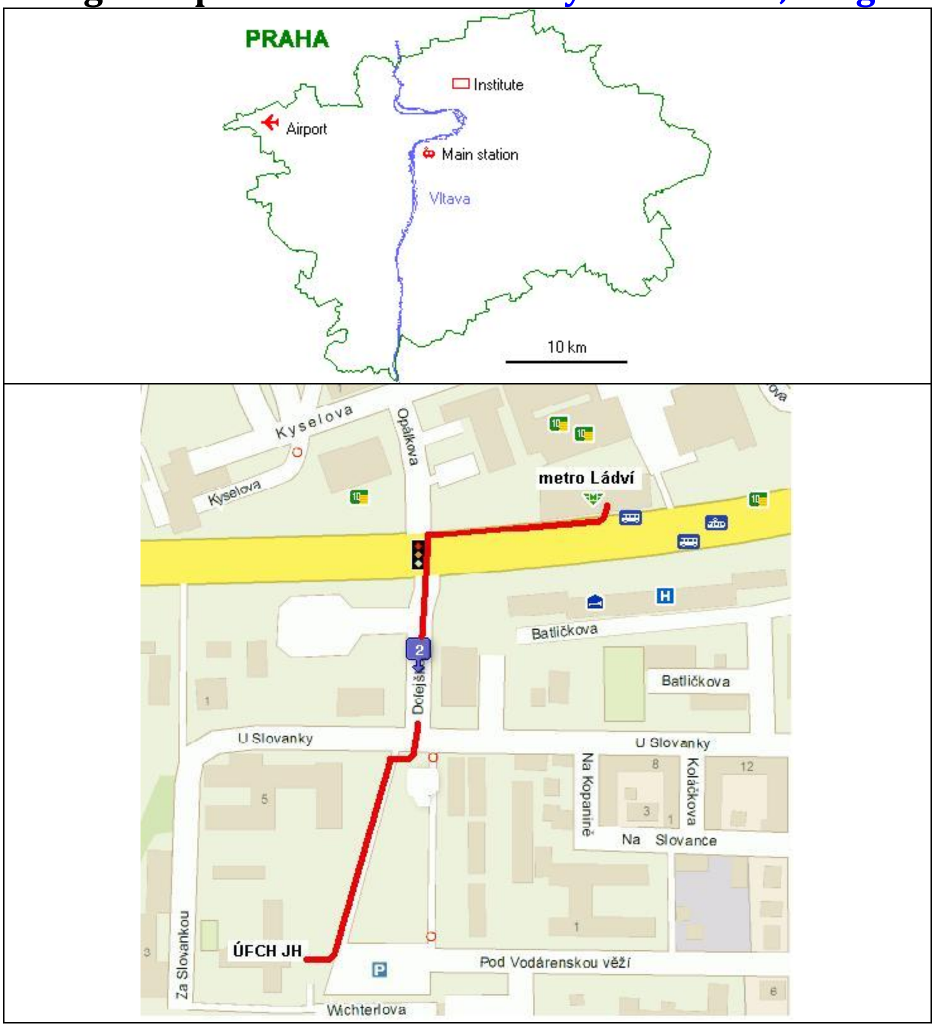
New Sensing Technologies for Air Quality Monitoring

Prague, Czech Republic, 5 - 7 October 2016

hosted at J. Heyrovský Institute of Physical Chemistry - Conference Hall
Dolejškova 3, 182 23 Prague, Czech Republic

How to reach J. Heyrovský Institute of Physical Chemistry - Conference Hall
Walk to the Institute (**UFCH JH**) from tram-stop or subway station Ladvi, line C (**depicted in red**)
Prague, Czech Republic

Google Map Link: **Czech Academy of Sciences, Prague**



WELCOME ADDRESS

This is a great honor and my pleasure to chair and welcome to ALL PARTICIPANTS of the **FINAL MEETING - SIXTH SCIENTIFIC MEETING**, including **Working Groups Meeting** and **Management Committee Meeting**, of our COST Action TD1105 *European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability - EuNetAir*, considered a *Top-Story* by COST Association.

This COST Meeting - held on 5-7 October 2016 - on ***New Sensing Technologies for Air-Pollution Monitoring*** is organized by **Academy of Sciences of the Czech Republic**, under management of Prof. Zdenek Zelinger, Dr. Vera Kurkova, our Action MC Members, and Roman Neruda, MC Substitute, and hosted at *J. Heyrovsky Institute of Physical Chemistry of Academy of Sciences*, in Prague, with Local Organizing Support from ASCR.

This **Final Meeting - Sixth Scientific Meeting** follows the previous *EuNetAir Meeting in Sofia* (16-18 December 2016), and it is attended from at least 55 Participants and includes 10 Sessions with 12 Invited Speakers, 26 Contributed Speakers and 15 Poster Presenters from at least 23 COST Countries including 1 Near Neighbour Country (Russia). 2 **Plenary Sessions** devoted to ***EuNetAir Celebration and Environment Quality Applications*** were participated by 5 Invited Speakers from 4 COST Countries. A Round-Table on **Which Future Initiatives After EuNetAir** has been organized with the attendance of *managers* and *researchers*. An international Advisory Board (*Steering Committee*) composed by 22 Members served with S&T inputs to define Workshop Programme. *Female participants* are as 33% and *Male participants* are as 67% with a quota of *Early Stage Researchers* as 25%.

The concerted COST Action TD1105 *EuNetAir* - related to R&D issues of the air quality monitoring including environmental technologies, nanomaterials, functional materials, gas sensors, smart systems, air-pollution modelling, measurements, methods, standards and protocols - is very pleased to connect international specialists and excellent scientists to create a networking of Pan-European R&D platform from 31 COST Countries and 7 Non-COST Countries. Most part of COST Countries are represented in this Meeting.

Special thanks to **COST Officers**: Dr. Deniz Karaca, *Science Officer* and Dr. Tania Gonzalez-Ovin, *Administrative Officer*, involved to manage policy & administration in our Action. An *Invited Talk* was given by Dr. Juan Daniel Prades, Spain, ERC Starting Grant.

On behalf of the Action Management Committee, I would like to thank **ALL Participants**, **Grant Holder**, **Action Scientific Secretary**, **Local Organizing Committee** by **Czech Academy of Sciences**, represented by *Director of J. Heyrovsky Institute*, and the COST National Coordinator from **Czech Ministry of Education and Science**, represented by *Director of Minister*, in order to give opportunity to disseminate the results of the COST Action TD1105 *EuNetAir* towards an international targeted audience involved in Air Quality Control. With their valuable scientific work and management, kind availability and great enthusiasm will make our Action Meeting very successful !

Enjoy our *EuNetAir* Meeting at *Academy of Sciences of Czech Republic* in Prague !

Brindisi, 30 September 2016

Michele Penza, ENEA, Brindisi, Italy
COST Action TD1105 Chair
michele.penza@enea.it

LIST OF PRESENTERS

FINAL MEETING - SIXTH SCIENTIFIC MEETING
Working Groups and Management Committee on
New Sensing Technologies for Air Quality Monitoring

Welcome Address

CZ COST National Coordinator - Ministry of Education
Josef Janda, CZ CNC - Ministry of Education Youth and Sports of the Czech Republic, Prague, Czech Republic

Academy of Sciences of the Czech Republic
Zdenek Samec, Director of the Heyrovsky Institute of Physical Chemistry - ASCR, Academy of Sciences of the Czech Republic, Prague, Czech Republic

COST Action TD1105
Michele Penza, Action Chair, ENEA, Brindisi, Italy

Plenary Session 1: Air Quality Sensor Applications - EuNetAir Celebration

COST Action TD1105: European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability - EuNetAir
Michele Penza, Action Chair, ENEA, Italy

Gas and Particle Sensors in the Framework of EuNetAir
Anita Lloyd Spetz, Action Vice-Chair, Linkoping University (Sweden) and University of Oulu (FI)

Plenary Session 2: Environment Quality Applications

The SENSIndoor FP7 Project: Main Results, Lessons Learned and Outlook
Andreas Schuetze, Action MC Member, Saarland University, Saarbrucken, Germany

The CITI-SENSE FP7 Project: From Sensor Technology to Citizen Engagement
Nuria Castell, Action MC Member, NILU - Norwegian Institute for Air Research, Kjeller, Norway

Assessment of Air Pollution Impacts on Human Health using AirQ+
Pierpaolo Mudu, Technical Officer of the WHO European Centre for Environment and Health, Bonn, Germany

WG1: Sensor Materials and Nanotechnology

Emerging Sensing Materials for Air Quality Monitoring

Marcel Bouvet, Action MC Member, Institut de Chimie Moléculaire de l'Université de Bourgogne, CNRS UMR 6302, Université de Bourgogne Franche-Comté, Dijon, France

Recent Developments of Complex Nanostructured Metal Oxide Entities for Chemical Sensors
Jyrki Lappalainen, Joni Huotari, Jarkko Puustinen, Action MC Member, Faculty of Information Technology and Electrical Engineering, University of Oulu, Oulu, Finland

Gas Sensors based on CuO-TiO2 Heterostructures
Zafer Z. Ozturk, O. Alev, E. Sennik, O. Sisman, Gebze Technical University, Kocaeli, Turkey

Solid Nanoporous Sensor for the Colorimetric Detection of Phenol
C. Theron, et al., Thu-Hoa Tran-Thi, NIMBE, CEA-CNRS, Gif-sur-Yvette Cedex, France

Photoluminescence based Gas Sensing with Rare-Earth Doped Oxide Nanopowders and Thin Films
Raivo Jaaniso, Tea Avarmaa, Leonid Dolgov, Marko Eltermann, Valter Kiisk, Margus Kodu and Sven Lange, Action MC Member, Institute of Physics, University of Tartu, Estonia

WG2: Sensors, Devices and Systems for AQC

Disposable Sensors and Instruments for Air Quality Monitoring
Danick Briand, Action MC Member, EPFL, Neuchatel, Switzerland

Multilayer Graphene Cantilever for Laser Photoacoustic Detection
Zdenek Zelinger; Action MC Member, J. Heyrovský Institute of Physical Chemistry, Academy of Sciences of the Czech Republic, Prague, Czech Republic

A New Concept of Environmental Camera through Volatile Organic Compounds Sensing
Thomas Walewyns, Nicolas Andrè, Laurent Francis, Université Catholique de Louvain, Electrical Engineering Department, Louvain-la-Neuve, Belgium

Dosimeter-Type Sensor for sub-ppm NOx Detection
Daniela Schoenauer-Kamin, I. Marr, Ralf Moos, Laboratory of Functional Materials, MC Substitute, University of Bayreuth, Bayreuth, Germany

Theoretical Modeling of QCM-D and SH-SAW Sensors in Environmental Applications
Marina Voinova[1,2], Anton Wikstrom[2], [1]Chalmers University of Technology, Gothenburg, Sweden, [2]National Technical University, Kharkiv, Ukraine

Implementation of Complex Gas Sensor Systems - Ideas for a Structural Model
Wolfhard Reimringer, T. Rachel, T. Conrad, 3S - Sensors, Signal Processing, Systems GmbH, Saarbrücken, Germany

Vulnerability of Classifiers to Adversarial Examples
Roman Neruda, Petra Vidnerova, Vera Kurkova, MC Member/Substitute, Institute of Computer Science, Academy of Sciences of the Czech Republic, Prague, Czech Republic

WG3: Environmental Measurements and Air-Pollution Modelling

Air Quality at Your Street - Public Assessable Digital Maps of Air Pollution from Traffic in Denmark

Ole Hertel, Steen Solvang Jensen, Matthias Ketzel, Jørgen Brandt, Thomas Becker, Morten Fuglsang, Marlene Plejdrup, Morten Winther, and Thomas Ellermann, Action WG3 Leader & MC Member, Aarhus University, Roskilde, Denmark

New Version of the Bulgarian Early Warning System in Case of Nuclear Accident over Europe

Dimiter Syrakov, Maria Prodanova, Kiril Slavov, Emilia Georgieva; Action MC Member, National Institute of Meteorology and Hydrology - Bulgarian Academy of Sciences, Sofia, Bulgaria

Summary of Activities during COST Action TD1105 Related to Air Phyto-Remediation Performed by Warsaw University of Life Sciences, Poland

Stanislaw W. Gawronski, MC Member, Warsaw University of Life Science, Warsaw, Poland

Air Quality Issues in Hungary

Krisztina Labancz, Action MC Member, Hungarian Meteorological Service, Budapest, Hungary

Application of Atomic Force Microscopy and Electrochemistry in Characterization of Marine Aerosols

Sanja Stevanović[1], Ana Cvitešić[2], Marija Marguš[2], Vladislava Jovanović[1], Nikola Batina[3], Irena Ciglenečki[1], Action MC Member; [1]ICTM, Department of Electrochemistry, University of Belgrade, Belgrade, Serbia; [2]Division for Marine and Environmental Research, Ruđer Bošković Institue, Zagreb, Croatia; [3]Departamento de Química, Universidad Autónoma Metropolitana-Iztapalapa, México

4 Year Experience of Application Low-Cost Sensors in Belgrade in the Framework of CITISENSE Project

Milena Jovasevic-Stojanovic[1], Dusan Topalovic[1], Milos Davidovic[1], Ivan Lazovic[1], Marija Zivkovic[1], Zoran Ristovski[2], Alena Bartonova[3], [1]Action MC Member, VINCA Institute, Belgrade, Serbia; [2]Queensland University of Technology, Brisbane, Australia; [3]NILU, Kjeller, Norway

Air Quality Modelling in Latvia: Recent Updating

Iveta Steinberga, Action MC Member, University of Latvia, Riga, Latvia

WG4: Protocols and Standardisation Methods

Life after EuNetAir

Kostas Karatzas, Environmental Informatics Research Group, Department of Mechanical Engineering, Aristotle University, Thessaloniki, Greece

Mapping Urban Air Quality using Low-Cost Sensors: Opportunities and Challenges

Philipp Schneider, MC Member, NILU - Norwegian Institute for Air Research, Kjeller, Norway

Conclusions from One Year Operating a Low-Cost Sensor Network in Zurich
Michael Mueller, WG Member, EMPA, Zurich, Switzerland

Particulate Matter Smart Sensors Validation In Real-World Conditions
Mariacruz Minguillon, WG Member, CSIC-IDAEA, Barcelona, Spain

Towards Intelligent Air Quality Monitoring Networks: How Machine Learning Improve the Accuracy of Air Quality Multisensors Systems
Saverio De Vito, MC Substitute, ENEA, CR Portici, Italy

Poster Session: New Technologies and Methods for Environmental Monitoring

P01: Intracavity Acetylene Detection with Fiber Loop Ring down Spectroscopy
Alim Yolalmaz[1], Farhad Hanifepour[2], *Mehmet Fatih Danışman*[1,3], and Okan Esentürk[3]
[1]Micro and Nanotechnology Department,Graduate School of Natural and Applied Science, Middle East Technical University (METU), Ankara, Turkey; Action MC Member;
[2] Department of Advanced Technologies, Institute of Science and Technology, Gazi University,Turkey; [3]Chemistry Department, Faculty of Arts and Sciences, METU, Turkey

P02: Specific Filters for the Trapping of Specific Air Pollutants
T-H.Tran-Thi[1], A.Borta1, L.Caillat[1], K.Aguir[2], M.Othmans[2], M.Bendahan[2], V.Vrignaud[3], S. Margeridon-Thermet[3], G. Le Chevallier[1], C.Rivron[1], C.Théron[1], C.Tran[1], L.Mugherli[1], F.Hammel[3]; [1]Department NIMBE, CEA-CNRS, Université Paris-Saclay, CEA-Saclay, Gif-sur-Yvette, France; [2]Aix-Marseille Université, CNRS, IM2NP, Faculté des Sciences, Marseille, France; [3]ETHERA, 628 rue Charles de Gaulle, Crolles, France

P03: Atmospheric Deposition of Trace Elements on Carbonate Material of Historic Buildings in two Urban Sites
Palma Orlović-Leko[1], Kristijan Vidović[2], Irena Ciglenečki[3]; [1]University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering, Zagreb, Croatia; [2]Center for Marine and Environmental Research, Ruđer Bošković Institue, Zagreb, Croatia, [3]Institute of Chemistry, Ljubljana Slovenia

P04: DAV³E - A Comprehensive Toolbox for Multisensor Data Fusion not only for Gas Sensors
Manuel Bastuck, Tobias Baur, Tizian Schneider, Andreas Schütze; Laboratory for Measurement Technology, Department of Mechatronics, Saarland University, Saarbruecken, Germany

P05: Gas Sensitive SiC-FET Sensors for Indoor Air Quality Control
Donatella Puglisi[1], Manuel Bastuck[1,2], Mike Andersson[1,3], Joni Huotari[3], Jyrki Lappalainen[3], Andreas Schütze[2], Anita Lloyd Spetz[1,3]; [1] Linköping University, Linköping, Sweden;
[2] Saarland University, Saarbrücken, Germany; [3] University of Oulu, Oulu, Finland

P06: Impedance Spectroscopy of Molecular Material - Based Heterojunctions for a Better Discrimination Between Ammonia and Water
M. Bouvet[1], T. Sauerwald[2], M. Schüler[2], J.-M. Suisse[1], A. Wannebroucq[1], P. Gaudillat[1], A. Kumar[1], A. Schütze[2]; [1]Institut de Chimie Moléculaire de l'Université de Bourgogne, CNRS UMR 6302, Université de Bourgogne Franche-Comté, Dijon, France; [2]Laboratory for

Measurement Technology, Department of Mechatronics, Saarland University, Saarbruecken, Germany

P07: Molecular Semiconductors - Doped Insulator (MSDI) Heterojunctions as New Conductometric Devices for Chemosensing

A. Wannebroucq, J.-M. Suisse, *M. Bouvet*; Institut de Chimie Moléculaire de l'Université de Bourgogne, CNRS UMR 6302, Université de Bourgogne Franche-Comté, Dijon, France

P08: The Implementation of the Health Impact Assessment (HIA) in Val D'Agri (Italy) and the Direct Involvement of Citizens in Monitoring Activities

Annamaria Demarinis Loiotile, Gianluigi De Gennaro, Stefania Petraccone, University of Bari, Department of Biology, Core-Group Member, Bari, Italy

P09: Thin Film Sensors based on 10% ZrO2 - 90% TiO2 Material for the Detection of Oxygen: Effect of Crystallization Conditions

A.V.G. Sevastianov[1], A.S. Mokrushin[1], E.P. Simonenko[1], V.S. Popov[1], N.P. Simonenko[1], *A.A. Vasiliev*[2,3], N.T. Kuznetsov[1]; [1] N.S. Kurnakov Institute of General and Inorganic Chemistry of RAS, Moscow, Russia; [2] National Research Center Kurchatov Institute, Kurchatov sq., 1, Moscow, Russia; [3] OSTEC Enterprise, Moscow, Russia

P10: A Comparison of Spectrometric Methods and Methods based on Electrochemical Principles

Branislav Hric[1], Jan Suchánek[1,2], Ivana Bartlová[1], Michal Dostal[1,2], Pavel Kubát[2], Svatopluk Civiš[2], Vaclav Nevrlý[1], Petr Bitala[1], Vaclav Valek[1], Zdeněk Zelinger[2]; [1]VŠB-Technical University of Ostrava, Faculty of Safety Engineering, Ostrava, Czech Republic; [2]J. Heyrovský Institute of Physical Chemistry, v.v.i., Academy of Sciences of the Czech Republic, Prague, Czech Republic

P11: Gas Detection by Quartz Enhanced Photoacoustic Spectroscopy

Michal Dostál[1,2], *Jan Suchánek*[1,2], Václav Válek[2], Václav Nevrlý[2], Petr Bitala[2], Simona Slivková[2], Pavel Kubát[1], Pavel Janda[1], Svatopluk Civiš[1], Zdeněk Zelinger[1]; [1]J. Heyrovský Institute of Physical Chemistry AS CR, Prague, Czech Republic; [2]Faculty of Safety Engineering, VŠB - Technical University of Ostrava, Ostrava, Czech Republic

P12: Measurement of PM2.5 Concentrations in Indoor Air using Low-Cost Sensors and Arduino Platforms

Visa Tasić[1], Milena Jovašević-Stojanović[2], Dusan Topalović[2], Milos Davidović[2]; [1]Mining and Metallurgy Institute Bor, Bor, Serbia; [2]University of Belgrade, Vinča Institute of Nuclear Sciences, Belgrade, Serbia

P13: Novel Graphene Cantilevers Employed in Photoacoustic Spectroscopy for Multicomponent Analysis of Acetic Acid

Jan Suchanek[1,2], Michal Dostal[1,2], Pavel Janda[1], Pavel Kubat[1], Svatopluk Civis[1], Martin Ferus[1],Antonín Knížek[1], Tereza Kaiserová[1], Jana Hrnčířová[1], Vaclav Nevrlý[2], Petr Bitala[2], Vaclav Valek[2], Zdenek Zelinger[1]; [1]J. Heyrovsky Institute of Physical Chemistry of the CAS, v. v. i., Prague, Czech Republic; [2]VŠB - Technical University of Ostrava, Faculty of Safety Engineering, Ostrava, Czech Republic

P14: SiC-FET based NOx Sensor for Automotive Applications

Peter Möller[1], Mike Andersson[1], Anita Lloyd Spetz[1,2], Jarkko Puustinen[2], Jyrki Lappalainen[2], Jens Eriksson[1]; [1]Linköping University, Linköping, Sweden; [2]University of Oulu, Finland

P15: The Dynamics of Viscoelastic Layered Systems Studied by Surface Acoustic Wave (SAW) Sensors Operated in a Liquid Phase

Anton Wikstrom[2], Marina Voinova[1,2]; [1]Chalmers University of Technology, Gothenburg, Sweden; [2]National Technical University, Kharkiv, Ukraine

SIG1: Network of spin-offs
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SIG4:Expert Comments for the Revision of the Air Quality Directive (AQD)

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Corinna Hahn, Grant Holder & Action MC Member, Eurice GmbH, Saarbrucken, Germany

Air Quality Networks: Lessons Learned, Current Status and Future Opportunities

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New Trends and Challenges of Air Pollution Monitoring using Low-Cost Sensors: What IDAD Learned?

Carlos Borrego, IDAD and University of Aveiro, Action MC Member, Aveiro, Portugal

Organic/Inorganic Hybrid Materials for the Development of Acoustic Wave Chemical Sensors Dedicated to BTEX Detection

Jerome Brunet, A.L. Ndiaye, A. Kumar, A. Pauly, C. Varenne, Action MC Member, Université; Blaise Pascal/CNRS, Clermont-Ferrand, Aubiere, France

High Performance SiC-FET Gas Sensors for Highly Sensitive Detection of Hazardous Indoor Air Pollutants

*Donatella Puglisi*1, Mike Andersson1,3, Jens Eriksson1, Manuel Bastuck1,2, Christian Bur[1,2], Joni Huotari[3], Jyrki Lappalainen[3], Andreas Schütze[2], Anita Lloyd Spetz[1,3]
[1]Linköping University, Linköping, Sweden; [2]Saarland University, Saarbrücken, Germany; [3]University of Oulu, Oulu, Finland

Low Temperature-Low Power Gas Sensors based on Germanium Nanowires

J. Samà[1], S. Barth[2], G. Domènech-Gil[1], M. Seifner[2], I. Gracia[3], C. Calaza[3], P. Pellegrino[1] and *Albert Romano-Rodríguez*[1], Action MC Substitute, [1]Universitat de Barcelona, Barcelona, Spain; [2]Technical University of Vienna; [3]Consejo Superior de Investigaciones Científicas (CSIC), Institut de Microelectrònica de Barcelona-Centro Nacional de Microelectrónica, 08193 Bellaterra, Spain

A Flexible Platform for Extremely Sensitive Gas Sensing: 2D Materials on Silicon Carbide

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FOLLOW-UP of the COST Action TD1105

Which Future Initiatives after EuNetAir

Updating on Report Innovation on Environmental Sensor Technologies
Marco Alvisi, Action SIG1 Leader, ENEA, Brindisi, Italy

Editorial Initiatives of EuNetAir
Michele Penza, Action Chair, ENEA, Brindisi, Italy

Discussion: Comments and Inputs from Participants and Stakeholders

Action WGs-SIGs GENERAL ASSEMBLY

Specific Presentations from Key Speakers, WGs and SIGs Leaders

Low-Power Heating for Conductometric Gas NanoSensors: Self-Heating Effects
O. Monereo, C. Fàbrega, O. Casals, J. Samà, F. Hernandez-Ramírez, A. Cirera, A. Romano-Rodríguez, *Juan Daniel Prades*, ERC Starting Grant & Action WG Member, Universitat de Barcelona, Barcelona, Spain
ERC Starting Grant (no. 336917): Nanodevice Engineering for a Better Chemical Gas Sensing Technology - BetterSense

High Spatial Resolution Air Quality Mapping using Data from an Opportunistic Mobile Monitoring Campaign
Joris Van den Bossche[1, 2], Bart Elen[1], Jan Peters[1], Dick Botteldooren[3], Bernard De Baets[2], *Jan Theunis*[1], STSMs Coordinator and Action MC Member, [1]VITO, Health Unit, Mol, Belgium; [2]Ghent University, KERMIT Research Unit Knowledge-based Systems, Belgium; [3]Ghent University, INTEC Acoustics, Belgium

Summary of Research and Innovation Needs from WG1: Sensor Materials and Nanotechnology
Jyrki Lappalainen, Action WG1 Vice-Chair - Oulu University, Oulu, Finland

Summary of Research and Innovation Needs from WG2: Sensors, Devices and Systems for AQC
Andreas Schuetze, Action WG2 Chair, Saarland University, Saarbrucken, Germany

Summary of Research and Innovation Needs from WG3: Environmental Measurements and Air-Pollution Modelling
Ole Hertel, Action WG3 Leader & MC Member, Aarhus University, Roskilde, Denmark

Summary of Research and Innovation Needs from WG4: Protocols and Standardisation Methods
Kostas Karatzas, MC Member, Aristotle University, Thessaloniki, Greece

Summary of Research and Innovation Needs from SIG1: Network of Spin-offs
Marco Alvisi, Action SIG1 Leader, ENEA, Brindisi, Italy

Summary of Research and Innovation Needs from SIG2: Smart Sensors for Urban Air Monitoring in Cities

Christoph Hueglin, Action SIG2 Leader, EMPA, Zurich, Switzerland

Summary of Research and Innovation Needs from SIG3: Guidelines for Best Coupling Air Pollutant - Transducer

Eduard Llobet, Action SIG3 Leader, Universitat Roviri I Virgili, Tarragona, Spain, substituted by *Marcel Bouvet*, Action MC Member, Institut de Chimie Moléculaire de l'Université de Bourgogne, CNRS UMR 6302, Université de Bourgogne Franche-Comté, Dijon, France

Summary of Research and Innovation Needs from SIG4: Expert Comments for the Revision of the Air Quality EU Directive

Carlos Borrego, Action SIG4 Leader, IDAD, Aveiro, Portugal

ABSTRACTS OF INVITED TALKS

Invited Talk

COST ACTION TD1105: EUROPEAN NETWORK ON NEW SENSING TECHNOLOGIES FOR AIR-POLLUTION CONTROL AND ENVIRONMENTAL SUSTAINABILITY. OVERVIEW

M. Penza - on behalf of the Consortium *EuNetAir*

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Abstract

This is a short overview of the COST Action TD1105 *EuNetAir* - *European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability* - funded in the framework *European Cooperation in the field of Scientific and Technical Research* (COST) during the period 2012-2016.

The main objective of the Concerted Action is to develop new sensing technologies for Air Quality Control at integrated and multidisciplinary scale by coordinated research on nanomaterials, sensor-systems, air-quality modelling and standardised methods for supporting environmental sustainability with a special focus on Small and Medium Enterprises.

This international Networking, coordinated by ENEA (Italy), includes over 120 big institutions and over 200 international experts from 31 COST Countries (EU-zone: *Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Luxembourg, The Former Yugoslav Republic of Macedonia, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom*) and 7 Non-COST Countries (extra-Europe: *Australia, Canada, China, Morocco, Russia, Ukraine, USA*) to create a S&T critical mass in the environmental issues.

This COST Action [1, 2] (see logo in Fig. 1) has focussed on a new detection paradigm based on sensing technologies at low cost for Air Quality Control (AQC) and set up an interdisciplinary top-level coordinated network to define innovative approaches in sensor nanomaterials, gas sensors, devices, wireless sensor-systems, distributed computing, methods, models, standards and protocols for environmental sustainability within the European Research Area (ERA).

The state-of-the-art showed that research on innovative sensing technologies for AQC based on advanced chemical sensors and sensor-systems at low-cost, including functional materials and nanotechnologies for eco-sustainability applications, the outdoor/indoor environment control, olfactometry, air-quality modelling, chemical weather forecasting, and related standardisation methods is performed already at the international level, but still needs serious efforts for coordination to boost new sensing paradigms for research and innovation. Only a close multidisciplinary cooperation will ensure cleaner air in Europe and reduced negative effects on human health for future generations in smart cities, efficient management of green buildings at low CO_2 emissions, and sustainable economic development.

Figure 1. COST Association and COST Action TD1105 EuNetAir Logo.

The aim of the Action is to create a cooperative network to explore new sensing technologies for low-cost air-pollution control through field studies and laboratory experiments to transfer the results into preventive real-time control practices and global sustainability for monitoring climate changes and outdoor/indoor energy efficiency. Establishment of such a European network, involving Non-COST key-experts, will enable EU to develop world capabilities in urban sensor technology based on cost-effective nanomaterials and contribute to form a critical mass of researchers suitable for cooperation in science and technology, including training and education, to coordinate outstanding R&D and promote innovation towards industry, and support policy-makers. Main objectives of Action are listed, but not limited to:

- to establish a top-level Pan-European multidisciplinary R&D platform on new sensing paradigm for AQC contributing to sustainable development, green-economy and social welfare
- to create collaborative research teams in the ERA on the new sensing technologies for AQC in an integrated approach to avoid fragmentation of the research efforts
- to train Early Stage Researchers (ESR) and new young scientists in the field for supporting competitiveness of European industry by qualified human potential
- to promote gender balance and involvement of ESR in AQC
- to disseminate R&D results on AQC towards industry community and policy makers as well as general public and high schools.

The Workplan is organized in four complementary Working Groups (WGs), each devoted to a progressive development of synthesis, characterization, fabrication, integration, prototyping, proof-of-concepts, modeling, measurements, methods, standards, tests and application aspects. The four WGs with the specific objectives are:

- **WG1**: *Sensor materials and nanotechnology*
- **WG2**: *Sensors, devices and sensor-systems for AQC*
- **WG3**: *Environmental measurements and air-pollution modeling*
- **WG4**: *Protocols and standardisation methods*

This Action will focus on the study of sensor nanomaterials and nanotechnologies exhibiting unique properties in terms of chemical and thermal stability, high sensitivity, selectivity. Nanosize effects of functional materials have been explored for integration in the gas sensors at low power-consumption. Furthermore, specific nanostructures with tailored sensing properties have been developed for gas sensors and sensor-systems with advanced functionalities.

Selected high-quality research products and innovative technologies developed by the partnership of COST Action TD1105 are shown in the Figure 2.

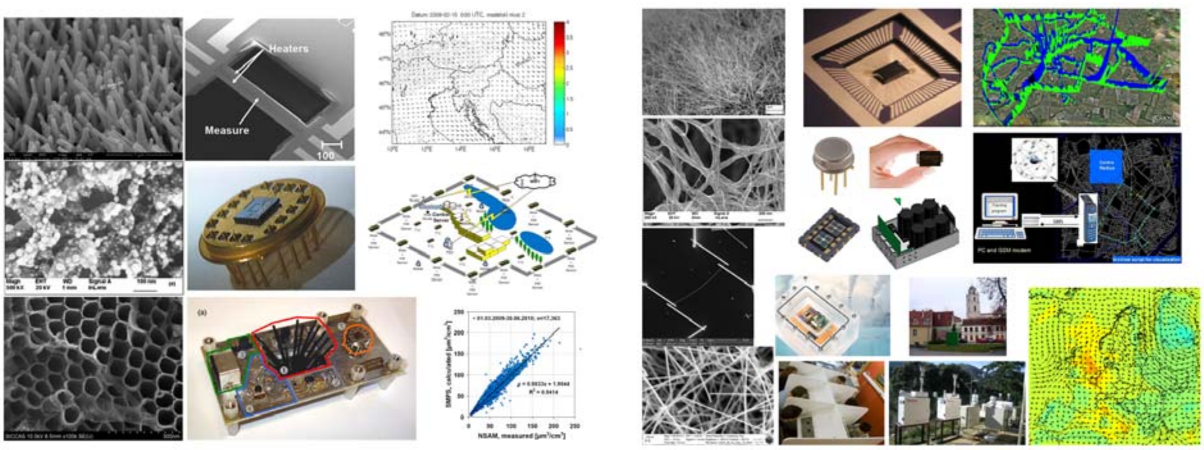

Figure 2. Selected R&D technological products developed by some partners (academia, research institutes, agencies, industry) involved in the COST Action TD1105 *EuNetAir*. Courtesy from *EuNetAir* partnership.

References

1. Action Memorandum of Understanding: http://www.cost.eu/domains_actions/essem/Actions/TD1105
2. Action website: http://www.cost.eunetair.it

Invited Talk

GAS AND PARTICLE SENSORS IN THE FRAMEWORK OF EuNetAir

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Abstract

The activities in the EuNetAir COST network TD1105 has provided a large number of dissemination possibilities, especially since the EuNetAir meetings have been spread to most of the participating countries. Through STSM (short term scientific mission) a number of new laboratory contacts were established. The activity in the network has regarded all the different parts of sensor systems, from deposition of sensing layers, the sensor elements, electronics, data processing and display to the exploration of the sensor system results by society. Active involvement of industry partners has emphasized reliability and long term stability.

Healthy environment, outdoor as well as indoor, rely on continuous monitoring of toxic species in a low pitched sensor network, which includes (mass produced) both gas and (nano)particle sensors. Packaging, where both sensor types together with other advanced functionality form an integrated sensor device, can be realized in LTCC, low temperature co-fired ceramic, technology. The LTCC provides high throughput and flexible processing of 3D sensor packages, sustainable even at high temperature in corrosive environment. Already LTCC package, in a one-step firing process, provided a hermetic device for the silicon carbide field effect transistor, SiC-FET gas sensor convenient for many applications [1]. Furthermore, LTCC technology has realized a preliminary version of a soot sensor based on soot detection by the SiC-FET employing a suspended gate [2]. As a third example, an LTCC device has been processed for electrical monitoring of cell growth with the special goal to study the influence on cells by nanoparticles and thereby avoiding animal testing [3].

Figure 1. LTCC mounted sensor devices

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2. M. Sobocinski, J. Kilpijärvi, D. Bilby, D. Kubinski, J. Visser, M. Anderson, J. Juuti, A. Lloyd Spetz, H. Jantunen, SiC MOSFET soot sensor in a co-fired LTCC package, Eurosensors 2016, September 4-7, 2016, Budapest, Hungary, oral presentaion.
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Invited Talk

The SENSIndoor project: main results, lessons learned and outlook

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Abstract

The SENSIndoor project [1] was started 2013 shortly after the start of the COST network EuNetAir. The project attained funding in the 7th framework program of the EU in the call "Nanotechnology-based sensors for environmental monitoring". The project partners consist mainly of partners active within EuNetAir. The inputs received during the various EuNetAir meetings were invaluable, not only for preparation of the project, but also during its operation. The SENSIndoor project will be completed by the end of this year and this presentation will give an overview not only concerning the main achievements of the project, but also on lessons learned during the project duration. One technical highlight is the realization of a novel gas sensor microsystem which incorporates a micro-preconcentrator – a Metal Organic Framework (MOF) layer deposited on a micro hotplate – with two micro gas sensors in a standard SMD package (Fig. 1, 2). Non-technical highlights were the joint dissemination activities at SENSOR+TEST 2016 and INDOOR AIR 2016, which achieved much greater visibility for the project and the target application than any individual efforts.

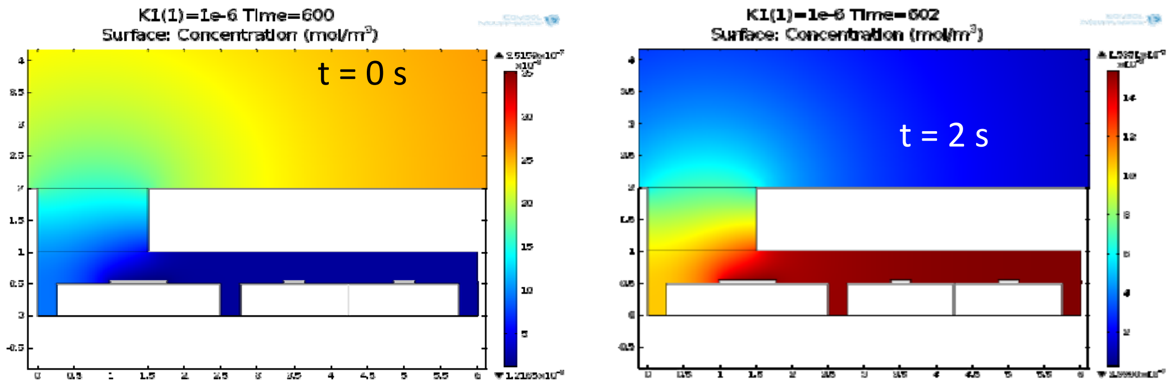

Figure 1. Simulation of the VOC accumulation (left) and thermal release (right) within the novel gas sensor microsystem combining a µ-preconcentrator and two metal oxide gas sensors.

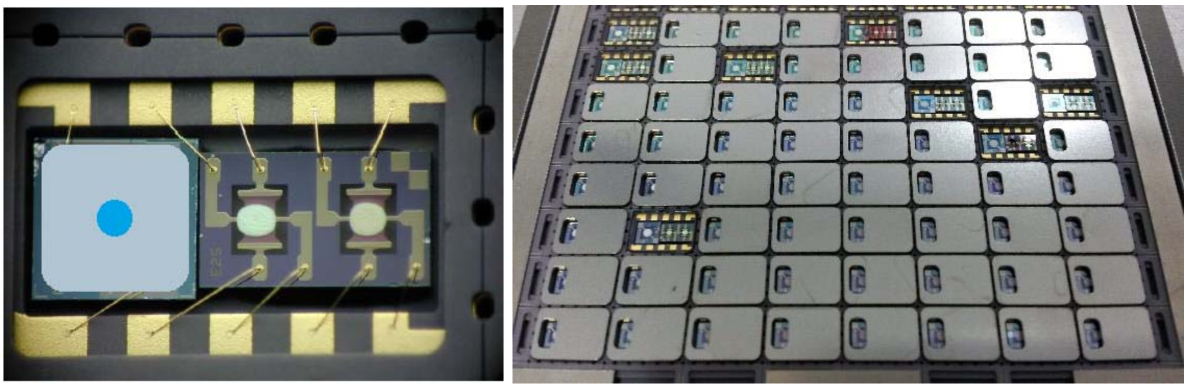

Figure 2. Novel integrated gas sensor microsystem shown w/o lid (left), batch produced for field tests (right).

References

1. Nanotechnology-based intelligent multi-SENsor System with selective pre-concentration for Indoor air quality control – SENSIndoor, grant agreement No 604311; for more details please visit http://sensindoor.eu/

Invited Talk

CITI-SENSE: FROM SENSOR TECHNOLOGY TO CITIZEN ENGAGEMENT

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Abstract
Clean air is a basic requirement for human health and well-being. Although air quality has improved in recent years, air pollution continues to pose a significant threat to the environment and human health. For example, in Oslo, during winter, on cold, clear days with low wind, we often experience the formation of thermal inversions. The inversion layer can persist for several days, causing an increase in the pollution levels, exceeding, in some occasions, the air quality thresholds defined for human health protection. In summer, there can also be episodes with high pollution levels, above the health protection thresholds, for example, in connection with long-range transport of air, or in connection with traffic.

The CITI-SENSE project[1] has been created to develop Citizens' Observatories[2] in different cities in Europe, related mainly to air quality. The main aim was to find ways to have a dialogue with the inhabitants on the subject, enabled by the new technological opportunities. We carried out different case studies in the following nine cities: Barcelona (Spain), Belgrade (Serbia), Edinburgh (UK), Haifa (Israel), Oslo (Norway), Ostrava (Czech Republic), Ljubljana (Slovenia), Vienna (Austria) and Vitoria-Gasteiz (Spain).

A range of different technical equipment has been provided to create Citizens' Observatories in each of the participating cities. In the city of Oslo, a total of 64 static monitoring platforms (AQMesh platforms v3.5 series provided by Environmental Instruments Ltd) have been deployed at different sites, including 51 kindergartens. AQMesh units are battery operated stationary platforms that measure four gaseous components (CO, NO, NO_2 and O_3) and particulate matter (PM_{10} and $PM_{2.5}$). We also employed wearable platforms (LEO platform provided by Ateknea) monitoring NO, NO_2 and O_3. The wearable platforms were carried by 32 volunteers in their daily commuting in the city during one week. The citizens could access to the data through a web portal. The data was presented using an Air Pollution Indication Index based on a five colour scale indicating if the air pollution was very low, low, rather low, rather high or high.

We also collected data on air quality perception (people as sensors) using an on-line survey and a smart phone application (CityAir app). An open dialogue with authorities, NGOs and citizens was kept through social media, focus groups, interviews and open events. CITI-SENSE has build a bridge between authorities and citizens and contributed to increase air quality awareness in Oslo.

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[1] CITI-SENSE – Development of sensor-based Citizens' Observatory Community for improving quality of life in cities. EU FP7 funded research project; www.citi-sense.eu/

[2] The term Citizens' Observatory describes a concept where citizens are empowered to contribute to environmental decision-making through their own observations. Usually, a sophisticated ICT system supports citizens in reporting their observations, and enables communication and exchange with authorities and other citizens.

Invited Talk

ASSESSMENT OF AIR POLLUTION IMPACTS ON HUMAN HEALTH USING AIRQ+

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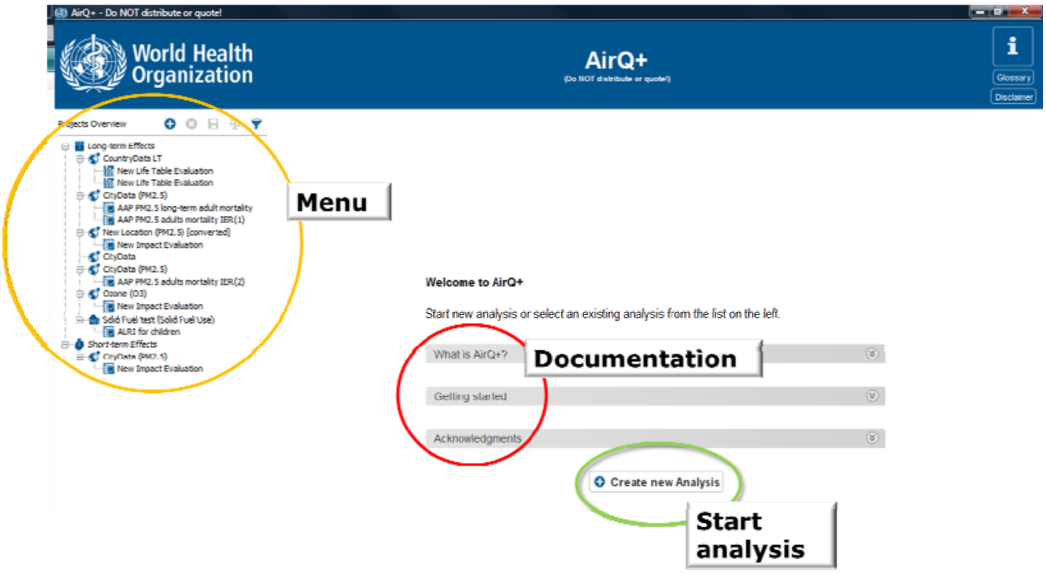
Abstract

Between 1998 and 2004, WHO European Centre for Environment and Health has developed the AirQ software to support the collection and analysis of air pollution data. AirQ has been available online since 2004 and has been downloaded by thousands of individuals and used in several health impact analyses. In response to increasing requests that WHO received during the years not only by member states but also by different institutions, experts and authorities, the software was updated and expanded upon methodological materials discussed along 2014 and 2015. AirQ+ has been available for download since May 2016 and an updated version is expected in 2017 [1]. AirQ+ estimates the burden of disease from ambient and household air pollution for one or several cities in a country or for a region.



AirQ+ welcome screen

AirQ+ has a user-friendly interface for a target group of public health or environmental specialists with little, preparation in atmospheric modelling, statistical methods, or epidemiology. AirQ+ guides the user in calculating health impacts of the most important and best recognized effects of air pollution. The work is based on the recent developments in the field and the recommendations by the HRAPIE project and the most recent available meta-analyses [2]. The aim of AirQ+ is to promote the assessment of air pollution impacts on health, support the implementation of agreed methodologies in countries and stimulate policies aiming at improving air quality, particularly in the WHO European Region.

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Invited Talk

EMERGING SENSING MATERIALS FOR AIR QUALITY MONITORING

M. Bouvet
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Abstract

It is of the utmost importance to carefully design sensing materials and to master their processing to get efficient sensors and optimize their performances for air quality monitoring. Beside inorganic materials and carbon nanomaterials, **molecular materials**, including macrocyclic molecules [1] and conjugated polymers [2] play an increasing role in the field of chemical sensors. In this mini-review we chose to separate sensing materials in three main categories, namely macrocyclic molecules, polymers and hybrid materials involving compounds from the two previous categories. Among **macrocyclic molecules**, the most important families used in chemosensing are phthalocyanines and porphyrins. They exist as monomacrocyclic molecules but also as double or triple decker complexes, mainly with rare earth metal ions as coordination centers. Engineering of side chains allows for solution processing generally at room temperature, which is compatible with plastic substrates used for the development of printable and flexible sensors. Among other molecules used as gas sensing materials, **cavitand** compounds, e.g. resorcinarenes, offer the possibility to form inclusion complexes with volatile organic guests. It was shown that their adsorption ability depends on the condensed vapour pressures of the adsorbates rather than on a structural match between host cavities and guest molecules. **Ionic Liquids** that exhibit high solubilizing properties for a broad range of gases are potentially good sensing materials for many target molecules. **Polymers** used for AQM can be classified in two main categories, namely conjugated polymers, often associated with conductometric transducers and dielectric polymers in capacitive sensors. Their physical properties are more subject to swelling and temperature effects than other molecular materials. The choice of the sensing materials depends not only on the target species, but also on the transduction mode and on the particular application.

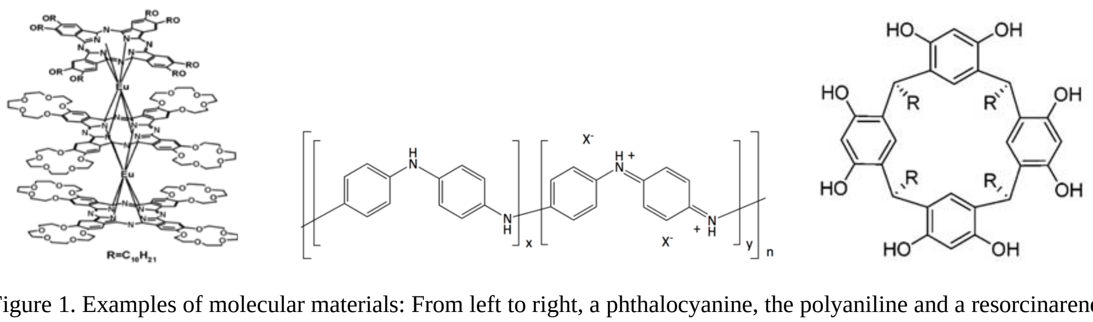

Figure 1. Examples of molecular materials: From left to right, a phthalocyanine, the polyaniline and a resorcinarene.

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Oral Presentation

RECENT DEVELOPMENTS OF COMPLEX NANOSTRUCTURED METAL OXIDE ENTITIES FOR CHEMICAL SENSORS

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Abstract

Pulsed laser deposition (PLD) is a method for depositing different types of nanomaterials ranging from porous layers to epitaxially grown superlattice structures. In the deposition process, a high energy laser pulse is guided in to a vacuum chamber on usually rotating target surface. The laser beam photons energy is absorbed in the surface layer of the target material and, in the so called laser ablation process, or by evaporation, plasma forms on the target surface, which then starts adiabatically expand into the vacuum chamber. Major advantage of PLD method is the straightforward control of film structure by adjustment of the deposition parameters, such as atmosphere gas partial pressure, laser beam fluence, and the substrate temperature during the deposition.

Several nanostructured metal oxide thin films of, such as WO_3, SnO_2, and V_2O_5, have been grown for chemical sensor applications. Their microstructure ranges from dense thin films to columnar nanoparticle films, and finally to fractal nanotrees formed of nanoparticle agglomerates, as shown in Figs.1(a-f). Several of these structures have shown exceptional sensing characteristics. For example in Fig.1, a very high sensitivity of a WO_3 layer to naphthalene, at least down to 2.5 ppb, is shown, with exceptional selectivity against benzene and formaldehyde, as well [1]. On the other hand, a very stable carbon monoxide (CO) sensing response of a SnO_2 layer with Pt additive was found to extend down to ~100 ppb concentrations. Finally, V_2O_5 nanostructures have shown very promising stable and selective long-term high-temperature performance as ammonia (NH_3) sensors when used in selective catalytic reduction (SCR) environment with CO and NO_x interference.

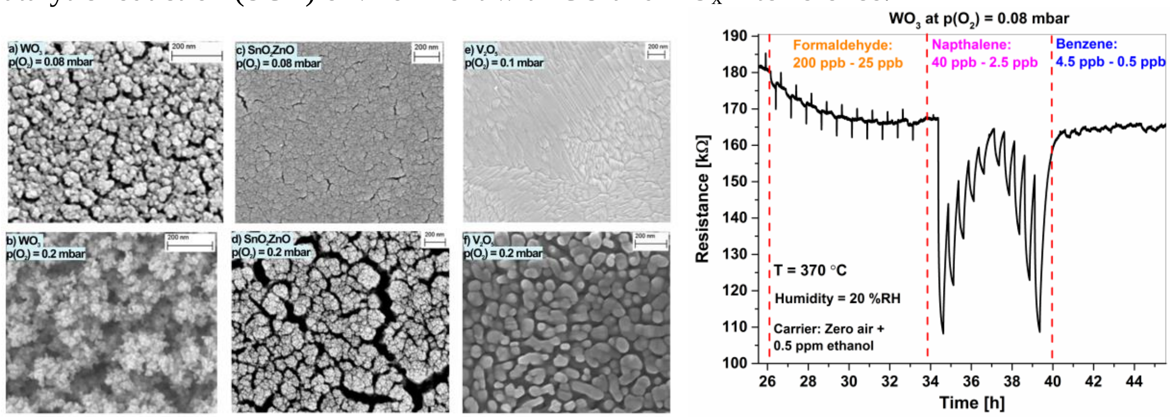

Figure 1. Scanning electron microscopy (SEM) micrographs of **(a,b)** WO_3, **(c,d)** SnO_2ZnO, and **(e,f)** V_2O_5 nanostructured thin films showing the dependence of microstructure on the fabrication parameters. On the right, responses of a nanostructured WO_3 sensor for formaldehyde, naphthalene, and benzene are showing the extreme selectivity and sensitivity of the sensor towards naphthalene.

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Oral Presentation

GAS SENSORS BASED ON CuO-TiO_2 HETEROSTRUCTURES

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Abstract

Gas sensors based on metal-oxides widely used in a number of applications. Recently, heterostructures have been reported that combination of two or more metal-oxides can efficiently improve properties of materials in different applications [1]. In sensor applications, heterojunction can improve sensor performance, especially the selectivity [2]. Combination of n-type TiO_2 with different metal-oxide might step further the surface modification due to high sensor properties of TiO_2 material.

In this study, TiO_2 nanotubes (NTs) were synthesized via electrochemical anodization of Ti foil. After anodization process, CuO thin film (TF) was coated on TiO_2 NTs.

The morphology, composition and crystal phase of the samples were measured by a scanning electron microscope (SEM), electron-dispersive X-ray spectroscopy (EDS) and with X-ray diffraction (XRD), simultaneously. Figure 2 shows SEM images of CuO TF/TiO_2 NTs and TiO_2 NTs.

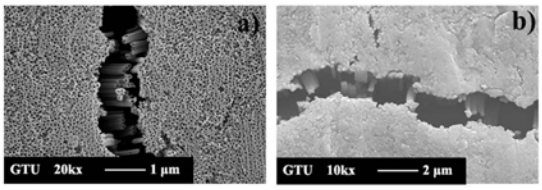

Figure 1. SEM image of TiO_2 NTs (a) and CuO TF/TiO_2 NTs (b).

Gas sensor study of the heterostructure was performed against different concentrations of H_2, NO_2, ethanol, chloroform, and acetone gases between room temperature and 200 °C. Figure 2 shows sensor devices used for gas sensor measurements.

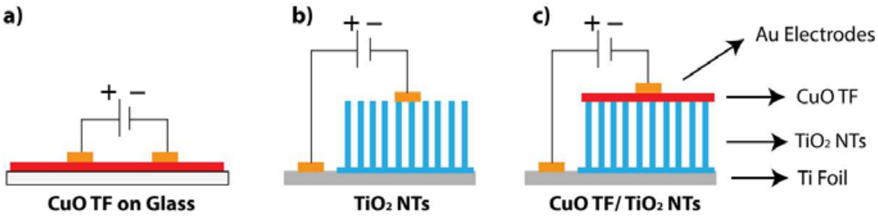

Figure 2. Fabricated sensor devices; CuO TF (a), TiO_2 NTs (b) and heterostructure (c).

According to the measurement results, the heterostructure sensor has not only enhanced sensitivity towards H_2 but also decrease sensitivity towards VOCs and NO_2. Notably, compared to pristine TiO_2 NTs and CuO TF, the heterostructure sensor showed excellent H_2 sensing performance including higher sensitivity and better linear detection range at 200˚ C. These improved sensor performance attributed to heterojunction between CuO and TiO_2. Gas sensing properties of the CuO/TiO_2 sensor indicate that heterostructure is a promising candidate for gas sensor applications.

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Oral Presentation

SOLID NANOPOROUS SENSOR FOR THE DETECTION OF PHENOL

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Abstract

Phenol production exceeds 6-billion pounds worldwide with the housing and construction industries accounting for about half of the uses. Phenol is used as disinfectant in medical products, as reagent in research laboratories and as a precursor or intermediate during the manufacture of phenolic resins, bisphenol A, alkyl- and chlorinated phenols. Phenol is suspected to be carcinogenic and was reported harmful for aquatic fauna. In 2009, the individual exposure limit to phenol for workers was set by the European Communities (EC) to 8 mg/m^3 (2 ppm) for 8 hours [1]. The maximum admissible concentration in the EC countries for phenols in waste water is 5 $mg.L^{-1}$ (1 ppm) [2].

The usual method of detection of phenol in air is based on adsorption-desorption of phenol on activated charcoal cartridges followed by gas chromatography analyses [3]. For phenol detection in water, many steps of extraction are needed before its analysis [4]. Although sensitive enough, both methods are expensive, time-consuming and require a heavy maintenance. The present work aims at developing a fast and easy-to-use colorimetric sensor for the direct detection of phenol both in air and in water.

The solid and transparent sensor is synthesized via the sol-gel process. When doped with a specific reactant such as amino-antipyrine, the sensor, initially yellow, undergoes a color change when exposed to a phenol-polluted atmosphere (Fig.1). The reaction also occurs when the sensor is immersed in water. We will show the sensor production steps including the characterization of its porosity and optical properties, the exposure procedures for gas and liquid phase detection and the establishment of calibration curves over a wide domain of concentration. The limit of detection is 25 ppb in air and 100 ppb in solution.

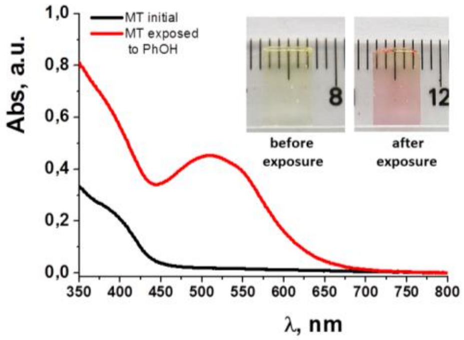

Fig.1. Color change and absorption spectra of the sensor exposed to phenol 100 ppb, 500 $mL.min^{-1}$, RH: 50%

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Oral Presentation

PHOTOLUMINESCENCE BASED GAS SENSING WITH RARE-EARTH DOPED OXIDE NANOPOWDERS AND THIN FILMS

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Abstract

Photoluminescence (PL) is widely used in oxygen sensing [1] but is relatively rarely studied as a transducer signal for key polluting gases [2]. Optical mode of sensing requires somewhat more complicated instrumentation as compared to conductometric mode but, at the same time, allows remote detection and eliminates several sources of drifts present in electrical sensors [3].

We have demonstrated PL based oxygen sensing with rare earth (Sm^{3+}) doped nanocrystalline TiO_2 [4]. Rare earths (RE), especially if UV excited via host (see processes *hv* and ET1 in Fig. 1), have strong PL with long lifetime, which facilitated lifetime based sensing. The study has been extended to pollutant gases (CO, NO_2, NH_3) and other materials (Eu:SnO_2, Eu-Nb:ZrO_2). In addition to sol-gel prepared nanopowders, thin films made with pulsed laser deposition were tested. As compared to organic materials [1], the mechanism of sensing (Fig. 1) is completely different and the materials are highly resistant to photochemical bleaching. In case of NH_3 gas, dual mode sensing was demonstrated by simultaneous detection of electrical conductance and PL (Fig.2). The observed responses are of opposite sign but the mechanisms behind both responses are directly related as seen from the closeness of temporal curves.

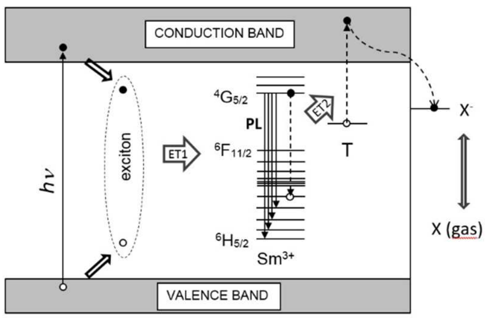

Figure 1. Mechanism of PL gas sensing for an oxidising gas. The excitation energy transfer (ET2) from RE to traps (T) decreases the PL lifetime. The ability of traps to accept the energy from RE is switched on and off by gas desorption and adsorption, respectively.

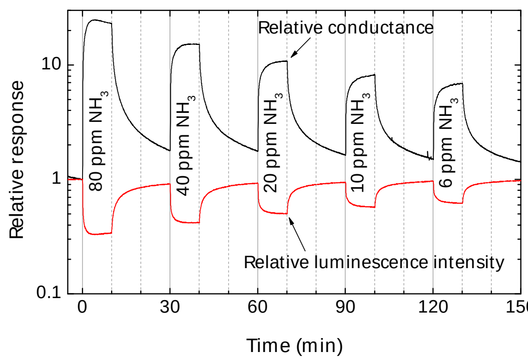

Figure 2. Simultaneously recorded PL and conductance responses of Sm:TiO_2 to ammonia at 150 ^oC.

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Invited Talk

DISPOSABLE SENSORS AND INSTRUMENTS FOR AIR QUALITY MONITORING

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Abstract

In this communication, we will present our work on the manufacturing of environmental friendly gas sensing technologies based on printing. The resulting devices have been functionalised with gas sensitive thick and thin films, as well as nanostructured materials.

We have been working on printing chemical gas sensors as well as metallic resistors used as temperature sensor as well as heating elements. We have shown printed hotplates on PEN substrate made of silver and Ni electroplated silver heaters with gold plated electrodes over a laminated interdielectric layer. These devices were coated with conducting polymer layers and successfully operated at temperatures of 80-100°C for gas detection. Different devices can be combined to realize a multi-sensor platform for environmental monitoring: temperature, humidity, gases. Recently we have reported on the development of more robust printed hotplate structures made of printed gold heater and electrodes on polyimide substrate for reliable operation at higher temperatures. These devices were coated with different types of metal-oxide materials and exhibited performing gas sensing characteristics. Finally, we have been also considering the use of printed hotplates on foil for the realization of tubular gas preconcentrators by rolling them up. We are now dedicating efforts on the realization at low-cost of analytical gas detection systems that could be disposable.

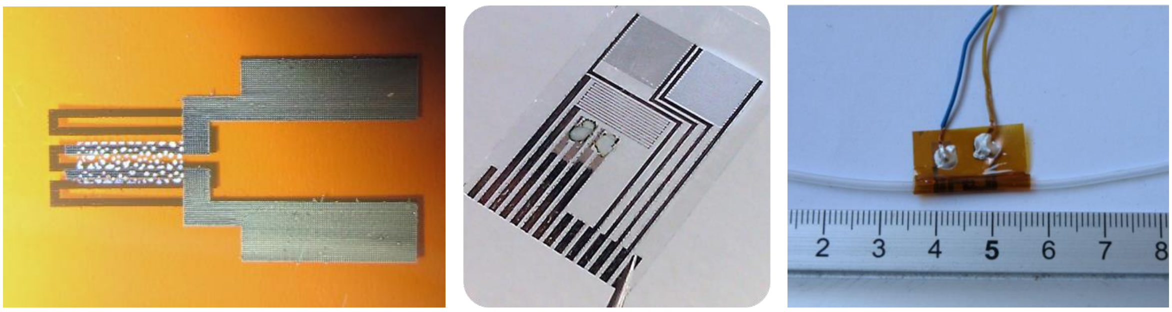

Figure 1. Foil based gas sensors and preconcentrators manufactured by printing.

In summary, we will present different printed and flexible gas sensors and their optimization highlighting advantages and drawback of using printing and large area manufacturing techniques. The resulting devices could be employed in applications where low-cost, lightweight, flexibility and/or disposability are required.

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Oral Presentation

MULTILAYER GRAPHENE CANTILEVER FOR LASER PHOTOACOUSTIC DETECTION

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Abstract

Graphene leaf has outstanding electromechanical properties and impressive sensitivity as a mass detector. Its mechanical properties offer utilization as nano/micro-lever in extremely sensitive pressure sensors or mass detectors. Such types of sensing devices represent important challenge for chemical analysis [1]. Micro-levers utilized as pressure sensors in the form of silicon cantilevers enhanced the sensitivity of laser photoacoustic spectroscopy (PAS) [2]. The mechanical behavior of multilayer graphene (MLG) membranes and cantilevers was investigated for sensitive detection of acoustic waves in gases. The aim of this work was to develop sensors in a form of cantilevers/membranes and to test their sensitivity by the laser photoacoustic spectroscopy. MLG membranes and cantilevers were prepared from highly ordered pyrolytic graphite (HOPG) by multiple mechanical cleavages [3] allowing simple adjustment of the membrane/cantilever thickness and relevant mechanical parameters. The MLG cantilever/membrane movements induced by pressure waves triggered by the absorption of the CO_2 laser pulse in the gas-filled photoacoustic cell were detected by a He-Ne laser beam reflected from the cantilever/membrane to a position sensing detector (optical microphone).The sensitivity of the MLG cantilevers for the photoacoustic detection of methanol vapors (testing gas) was more than one order of magnitude higher in comparison with a top class microphone (Brüel & Kjaer). The signal-to-noise ratio of 19, 61, and 70 together with the limits of detection of 0.75 ppm, 0.42 and 0.33 ppm were calculated for the condenser microphone, the MLG membrane, and the MLG cantilever, respectively. The utilization of MLG elements for the photoacoustic detection appears to be particularly promising thanks to its layered structure and thus the possibility to decrease further its thickness down to nanometer scale, enhancing its sensitivity.

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Oral Presentation

A NOVEL CONCEPT OF ENVIRONMENTAL CAMERA THROUGH VOLATILE ORGANIC COMPOUNDS SENSING

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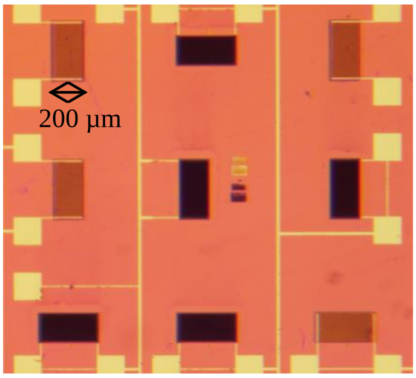
Abstract

Looking for better environmental monitoring and integrated industrial control systems, ultra-low-power and low-cost gas sensing is of main interest in the scope of the IoT based on interconnected sensor nodes[1]. Selectivity and power consumption still remains a big issue in chemical gas detection systems, mostly based on heated metal oxide sensors, and raises challenges for new developments, particularly in the field of miniaturized devices[2].

We designed a novel CMOS compatible multi-pixel platform dedicated to ultra-low-power environmental sensing, especially looking at volatile organic compounds (VOC) monitoring. Each pixel, made of interdigitated microelectrodes, is functionalized with a Molecular Imprinted Polymer (MIP) specific to the target VOC. Thanks to the tuning capabilities of the MIP materials, the selectivity can be highly increased[3]. Also, as the MIP materials are working at room temperature, no heater is needed, which considerably reduces the power consumption. Additionally, humidity detection can be performed by covering a pixel with moisture sensitive material such as polyimide. Finally, temperature monitoring can be achieved with an on-chip diode. A 3x3 pixels² sensor has been fabricated as proof-of-concept as shown in Figure 1(a). Figure 1(b) presents the first results under formaldehyde (HCHO) exposure up to 30 ppm in N_2 atmosphere, featuring gas absorption within the polymer.

(a) 

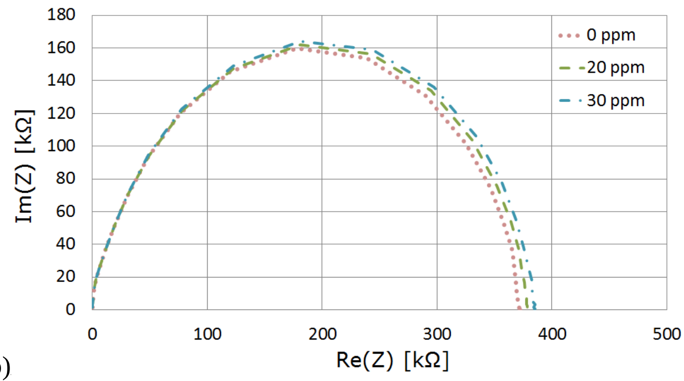
(b) 

Figure 1. (a) Example of a 3x3 pixels² sensor covered by MIP. (b) Nyquist plots at 0, 20 and 30 ppm HCHO/N_2.

This novel "environmental camera" is promising for low-cost ultra-low-power multi-gas analysis, as preventive qualitative monitoring and warning system through dosimetry analysis. Further developments will be achieved in order to improve both sensitivity and detection limit.

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Oral Presentation

DOSIMETER-TYPE SENSOR FOR SUB-PPM NOX DETECTION

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Abstract

In contrast to typical gas sensors, resistive NO_x gas dosimeters measure continuously the amount (or the dose, i.e. the timely integrated concentration) of NO_x in the test gas. They are therefore appropriate to detect daily or hourly mean values of NO_x. The complex impedance of the sensing device, which is the sensor signal, decreases linearly with the integrated NO_x concentration in the test gas. During NO_x absence, the sensor signal remains constant.
The sensor device consists of an interdigital electrode (IDE) structure on an alumina substrate with a backside heater. As functional thick-film, K/Mn-La-Al_2O_3, a NO_x storage material, is applied and covers the IDE structure [1]. All measurements were conducted at 350 °C in 20% O_2 and 2% H_2O in N_2. NO_x was added in defined concentration steps.
Figure 1 presents the measured complex impedance $|Z|$ of a K/Mn-La-Al_2O_3 based sensor at a frequency of 200 Hz and the NO_x concentration analyzed by CLD during the exposure to three 25 ppb NO_x pulses (each 1200 s) with NO_x pauses in between (each 600 s). During NO_x exposure, the $|Z|$ decreases with a concentration-dependent slope, whereas it remains constant during pauses of NO_x. It is possible to analyze the amount of NO_x over a long period (depending on NO_x concentration and layer thickness of the functional film) and the slope of the sensor signal depends on the NO_x concentration, even in the sub-ppm range.
The sensing mechanism bases on the adsorption of NO_x molecules on active sites of the material and the NO_x storage behavior of the functional film [2]. A linear correlation between sensor response and NO_x dose was found at a low loading state. At higher NO_x loading, the sensor response gets non-linear and the sensing device becomes regenerated by heating to 650 °C.

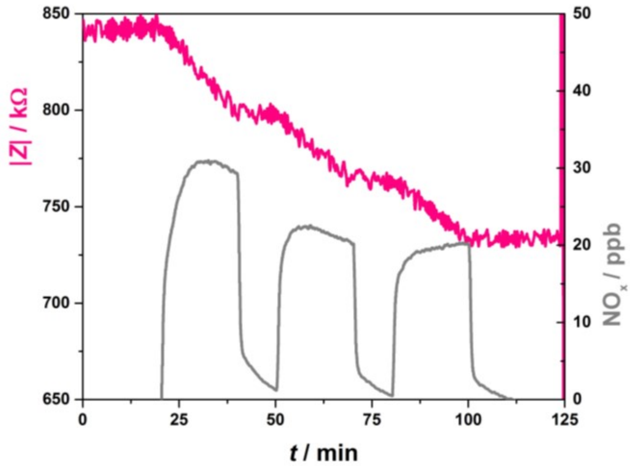

Figure 1. Complex impedance $|Z|$ of the sensing device during exposure to three 25 ppb pulses.

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Oral Presentation

THEORETICAL MODELING OF QCM-D AND SH-SAW SENSORS IN ENVIRONMENTAL APPLICATIONS

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Abstract

Physico-mathematical modelling of the propagation of surface acoustic waves and bulk acoustic waves in thin layered materials is considered as a powerful analytical tool supporting the experimental research in acoustic sensors. Softness of the materials was shown may essentially influence the characteristics of acoustic waves such as the resonance frequency shift and the dissipation [1]. Theoretical analysis of SAW- and QCM-D based sensors operated in gases and liquids supplemented with numerical calculations provides a way to quantify the results of measurements to improve the devices mass sensitivity taking into account the viscosity of liquid or materials viscoelasticity corrections [1-3]. In the presentation the achievements, new trends and bottlenecks in the acoustic sensors for the environmental applications are critically reviewed. The recommendations and the outlook will be presented.

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Oral Presentation

IMPLEMENTATION OF COMPLEX GAS SENSOR SYSTEMS – IDEAS FOR A STRUCTURAL MODEL

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Abstract

Measuring gases is a task of tremendous complexity, especially when using cost efficient chemical sensors. Prominent aspects in current research cover materials, sensor processing, data analysis and simulations of promising target applications. However, for successful commercialization of solutions based on gas measurement techniques it is crucial to cover the complete scope of the corresponding problem. Blind spots will cause false interpretation of the actual functionality and inevitably result in overall failure as detailed in [1] and [2].

In the process of designing a self-contained product, completeness can be assessed in various ways. One feasible albeit time-consuming approach is to identify use cases from which requirements and specifications can be derived, a thorough guide is given in [3]. This strategy can achieve good results but is limited regarding necessary interaction between providers of components in a distributed solution.

In order to streamline collaboration between specialists in the various scientific fields connected with gas assessment and to facilitate completion of marketable solutions, it seems essential to sketch out all necessary aspects within the toolchain and to highlight the interfaces. Inspired by the ISO-OSI model [4] which covers the interconnection between communication systems, a sensor-system interconnection model (SSI) is proposed in Fig. 1.

#10	Key benefits
#9	Application Parameters
#8	Data Management
#7	Value Derivation
#6	Raw Data Acquisition
#5	Sensor Read-out
#4	Sensor Operation
#3	Sensor
#2	Sampling
#1	Process/Atmosphere

Figure 1. Layers of the proposed structural model SSI with key questions

Motivation of the layers defined in this model and application thereof have been assessed using various system designs of already implemented as well as prospective solutions. The SSI conveniently lays out an abstract overview, clarifying respective roles and potential shortcomings. Put in use for complex considerations like plug-in alternatives and networked systems, it should prove a handy vehicle for applications with large inherent diversity, e.g. air quality nodes for smart cities. Further work will include refining layer and interface definitions as well as developing application notes in collaboration with the sensor community.

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Oral Presentation

VULNERABILITY OF CLASSIFIERS TO ADVERSARIAL EXAMPLES

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Abstract

Studying vulnerability of machine learning models to adversarial examples is an important way to understand their robustness and generalization properties. We propose a genetic algorithm for generating adversarial examples for machine learning models without access to inner parameters of the models [2]. The algorithm is performing small perturbances on original data with the aim to misclassify it by the model. An interesting property is that the adversarial examples are often still recognizable as original category by humans (cf. Fig. 1). In our experiment, different models are tested, including both deep and shallow neural networks architectures [1]. Namely, we utilized: *MLP* – multilayer perceptron with three fully connected, layers, two hidden layers have 512 ReLUs each, using dropout; the output layer has 10 softmax units; *CNN* – convolutional neural network with two convolutional layers with 32 filters and ReLUs, each, max pooling layer, fully connected layer of 128 ReLUs, and a fully connected output softmax layer; *ensamble* - 10 MLPs; *RBF* – Radial Basis Function network with 1000 Gaussian units; *SVM* – Support Vector Machine with RBF kernel (SVM-rbf), polynomial kernel of grade 2 and 4 (SVM-poly2 and SVM-poly4), sigmoidal kernel (SVM-sigmoid), and linear kernel (SVM-linear); and a *DT* - decision tree.

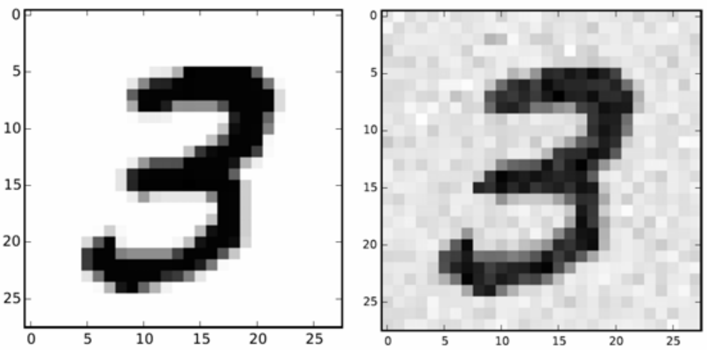

Fig. 1: Original training pattern vs. adversarial pattern that is missclassified by a machine learning model.

Our experiment showed that many machine models suffer from vulnerability to adversarial examples. Models with local units (RBF networks and SVMs with RBF kernels) are quite resistant to such behavior. The adversarial examples evolved for one model are usually quite general – often misclassified also by other models. To avoid the problem with adversarial examples, we recommend to use ensembles with high variety of models. The natural next step is the use of adversarial examples to improve the classification capabilities of the model itself, by incorporating them into the training set, or by training another model to classify the adversarial examples only.

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Invited Talk

AIR QUALITY AT YOUR STREET - PUBLIC ASSESSABLE DIGITAL MAPS OF AIR POLLUTION IN DENMARK

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Abstract

Road traffic is one of the main contributors to human exposure to air pollution in Europe. In many of the European countries, including Denmark, health effects related to air pollution is a big concern in the population. A number of NGOs with focus on environmental pressures have been formed with the aim of influencing environmental policy towards sustainable development. Citizens seek information about air pollution when they are deciding for where to buy houses and apartments, or when they are concerned about asthmatic children or own health issues etc. This has been the main driver for developing an information system called "air quality at your street", where the Danish population can access information about air pollution loadings at any address in the country. The system has been online at: http://luftenpaadinvej.au.dk since 1st September 2016 (until now the webpage is unfortunately only in Danish). The release took place during a period where the press had focus on other topics, but two days later the news about the system hit the front page of the webpage for the two Danish TV stations. Shortly after the advertisement on these webpages, the number of simultaneous sessions reached 15,000 (a session lasts two hours from a user has made a search). The system consists of a digital map of Denmark where the user can zoom in or search on specific addresses and see pollutant loadings for various hazardous pollutants. In the released system, data include annual mean values of NO_2, $PM_{2.5}$ and PM_{10} for the year 2012.

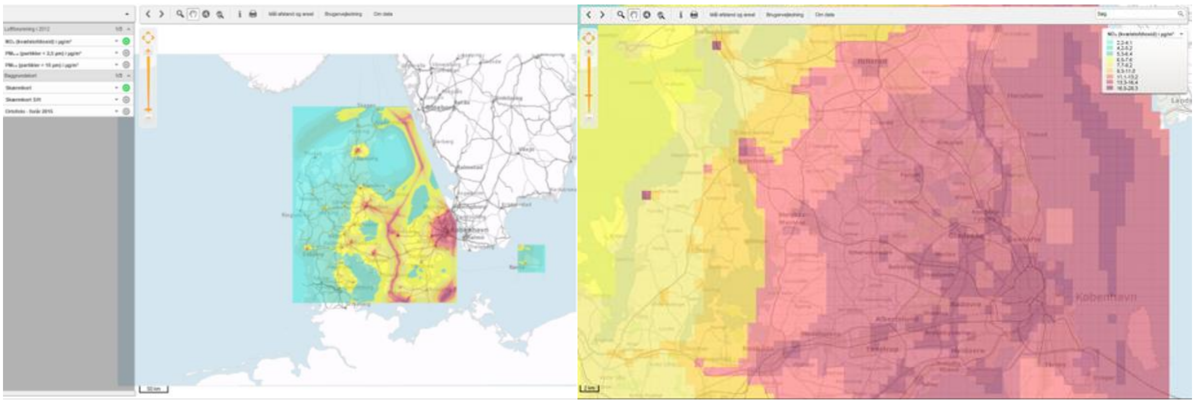

Figure 1. The user interface in the "Air on your road" system. To the right is the countrywide map of nitrogen dioxide in Denmark. To the left a zoom to the Greater Copenhagen Area. The user can continue to zoom in to single address level. http://luftenpaadinvej.au.dk

The air quality data in the system has been generated using the AirGIS system based on a suite of air quality models operated under the integrated model system, THOR (Brandt et al., 2001) developed at ENVS AU. The AirGIS system includes a 2½ dimensional urban landscape model for deriving the necessary input data for running local scale air quality models. Long-range transport is covered by the Danish Eulerian Hemispheric Model (DEHM) (Christensen, 1997; Frohn et al., 2001; Brandt et al., 2012). DEHM has a zooming capability (nested grid), and covers the entire Northern Hemisphere with a resolution of 150 km x 150 km for the outer grid, a 50 km x 50 km grid for Europe, 16.67km x 16.67 km for Northern Europe, and a 5.6 km x 5.6 km grid for Denmark nearby surroundings. The local scale models include an Urban Background Model (UBM) for calculation of the general pollution load above roof level in urban areas (Hertel and Berkowicz, 1990; Berkowicz, 2000b; Brandt et al., 2001), and the Street Pollution Model (OSPM) (Berkowicz, 2000a) - a model tool that is currently applied in >17 countries worldwide (Kakosimos et al., 2010). The AirGIS system has been applied for assessing address level air pollution exposure for a variety of Danish cohorts in studies of exposure – effect relationships (Hertel et al., 2013). A total of 2.4 million home addresses have been identified for Denmark. Street pollution calculations (using OSPM) have been performed for all addresses within 34 m of street links and with ADT (annual diurnal traffic) of >500 vehicles. In total, street calculations have been carried out for 201,036 addresses. For the remaining addresses, urban background levels (UBM calculations) have been assumed to be representative for the address pollution levels.

Acknowledgement

The air quality at your street system was supported by a grant from Danish Centre for Environment and Energy (DCE), Aarhus University.

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Oral Presentation

NEW VERSION OF THE BULGARIAN EARLY WARNING SYSTEM IN CASE OF NUCLEAR ACCIDENT OVER EUROPE

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Abstract
The Bulgarian Emergency Response System (BERS) for short term forecast in case of accidental radioactive releases is developed and is in operational use since 2001 at NIMH. BERS comprises of two main parts - operational and accidental ones, for two regions “Europe” and “Northern Hemisphere”.

The operational part runs automatically twice a day using the numerical weather forecast, provided by German DWD. A pre-processing module prepares specific meteorology input file to be used both in the operational and in the accidental parts. Further on, it calculates trajectories for selected Nuclear power plants (NPPs). After visualization they are sent to a dedicated web-page of NIMH’s site.

The accidental part is invoked by experienced operator in case of a real or training radioactive releases. Apart the meteorological input, created during operational part’s execution, additional information about the source parameters (coordinates, height, strength, duration etc.) must be introduced by the operator. The core of the accidental part of the system is the Eulerian 3D dispersion model EMAP performing long-range dispersion calculations, accounting for the transport, dispersion, and radioactive transformations of pollutants. In 2007 the system was upgraded with a “dose calculation module” for estimation of the prognostic dose fields of 31 important radioactive gaseous and aerosol pollutants. BERS was upgraded also to be able to simulate the dispersion of aerosols from Iceland volcano eruption in 2010 and of nuclear materials from Fukushima NPP accident.

BERS, respectively EMAP, was tested during several international exercises (ETEX, RTMOD, ENSEMBLE).

The increase of computational abilities of the new generation of computers together with the appearance of new complicated data bases with open access forces the creation of a new version of BERS. The main improvement concerns the operational part of the system. It exploits Linux workstation and complicated weather forecast from US NCEP (so called GFS data). As far as the resolution of this data is quite rough (1 x 1 deg, 6 hours) it is processed by the meso-meteorological WRF model for a European area of 250 x 210 points with 20 km resolution (Lambert projection). The output has 1-hour time resolution. The WRF output is processed with the MCIP model, important part of the US EPA Models-3 system. A new met-pre-processing module is created as to prepare the specific meteorological file used in both operational and accidental part of the System. The next step is the calculation of the 3-day forecasted trajectories for 36 European NPPs, packed and saved in a specific format.

The new important enhancement of the operational part of BERS is the calculation of the concentration and deposition fields for all 36 NPPs, exploiting dedicated source strength, height and duration, specific for a powerful nuclear accident. All this data is formatted and packed in a specific format. In a fixed moment another, already Windows, machine is activated. Via FTP it transfers the met-, trajectory and pollution data, unpacks them and performs the required visualizations. The trajectories are grouped in 6 pictures (6 NPPs in each) and the concentration and deposition field for each NPP are animated. The graphic files are sent to an enhanced web page permitting to have a look not only on the trajectories but on the evolution of concentration and deposition fields of each NPP.

Oral Presentation

SUMMARY OF ACTIVITIES DURING COST ACTION TD1105 RELATED TO AIR PHYTOREMEDIATION PERFORMED BY WARSAW UNIVERSITY OF LIFE SCIENCES, POLAND

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Abstract

Impacts of air pollution on human health and wellbeing are well documented. Every year 4.3 million deaths occur from exposure to indoor air pollution and 3.7 million deaths are attributed to outdoor air pollution (WHO 2015), with the major health effects being respiratory and cardiovascular diseases. Some data showed that between 10.2 and 33.7% of stroke burden are due to exposure to air pollution, which is mostly of anthropogenic origin (Feigin et al. 2016). In the solution of this problem practically our only partner are plants with their enormous biologically active surface area. Process of removing pollutants from air by some species is conducted very efficiently, therefore they are used in the environmental friendly biotechnology - phytoremediation. Urban areas often create high polluted sites as streets canyons, road crossings, bus stops, and surroundings of heavy traffic freeways, at which air pollution can be mitigated by the presence of selected plant species. Additionally agronomic practices allows to maintain them on a polluted site and to form them in configuration for optimal pollutants deposition. Air pollution is usually a mixture of a number of pollutants, therefore it is necessary to grow species known as highly tolerant to adverse environmental conditions. There are significant genotypic differences in plant ability to air phytoremediate, which depends also on the levels and types of dominant pollutants. Over 60 trees, shrubs and grass species, recommended for urban areas, were evaluated in our Lab for ability of PM accumulation in 3-4 years study. Great differences exist between examined species in their ability to accumulate PM (up to 10 times). The results of these studies allow for recommendation of species with high phytoremediant abilities to be cultivated both in the parks and roads surrounding traffic.

Nowadays, in civilized countries, between 85-95% of time man spent indoor where air quality often is worse than outdoor. This is because besides fact that indoor air, due to exchange became soon nearly the same as outdoors, there are also indoor sources of air pollution. Besides various industrial technologies an important role may play phytoremediation in which we "hire" plants to work for pollutants absorbing/adsorbing, and/or degradation/deactivation. In many places in the world to achieve clean air in the coming years will be not possible, but we can just clean up air in our rooms as offices, apartments, schools etc. with a relatively low cost by applying indoor air phytoremediation. To implement this environmentally friendly biotechnology important are: (i) knowledge on type and level of pollutants in a given rooms, (ii) selection of most effective plant species; one may expect great differences in this respect as in case of outdoor grown plants which differ by about 10 times in the efficiency of phytoremediation, (iii) proper design of plants in particular rooms that would combine their aesthetic functions with phytoremediation purposes. Each of these points will be addressed in the presentation.

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Oral Presentation

AIR QUALITY ISSUES IN HUNGARY

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Abstract
The Hungarian Meteorological Service took part in the EuNetAir action with the motivation of contributing to the following objectives: environmental measurements at laboratory, high-cost standard monitoring, and air quality modelling.
In Hungary, the high-cost standard air qualiy monitoring is a governmental task. During the work of this action we presented our activities and the changes in our circumstances. As we presented in the Riga workshop, in recent years, the responsibilities of governmental authorities related to monitoring and controlling air quality issues had gone through fundamental changes in Hungary. The responsibilities of the Hungarian Meteorological Service related to the air quality control are basically organised around four main themes: measurement of background air pollution, dispersion modelling of pollutants, performance of duties of Air Quality Reference Centre as well as preparation of inventories of greenhouse gases and other air pollutants.
The European legislation supports the modelling activity on many areas of air quality issues. Different air quality tasks need different models to make cost-effective calculations as the studied processes have different effects depending on the spatial and temporal resolution or the aim of the application. The air pollution dispersion modelling is the responsibility of the Hungarian Meteorological Service. One regional and two local scale meteorological-chemical models are run at HMS, namely: the regional scale FLEXPART model for calculating the transport and dispersion of air pollutants in case of industrial (e.g. nuclear) catastrophes; the local scale AERMOD model for regulatory purposes for the long-term effects of industrial point sources, and the CHIMERE chemical transport model, an air quality prediction model system for forecasting the concentration of air pollutants for two days in advance for the area of Budapest.
This presentation summarizes the activities of the HMS during the EuNEtAir action. Air quality related tasks of the Hungarian authorities including high-cost standard air quality monitoring and cost-effective modelling activities are presented indicating the capacities and possibilities a governmental control can have on this field in changing circumstances. Also, a new development is presented: in 2016, the Hungarian government issued a fund for developing new, cheap, portable sensing equipments, and the HMS is called to take part in this work.

Invited Talk

APLICATION OF ATOMIC FORCE MICROSCOPY IN CHARACTERIZATION OF MARINE AEROSOLS

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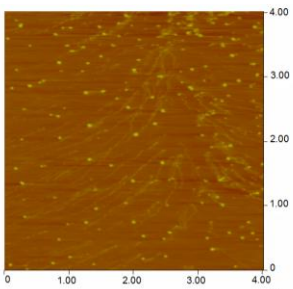
Abstract

The current knowledge in aerosol science is still incapable to give a real and quantitative assessment of their actual impact on global climate and health. This problem arises from the fact that, until today, there is insufficient knowledge regarding aerosol sources, mechanisms of formation, aerosol properties and chemical composition.

In this study, we combined state-of-the art analytical tools of atomic force microscopy (AFM) with high temperature catalytic oxidation (HTCO) and electroanalytical methods for characterization of water soluble fraction of marine aerosols. Each technique characterized different chemical components of marine aerosols and provided complementary information not generated by a single technique. This comprehensive assessment confirmed significant difference between winter and summer samples that was imaged by AFM.

In summer samples, which due to biological activity were characterized by higher concentration of PM mass, total organic carbon (TOC), water soluble organic carbon (WSOC), and its surface active components (SAS), presence of higher concentration of nanoparticles (NPs) with sizes between 86 and 91 nm were detected (Fig.1a). Winter sample (Fig.1b), depleted with organic matter content was characterized by smaller NPs, with sizes between 56 and 63 nm. We assume that quantity and quality of organic matter influence size distribution of recorded nanoparticles.



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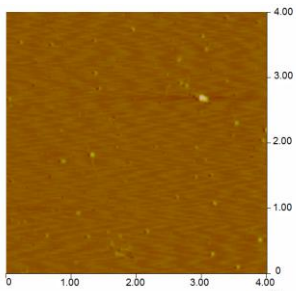

b

Figure 1. AFM images of water soluble marine aerosol samples from summer (a) and winter (b) seasons in Central Dalmatia. The image size: 4 µm x 4 µm, with z scale of 60 nm.

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Oral Presentation

4 YEAR EXPERIENCE OF APPLICATION LOW-COST SENSORS IN BELGRADE IN FRAMEWORK OF CITI-SENSE PROJECT

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Abstract

According to recent EEA report, air pollution is the single largest environmental health risk in Europe. Serbian Environmental Agency (SEPA) reported that more than 30% of citizens of Serbia were exposed to air that is considered not healthy in 2014. Currently more and more cities provide timely air quality information to the public through printed and electronic media. However the information on the content of ambient air and related hazards is currently mostly generic, and seldom personally relevant. It would be necessary to offer information to a person about air quality level in microenvironment and on the route s/he frequents, and what does that mean for her/him. The CITI-SENSE project aims to develop a mechanism through which the public can easily be involved, a set of Citizen Observatories [1]. Using a combination of citizen science and application of low-cost units for environmental monitoring, CITI-SENSE developed technological tools for public involvement, and tested these devices and tools to investigate their potential for a large scale public use. This paper describes characteristics of the units we used in framework of CITI-SENSE case studies in Belgrade, Table 1. All unit types have integrated Alphasense EC sensors for gases while static units have in addition optical sensor for RPM. All static unit types were collocated at AMS that belong to State Monitoring Network, running by SEPA. In addition we tested RPM nodes in laboratory with conventional particle counters and sizers. For calibration of static units collocated with AMS we used several approaches such as simple linear regression (all used unit types), multivariate liner regression models and artificial neural networks (ANN) with specific architecture (AQMesh and EB700). According to analyses it may be concluded that ANN shown the best statistical results in comparison with other two approaches.

Table 1. Pearson correlation coefficient within unit type EB700, AQMesh and Model 510

sensor	Unit type (number of units of each type depolyed in Belgrade)		
	EB700, Dunavnet (n=10)	AQmesh, Geotech (n=25)	Modle 510 Remote Air Quality Systems, Atmospheric (n=12)
NO_2	0.10-0.92	0.40-0.70	0.50-0.98
NO	0.20-0.97	0.15-0.45	n.a.
CO	0.50-0.98	0.50-0.90	0.96-0.98
CO_2	0.64-0.96	n.a.	0.94-0.98
O3	0.40-0.90	0.01-0.60	0.69-0.91
$PM_{2.5}$	0.70-0.96	0.60-0.90	0.52-0.85
PM_{10}	0.60-0.88	0.50-0.80	0.50-0.70
Meteo (T, RH, P)	>0.90	>0.90	>0.90

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Oral Presentation

AIR QUALITY MODELLING IN LATVIA: RECENT UPDATING

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Abstract
The aim of the air quality modelling instead of monitoring is clear and could be attracted to several points: (1) due to stricter financial resources modelling is much cheaper than monitoring; (2) models could and should be used for spatial assessment of various pollutants; (3) models are often effectively used for planning purposes. Since the air quality modelling becomes very popular and useful some crucial points should be taken account in order to avoid mistakes and unsatisfied results. This report indicates modelling application intensification and introduction more and more in spatial planning processes and for management purposes as well.

Models and Parametrization

In Latvia air quality modelling for planning and development purposes according to EU directive requirements has been carried out since 1998. From mathematical point of view Gaussian dispersion models (offered by various companies such as OPSIS or USA EPA) have been used, but for parameterization of atmosphere algorithms from Monin-Obukhov were used. There are also some cases of simpler parameterization used (such as Paskvel-Gifford) for risk assessment in civil engineering in case of chemicals emergency discharge.

Emission Sources

Over the last years modelling has been done for particular territory – Riga (capital city of Latvia with densest set of stationary pollution sources, heavy traffic flow and traffic jams, specific architecture with street canyon systems and 50 % of population of Latvia). Identification of sources and localization in model has been carried out manually because official reports from operators contain various mistakes, most common of them (1) inaccurate geographical coordinates; (2) loss of physical description of sources (no any height of source, unbelievable high discharge rate, etc.); (3) emissions of pollutants are calculated in order to pay less taxes contrary to real situation assessment (misapplication of methodology); (4) daily and monthly variability of source working hours were improperly estimated; (5) traffic flow quantitative and structural assessment was done based on 1 hour counting during traffic jam. Depending on particular substance, number of point source varies from approx. 50 to 1000, where major part depend to point sources.

Results

Over the last years successful air quality modelling for PM_{10}, NO_2 and benzene were performed not only for Riga city, but also for other local economical centres (cities) – Liepaja, Ventspils, Daugavpils, etc. Additionally air pollution issues for individual operators are issued only based on modelling results what could be prepared by official institutions (e.g. Latvian Environmental, Geology and Meteorology service) or private companies. Modellers are quite free in choose of models, preferably Gaussian dispersion models were recommended, but if data uncertainty limits are achieved any other model could be used as well.

Oral Presentation

LIFE AFTER EUNETAIR?

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Abstract
EuNetAir has contributed in bringing AQ microsensors in the everyday life of citizens. This was materialised by, among others: providing access to AQ information in the close vicinity of human activities and (b) allowing for the recording of air emission patterns within the urban web. The Aveiro intercomparison exercise investigated the accuracy of AQ readings and demonstrated the abilities as well as the research challenges concerning the suitability of microsensors in properly reporting the quality of the atmospheric environment. The next step should be to combine AQ microsensor technology with deterministic and data-driven modelling, in order to extract spatial and temporal patterns from sensor data and associate them with everyday utility for citizens (Nyhan et al., 2016). On this basis life after EuNetAir should address the challenges of citizen science resulting from AQ microsensors integrated to smartphones, and should link them with other personal microsensor data reporting on health status, consumer habits, mobility patterns and digital media content consumption. In this way the post EuNetAir world will embrace AQ microsensor technologies to support smart data and ambient context oriented applications that address quality of life within a smart city environment.

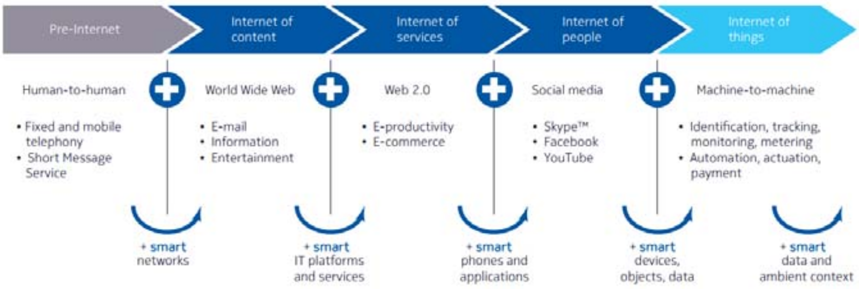

Figure 1. The internet evolution (NOKIA, 2016)

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Oral Presentation

MAPPING URBAN AIR QUALITY USING LOW-COST SENSORS: OPPORTUNITIES AND CHALLENGES

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Abstract

Small and low-cost sensor platforms measuring air quality have considerable potential for detailed mapping of urban air quality [1]. Due to their relatively low price and small size they can be deployed throughout the urban environment in much larger numbers than would be feasible with traditional air quality monitoring stations based on standard reference equipment. This significantly increased deployment density allows for a much more comprehensive set of observations of parameters relevant for air quality and can be used for creating highly detailed maps of air quality in general and in urban areas in particular.

Even though a dense network of low-cost air quality sensors allows for mapping air quality at an unprecedented level of detail, most datasets of observations collected within a crowdsourcing framework contain substantial data gaps in both space and time. In addition, the observations are generally point measurements, which are only representative of a relatively small area. This poses a significant challenge for mapping applications. One way to overcome these issues is to combine the crowdsourced data with spatially exhaustive data from a model. We present a geostatistics-based technique [2] for combining real-time crowdsourced observations with output from the EPISODE dispersion model [3] that allows for providing highly detailed, up-to-date maps of urban air quality.

The results indicate that the method under the right conditions is capable of providing realistic-looking up-to-date maps or urban quality. These maps inherit the spatial patterns provided by the model and are thus able to contain information even in areas where no observations are available, while at the same time the maps inherit the overall magnitude of the sensor observations which are used to locally modify the underlying spatial patterns and concentration values.

Based on the high-resolution urban air quality maps, we further present recent progress towards providing users with near-real-time personal exposure estimates. Quantifying exposure to pollutants in a personalized way is helpful for a wide variety of applications related to outdoor activities in urban environments, including but not limited to 1) finding the least polluted route from point A to point B and thus minimizing one's exposure 2) identifying the best time for outdoor exercise (bicycling, running) for a given track 3) estimating the personal inhaled dose of one or multiple air pollutants over a given path.

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Oral Presentation

CONCLUSIONS FROM ONE YEAR OPERATING A LOW COST SENSOR NETWORK IN ZUERICH

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Abstract

Low-cost gas sensors sensitive to ambient pollution levels and capable of being integrated in wireless sensor nodes are obviously an attractive tool for air quality monitoring. Provided that sensor performance is sufficient, such nodes could extend existing air quality monitoring networks or replace measuring techniques such as passive samplers. We performed a dedicated test case in order to learn about specific requirements of these two applications.

We jointly developed with Decentlab GmbH a low-cost sensor unit ("Aircubes") for ambient NO_2 and O_3 measurements. The Aircubes consist of two boxes. The first one contains two Aeroqual SM50 O_3 sensors and a GSM module for data transmission, the second one contains three Alphasense B42F NO_2 sensors.

We operated the Aircubes in parallel with instruments of routine air quality monitoring stations for about three months and subsequently within a small sensor network consisting of 6 sites in the city of Zurich (June 2015–August 2016). NO_2 passive samplers were continuously exposed next to the Aircubes at all six locations of the sensor network (two-week intervals). We have access to NO_2 and O_3 data from 6 air quality monitoring (AQM) sites for regulatory purposes in the city of Zurich. Moreover, we conducted specific test series in the laboratory in order to analyse properties of the utilized NO_2 sensors.

The performed test case is based on a specific sensor configuration but findings are most likely transferable to other settings. It clearly revealed the importance of thorough sensor testing as well as performance monitoring during the operation period for the generation of meaningful data. As an example, laboratory tests showed that changes in relative humidity effect signals in the NO_2 sensor readings lasting several minutes to hours. These are similar in magnitude as those effected by changes in ambient NO_2 concentrations. Dedicated processing strategies are required to mitigate this issue. Further, we observed that the NO_2 and the O_3 sensors are not stable over time and, noted for the O_3 sensors, can significantly deteriorate. We found that the link of sensor measurements to measurements of AQM stations is a suitable method for analysing and even calibrating individual sensors in the city of Zurich.

The achieved accuracy of two-week NO_2 concentrations is below that of the passive samplers. However, the sensors revealed reasonable patterns of average sub-daily NO_2 concentrations for the locations of the sensor network. Further improvements (e.g. w.r.t. sensors/sensor integration, mathematical sensor model) are required to bring these sensor systems to a performance level which is sufficient for the described applications.

Oral Presentation

PARTICULATE MATTER SMART SENSORS VALIDATION IN REAL-WORLD CONDITIONS

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Abstract
Portable low-cost monitors and sensors are a useful tool to complement existing air quality monitoring networks and hence their use is increasing [1]. However, assessment of their field performance found large divergences between sensor and reference data, and even between different units of the same sensor type [2].
Given that particulate matter is a key pollutant [3] for both health and climate impacts [4, 5], the present work aimed to assess the field performance of current low-cost sensors for particulate matter monitoring under real-world conditions. The technology used was laser-based sensors for particle number. Inter-comparison exercises were carried out for periods ranging between 1 month and 1 year. The chosen location was an urban area in Spain (Barcelona) and hence the sensors monitored representative urban background aerosols and aerosol concentrations typical of the urban background in the Mediterranean region.
The data obtained from the sensor nodes were compared to data from an optical particle counter (OPC, GRIMM 180) laser spectrometer, previously calibrated by comparison with an EU-reference high-volume sampler. The parameters evaluated were: comparability between units of the same sensor, correlation with regard to the reference data, and stability over time. Three different sensors were tested:

- Dylos DC1700: good agreement between different units (R^2>0.95). Good agreement with reference data (R^2>0.70). Stable over one-to-two months periods. Required cleaning maintenance and crosscheck with reference for longer periods, given that correction against reference data changes over time.
- Airbeam: good agreement between different units (R^2>0.95). Good agreement with reference data (R^2>0.75) over one-month period. Long-term stability not tested yet.
- AQMesh: good agreement with reference data after removing outliers (R^2>0.70). Stable over five-months period. Long-term stability not tested yet.

Further testing and improvement of both sensor technologies and data processing is required, although satisfactory results have been obtained to date. Hence, the use of such low-cost technologies for air quality assessment is feasible, provided that the necessary quality assurance procedures are implemented and results are interpreted knowing the limitations.

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Oral Presentation

TOWARDS INTELLIGENT AIR QUALITY MONITORING NETWORKS: HOW MACHINE LEARNING IMPROVE THE ACCURACY OF AIR QUALITY MULTISENSORS SYSTEMS

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Abstract

During the last years, significant efforts have been produced in the framework of EuNetAir COST Action to improve the accuracy and precision of air quality multisensor systems. Along with technology based sensors performance amelioration approaches, sensors data processing and specifically machine learning approaches have shown up as an increasingly efficient tool to boost overall multisensor system performances when operating in field. This contribution is designed to oversee the multiple lesson learnt by the EuNetAir community about the power of these approaches. Practically, all of these approaches have shown performance improvement that are irrespective of the specific machine learning tool (e.g. neural networks, support vector machines, regression trees, etc.).

One of the basic issue of our systems is the so called cross-sensitivity, i.e. the residual response to non target gases expressed by sensors that affect the accuracy of the concentration estimation task. Multiple works, some of them performed during our COST Action have shown that significant improvement can be obtained by non linear multivariate regression [1][2]. These improvements are basically due to the possibility for the network to learn the complex relationships about the sensor responses and the simultaneous exposure to mixture of pollutants. This allows for learning a non linear function that, taking into account all the sensor responses, efficiently deletes unwanted contribution to the estimated concentration of a target gas. These findings have been confirmed by multiple studies conducted both in laboratory and on the field settings. Remarkably, in some cases, this improvement has led to the possibility to meet EU 2008 Directive DQO limits [2]. It is important to highlight that a sufficient amount of data, concisely covering the multi target gases manifold expected on the field, must be sampled to be used as training set for the network. We want to stress that some of this algorithm can now be embedded on board of so called smart cyber chemical systems as well as used in centralized big data processing systems in order to provide fully functional personal exposure monitors and distributed air quality monitoring networks.

Concept and Sensor Drift, usually simultaneously present, are significant issues limiting the application of our solutions on long term deployments. Multiple works have shown the possibility for machine learning approaches to counteract it. Semisupervised learning has shown the possibility to adapt the learned knowledge by updating it with non labeled samples, i.e. by using sensors data whose corresponding real gas concentration is not known. This principle has proven useful in both gas concentration estimation and mixture classification problems [3][4]. Rendez vous calibration approaches may represent significant tools to correct the errors induced by drift effectively updating the knowledge embedded in a calibration algorithm that may become obsolete because of drift [5]. Recently, deep learning approach, based on multistage neural networks built by stacked autoencoders and linear classifiers/regressors seems to provide empirical evidence of increased robustness to drift effects. Our opinion is that this is achieved by exploiting a more robust inner representation developed in the network hidden layers. Last few years have been characterized by novel

possibilities opened by the availability of near "wearables" mobile gas multisensor systems. Those systems, together with fixed systems located near pollutant emission sources (i.e. on the roadside), will be subjected to rapid concentrations changes that challenges the intrinsic slow (and different) dynamic of single gas sensors. Recently, our group have shown that the use of dynamic machine learning tools, using a time observation window of sensor responses as input, may significantly boost the dynamic and precision performance of a gas multisensor system [6]. These results have been obtained in real world settings during a multi-week measurement campaign in a city setting. This specific dataset shown a remarkable correlation between the real concentration derivatives (an index of transient rapidness) and concentration estimation errors performed by either single uncalibrated sensors responses or state of the art non linear multivariate regression tools operating on the entire sensor array response. Fault detection is another relevant application for machine learning, making possible to easily detect the presence of a faulty sensor calling for maintenance actions as well as the activation of graceful performance degradation tools. Finally, all of these approaches suffer from a "locality" effect being bound to the specific sensor array due to the variance that can be still observed in the fabrication process of sensors. Unfortunately, the knowledge obtained by the machine learning systems may be severely limited to the point that it could be only used for a specific sensor array. Calibration transfer or highly robust approaches are hence used to make it useful for any other device. Recently, calibration transfer is a field of research that is becoming particularly active in our community with multiple works showing promising results [7].

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Oral Presentation

H2020 OPPORTUNITIES OF FUNDING IN THE AIR QUALITY MONITORING AND RELATED TOPICS

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The aim of the talk is to inform about the funding opportunities for Academic institutions and SMEs in HORIZON2020. The thematic focus will be on air quality monitoring and related topics.

Horizon 2020 is the financial instrument implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness. Running from 2014 to 2020 with a budget of just over €70 billion[1], the EU’s new programme for research and innovation is part of the drive to create new growth and jobs in Europe.

The talk will give an overview of upcoming calls for proposals under the “Industrial Leadership” and “Societal challenges” as well as “Excellent Science” programmes.

Oral Presentation

AIR QUALITY NETWORKS: LESSONS LEARNED, CURRENT STATUS AND FUTURE OPPORTUNITIES

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Air quality is an increasingly important global concern. Air quality monitoring stations (AQMs or AURNs) are very good point sampling analysers but the purchase and maintenance costs limit their deployment. Recent developments have led to use of low cost air quality networks in cities.

We will review deployments in Cambridge, Heathrow airport, MIT, London, UNEP/ Nairobi and the EU funded CITISense project. The greatest technical challenge has been sensor performance for monitoring inorganic gases, VOCs and particulates. We now understand their capabilities and shortcomings, and improvements will continue for the foreseeable future.

Challenges in big data networks will be considered: deployment and maintenance of the network will involve local politics; validation to ensure data quality is an added but necessary cost; access to detailed air quality data can interfere with privacy rights. Our four-sector approach of equipment, deployment, analysis and validation will be presented as a generic model for low cost air quality networks.

Fixed site networks have been tested but the future is even more challenging- mobile networks on cars and trams, portable networks for rapid profiling, citizen scientists and hobbyists using Raspberry PIs and wearables are all being developed. We will discuss.

Oral Presentation

NEW TRENDS AND CHALLENGES OF AIR POLLUTION MONITORING USING LOW-COST SENSORS: WHAT IDAD LEARNED?

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Abstract

The Institute of Environment and Development-IDAD acts as the interface unit of the University of Aveiro for development, consulting and services to the Society, which main areas of activity include air pollution, impact assessment, environmental monitoring and sustainable development. New sensing technologies for air quality assessment are also a key area for IDAD strategy, being presently responsible for several environmental monitoring programs, including air quality monitoring and modelling. Then, the participation in the present COST Action complemented IDAD's knowledge, ensuring at the same time the framework to test new sensor technologies for air pollution control against conventional techniques. During recent monitoring programs, IDAD studied and implemented new air quality monitoring strategies, including the design of a wide network of air quality and noise sensors in port areas or indoor air quality assessment using microsensors and conventional methods. Also, the opportunity provided by a Short-Term Scientific Mission offered the possibility to consolidate the cooperation between sensor manufacturer and end-user regarding microsensor evaluation and improvement of sensor performance. As a result, a first field comparison exercise allowed identifying measurements with a strong correlation between microsensors and reference methods (Fig 1).

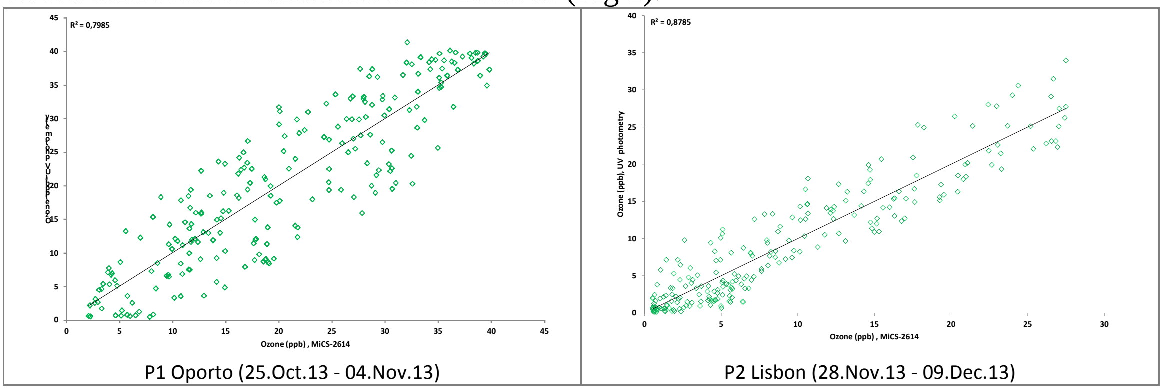

Figure 1 - Example of correlation between microsensor and UV analyser

Finally, a Joint Exercise Sensors-versus-Analysers was held at Aveiro city centre, during the two-week experimental campaign (October 2014). The IDAD Air Quality Mobile Laboratory, equipped with referenced analysers was used to host 130 advanced low-cost sensor systems. This was an important cooperation between 15 teams from research centres, universities and companies coming from 12 countries, to compare the sensing performance in real scenario. The results are published in an international peer-reviewed journal, showing promising results for O_3, CO, and NO_2, where correlations up to 0.9 were achieved for some sensors. Up to now, air pollution monitoring use complex, expensive and stationary equipment, which limits the data gathering. The pattern is changing with the development of advanced low-cost, easy-to-use and portable sensor-systems, which will allow expanded use by communities and individuals, new and enhanced applications and increased data availability and access.

Invited Talk

ORGANIC/INORGANIC HYBRID MATERIALS FOR THE DEVELOPMENT OF ACOUSTIC WAVE CHEMICAL SENSORS DEDICATED TO BTEX DETECTION

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Abstract

The emergence of composite nanomaterials is an attractive opportunity to benefit not only from the intrinsic properties of each compound but beyond, from their synergic association. Such an approach can lead to the improvement of performances achieved by individual materials or/and the development of new properties. Associating organic and inorganic materials, hybrid nanomaterials have opened the way to different advances in the field of mechanics, optics, microelectronics, surface treatment, filtering membranes and gas sensors.

Our works are focused on the synthesis, characterization and application of hybrid nanomaterials obtained by the functionalization of nanocarbons by organic macromolecules such as porphyrins and phthalocyanines. Because of the great specific surface area of nanocarbons and the high adsorption rate of aromatic molecules on phthalocyanine macrocycles through π-π interactions, the sensing properties of these hybrid nanomaterials were studied towards BTEX pollutants. Taking into consideration the nature of gas/material interactions (no charge transfer involved), QCM and SAW device were preferred as transducers for sensor development.

The non-covalent functionalization has been established and monitored by Transmission Electron Microscopy (TEM), Fourier transform infrared spectroscopy (FT-IR) and thermogravimetric analysis (TGA). Layered on quartz crystals and SAW transducers by drop-casting process, the sensing properties have been determined by gas exposures. Especially, the interest of phthalocyanines as functional groups for BTEX detection as compared to porphyrins is established. Moreover, experimental results obtained on QCM and SAW-based gas sensors implementing hybrid nanomaterials exhibit higher responses as compared to those measured on nanocarbons and phthalocyanine separately. At last, cross-sensitivity measurements with CO, NO_2, H_2S and ethanol as interfering analytes reveal a partial selectivity towards BTEX. All the experimental results highlight the enhancement in sensing performances obtained on phthalocyanine/nanocarbon hybrid material as sensitive layer.

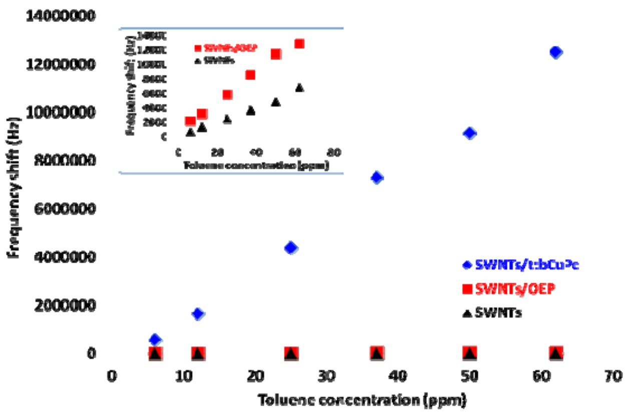

Figure 1. Responses of hybrid nanomaterial-based SAW sensors towards toluene in the 5-60 ppm range.

Invited Talk

HIGH PERFORMANCE SIC-FET GAS SENSORS FOR HIGHLY SENSITIVE DETECTION OF HAZARDOUS INDOOR AIR POLLUTANTS

D. Puglisi[1], M. Andersson[1,2], J. Eriksson[1], M. Bastuck[1,3], C. Bur[1,3], J. Huotari[2], J. Lappalainen[2], A. Schuetze[3], A. Lloyd Spetz[1,2]

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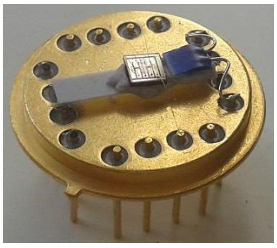
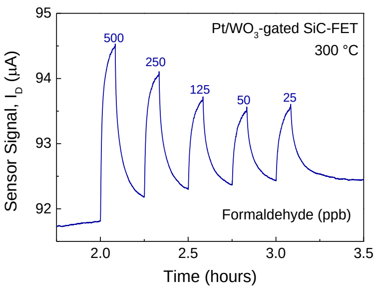
Abstract

In the framework of the EU-project SENSIndoor [1], metal insulator semiconductor field effect transistors with catalytic metal or metal/metal-oxide gate contacts were fabricated on top of 4 inch n-type 4H-SiC wafers (SiC-FETs). Five different materials for the gate contact, Ir, Pt, WO_3, Ir/WO_3, and Pt/WO_3, have been processed and characterized. Porous Ir or Pt were deposited by means of DC magnetron sputtering, whereas porous or dense thin films of WO_3 were deposited by means of pulsed laser deposition (PLD) [2]. Pure Ir-gate SiC-FETs showed the highest sensitivity to the three target VOCs, formaldehyde (CH_2O), benzene (C_6H_6), and naphthalene ($C_{10}H_8$), with detection limits under 0.2 ppb in dry air, and under 10 ppb CH_2O, 3 ppb C_6H_6, and 0.5 ppb $C_{10}H_8$ at 60 % of relative humidity [3]. Pure WO_3-gate SiC-FETs were not suitable as gas sensors since low conductivity of the gate material results in poor sensitivity and stability, and short lifetime. The addition of a noble metal (Ir, Pt) to the semiconducting oxide (WO_3) has been an effective means to enhance detection of specific gases because these metal catalysts increase the rate of interaction differently for distinct gases. Ir/WO_3 SiC-FETs were operated for several hundred hours from 180 °C to 300 °C in static and dynamic operation modes. Detection limits below 5 ppb benzene and 5 ppb formaldehyde were demonstrated during several repeated measurements. Ir/WO_3 SiC-FET showed enhanced selectivity to naphthalene in comparison with pure Ir-gate SiC-FET [4].



(a)



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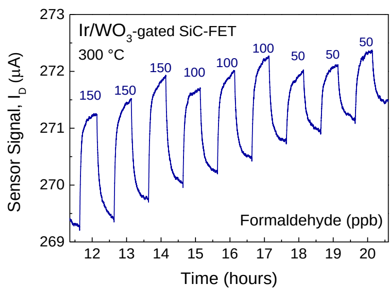

(c)

Figure 1. (a) Mounted sensor chip, (b) and (c) Sensor response to CH_2O with a Pt/WO_3 and an Ir/WO_3 SiC-FETs.

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Oral Presentation

LOW TEMPERATURE-LOW POWER GAS SENSORS BASED ON GERMANIUM NANOWIRES

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Abstract

We present a novel gas sensor based on Ge nanowires (NWs) that is used for the sensing of humidity at temperatures up to 100ºC. By means of a modified CVD method, the Ge NWs are grown on well defined locations of micromembranes or microhotplates equipped with a buried heater and top interdigitated electrodes, using the heater for providing the temperature required for the growth. The heater can be used, afterwards, for the sensing operation. In this way the deposition is carried out right onto the sensing area, and with a negligible power budget of just few milliwatts.

We will demonstrate that germanium nanowires react in the presence of both reducing and oxidizing gases, acting as a chemiresistor, with some similarities to metal oxide materials in what concerns most of the gas responses, driven by the chemisorption of the gas to the material's surface. However, the response to humidity is based on a different mechanism, which we propose that is physisorption onto phenyl groups remaining at the surface of the material after the growth. The proposed mechanism could account for the response to water vapor at this low temperature and would justify the fact that the response to the other gases is comparatively small. The modelling of the sensing behavior is based on the presence of a native substoichiometric and subnanometric germanium oxide, which forms as a shell around the nanowires and remains after the growth.

Invited Talk

A FLEXIBLE PLATFORM FOR EXTREMELY SENSITIVE GAS SENSING: 2D MATERIALS ON SILICON CARBIDE

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Abstract

2D materials offer a unique platform for sensing with extremely high sensitivity, since even minimal chemical interaction causes noticeable changes in the electronic state. However, the sensitivity has to be complemented with selectivity. This has been addressed, for example, by combining graphene (for sensitivity) with metal/oxide nanoparticles (for selectivity). On the other hand, functionalization or modification of the graphene often results in poor reproducibility. We have investigated the gas sensing performance of epitaxial graphene on Silicon Carbide (SiC) decorated with nanostructured metals and metal-oxide nanoparticles deposited using scalable thin-film deposition techniques, like hollow-cathode pulsed plasma sputtering [1]. Under the right deposition conditions the electronic properties of the graphene remain intact, while the surface chemistry can be tuned to improve sensitivity, selectivity and speed of response to gases relevant for air quality monitoring and control [2,3], yielding detection at low ppb concentrations of toxic gases such as nitrogen dioxide, benzene, and formaldehyde [4]. Studies have also been initiated on other monolayer sensing layers like 2D catalytic metals on SiC, which offer additional possibilities like faster response and operation at high temperature and in harsh conditions, while maintaining the promises of 2D materials as extremely sensitive transducers.

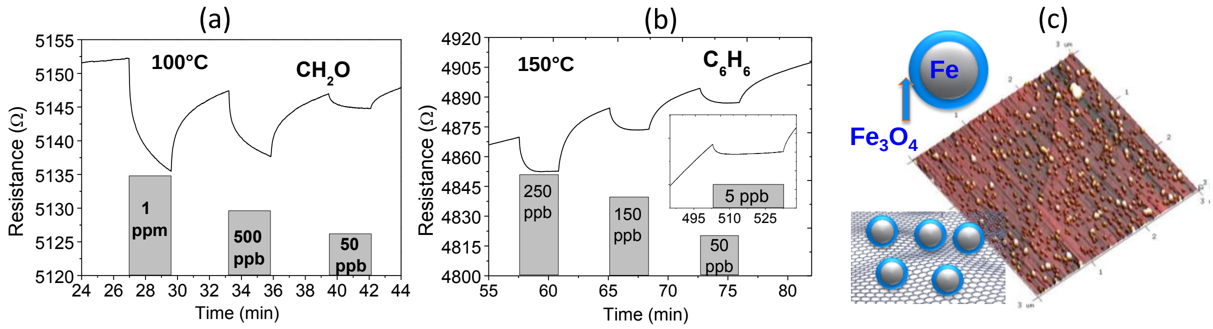

Figure 1. Response of a Graphene on SiC sensor decorated with Fe_3O_4 nanoparticles (≈ 60 nm in diameter) to (a) CH_2O concentrations from 1 ppm to 50 ppb, and to (b) C_6H_6 concentrations in the range 250-5 ppb (b); (c) shows a 3 μm × 3 μm AFM micrograph of the Fe_3O_4 nanoparticles on EG/SiC.

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Invited Talk

LOW-POWER HEATING FOR CONDUCTOMETRIC GAS NANO SENSORS: SELF-HEATING EFFECTS

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Abstract

The energy needed to activate the chemical processes occurring at the surface of solid-state sensor materials is the main source of power consumption of this technology. The efficient self-heating in nanostructures is a promising but barely exploited approach to reduce power consumption into the µW regime [1]. The technical complexity of fabricating suitable devices for such an approach has hampered its further development for nearly a decade. Recent results show that efficient self-heating also occurs in larger systems, which are simpler to fabricate [2,3]. Moreover, new findings about the origin of the unexpectedly high efficiency of these large systems are opening doors for truly engineering self-heated devices, which are then easy to implement [4]. In this presentation, we will review recent advancements in self-heating use and application, identifying which are the key parameters to achieve effective and efficient heating by this method. The research leading to these results was carried out in the framework of the FP7 EU Project ERC Starting Grant "BetterSense: Nanodevice Engineering for a Better Chemical Gas Sensing Technology" [5] and in collaborations stablished within the EuNetAir COST Action.

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Oral Presentation

HIGH SPATIAL RESOLUTION AIR QUALITY MAPPING USING DATA FROM AN OPPORTUNISTIC MOBILE MONITORING CAMPAIGN

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Abstract

A sufficient number of repeated measurements is required to map urban air quality with mobile measurements in a reproducible way and at a high spatial resolution [1]. However, this is generally quite labour intensive. To collect the necessary data, advantage can be taken of existing mobile infrastructure or people's common daily routines to move measurement devices around through the city, without specifically designing the travelled route of the mobile carrier for the measurement campaign. We call this opportunistic mobile monitoring.

A case study was set up to map the average exposure to black carbon (BC) in streets and public spaces in Antwerp, Belgium, during a one-year period (July 2012 - June 2013) [2]. City wardens carried micro-aethalometers during their daily surveillance tours. The spatial coverage within the study area was very high, although there is a large variation in the number of passages between different segments. For a lot of the streets and street segments only a small number of repeated measurements were recorded. The temporal coverage also showed a non-uniformly spread pattern.

A temporal adjustment can partly counteract this bias, but there is still a rather large uncertainty on the average concentration levels at the individual locations. Despite this, large spatial patterns are clearly captured. The results emphasize the challenges with unstructured opportunistic mobile monitoring. Repeated measurements and careful processing and interpretation of the results are very important.

In a further step the dataset was used to build a spatio-temporal LUR (Land Use Regression) model. Next to typical spatial LUR components, temporal components were introduced by including meteorological and fixed site BC measurements into the model. The model captured spatial variation as well as a spatial LUR model based on the same data. The fixed site BC measurements were essential to model the temporal variability. Exposure estimates of cyclists or pedestrians to traffic related pollution based on the hourly LUR models were more accurate than based on a fixed site monitoring station or on a spatial LUR model. The model can be used to estimate exposure of cyclists or pedestrians to traffic related pollution based on a GPS track. This demonstrates that continuous unstructured opportunistic measurements can be used to make a real-time dynamic pollution map with increasing accuracy that provides personalized exposure information based solely on a GPS track [3].

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ABSTRACTS OF POSTER PRESENTATIONS

Poster Presentation

Intracavity acetylene detection with fiber loop ring down spectroscopy

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Abstract

As a multi-functional sensing technique fiber loop ring down spectroscopy (FLRD) has unique properties such as fast response, low detection limit, adjustable sensor region, and being independent of laser power fluctuation or detector performance. In this study, an easy to construct and sensitive intracavity FLRD spectrometer was built by commercially available basic components and its application on chemical sensing is presented. The spectrometer was constructed with a 1534 nm pulsed laser, SMF-28 fiber, two collimators, coupler, isolator, and a sensing region. The spectrometer's capability was shown by various acetylene/nitrogen mixture gases and a calibration curve is established. The instrument has an ability to detect 0.1 % acetylene in a mixture of acetylene and nitrogen gases, and there is much room for improvement by using different sensor region configurations. With the current design of the spectrometer, the change in type and/or concentration of species in the sensor region can be monitored in real time.

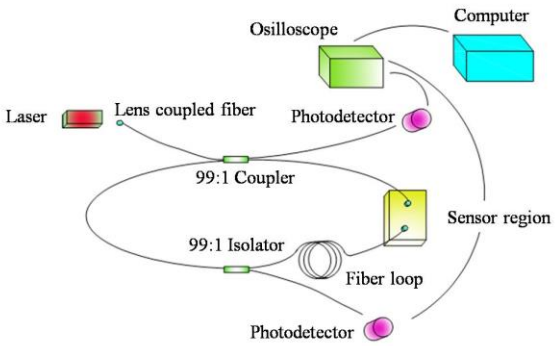

Figure 1. Schematic configuration of the intracavity FLRD spectrometer

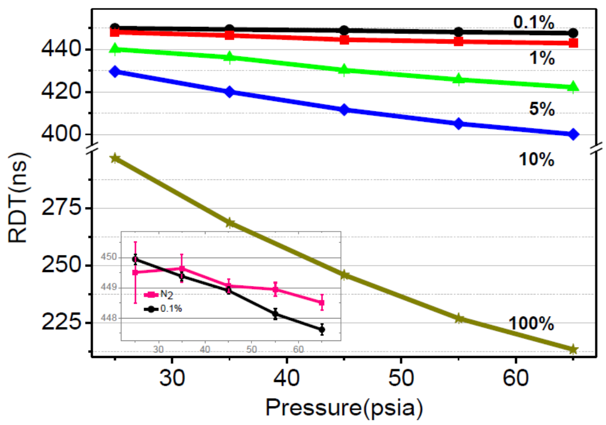

Figure 2. Ring down time of different concentration of acetylene and nitrogen mixture at different pressures. Inset shows the reference N2 and 0.1 % acetylene.

Poster Presentation

SPECIFIC FILTERS FOR THE TRAPPING OF SPECIFIC AIR POLLUTANTS

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Abstract

There are thousand of volatile molecules in indoor air. They are emitted from various sources such as cigarette smoke, house-hold products, cosmetics, pesticides, mold, materials in building, furniture or cooking. The most ubiquitous were found to be aldehydes (formaldehyde, acetaldehyde, hexaldehyde, acrolein...) and monocyclic hydrocarbons (benzene, toluene, xylenes). Some other toxic gases can also come from outdoor air such as ozone and nitrogen dioxide.

Due to their variety, the measurement of indoor air pollutants often requires active or passive methods, with the use of many different cartridges for the specific trapping of families of compounds. The trapped pollutants are then desorbed thermally or via liquid phase elution and separated by gas or liquid phase chromatography and then detected. These methods, though reliable, imply many steps and often give averaged values of the pollutant concentration. On the other hand, there exist many sensors, which are sensitive and fast, but the low-cost ones often lack of selectivity.

The present work aims at providing up-stream filters able to trap the undesired pollutants, thus providing to any type of sensors an enhanced selectivity. Examples will be given on various specific filters including ozone/NO_2, carbonylated compounds and monocyclic hydrocarbons. The filters are based on functionalized nanoporous materials produced via the sol-gel method. The filters can either be reversible or irreversible, depending on the nature of the pollutants and the chemical interaction with the functionalized matrix.

Poster Presentation

ATMOSPHERIC DEPOSITION OF TRACE ELEMENTS ON CARBONATE MATERIAL OF HISTORIC BUILDINGS IN TWO URBAN SITES

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Abstract

The interaction of carbonate building materials with an SO_2-loaded atmosphere leads to the transformation of calcium carbonate (calcite) into calcium sulfate dihydrate (gypsum) which, together with the embedded carbonaceous particles, consequently forms the black crusts (BCs) on the stone surface [1]. The study of trace elements, such as heavy metals in the BCs developing on monuments, provides useful information on pollution sources [2]. In this study, trace element concentrations were determined by ICP-MS method on the BCs from the two monuments: Cathedral in Zagreb, Croatia and St. Mary Church in Jajce, B&H, and in the limestone from the quarries, where the stone for the Cathedral was exploited. The concentrations (ppm) of trace elements in some BCs from Jajce and Zagreb are given in Fig.1a as well as the concentration of elements in BCs (samples from the Zagreb Cathedral) normalized to those of limestone (Fig1b).

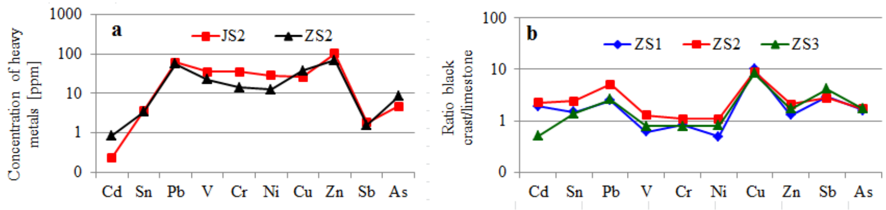

Fig.1 (a) Logarithmic plot of metals concentrations in the BCs samples: Jajce (JS2) and Zagreb (ZS2); (b) Concentrations of metals in BCs samples (Zagreb) normalized to those of limestone.

The higher concentrations (10-100 ppm) of Zn, Pb, V, Cr, Ni, Cu and As were found in the investigated samples. These metals are commonly generated by traffic (motor exhaust or vehicle related particles, such as brake abrasion, corrosion of metallic parts of cars). Higher values of V, Cr and Ni in the sample from Jajce than those from Zagreb can be associated with coal combustion from local industry. Furthermore, in the Zagreb samples, Cu, Pb, Sb, Zn and As are enriched in the BCs with the Enrichment factor ranging between 2-10: Cu (up to 10), Pb (up to 5), Sb (up to 4), Zn, Cd, Sn and As (about 2). Due to the absence of industry in Zagreb, Cathedral enrichment of heavy metals in the BCs can be attributed to air pollution produced by domestic heating, traffic and thermal power plants.

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Poster Presentation

DAV³E – a comprehensive toolbox for multisensor data fusion not only for gas sensors

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Abstract

DAV³E (Data Analysis and Verification/Visualization/Validation Environment) is an object-oriented MATLAB toolbox developed to facilitate the process of building a statistical model out of data generated by cyclically driven sensors. Cyclic operation is a common approach in the gas sensors field where temperature cycled operation (TCO) increases sensitivity and selectivity of gas sensors [1]. In general, however, the toolbox is suitable for any kind of measurement that can be described in terms of time-discrete observations characterized by a number of features, e.g. on-line condition monitoring for hydraulic systems [2]. A common problem of such data is that the final result depends strongly on the data structure of a specific problem, and finding the best combination of processing steps (Fig. 1a) is time-consuming. The toolbox provides a graphical user interface (GUI) for easy handling and data visualization throughout the whole process. The GUI pursues a modular approach, i.e. there is one tab for each step for user guidance and structuring of information. Any number of raw measurement files can be imported and concatenated horizontally or vertically, increasing either the number of observations or the number of features per observation. The raw data can be preprocessed and an easy and efficient interface for building target vectors is available (Fig. 1b). The raw data can be reduced in dimension by computing mathematical (mean, slope) or statistical (n^{th} statistical moment) measures over certain areas of the sensor cycle. Models can be custom-built from any number of many predefined building blocks for feature and response preprocessing, dimensionality reduction, classification or regression, and validation. All these building blocks provide a common programming interface for easy extensibility of the toolbox. Some automatisms, e.g. feature selection algorithms and automatic target vectors, are already implemented and planned to be extended by an automatic parameter search for all steps in the workflow. Once a suitable data processing approach has been found using the GUI, DAV³E's classes can be used to quickly write batch processing scripts.

(a)

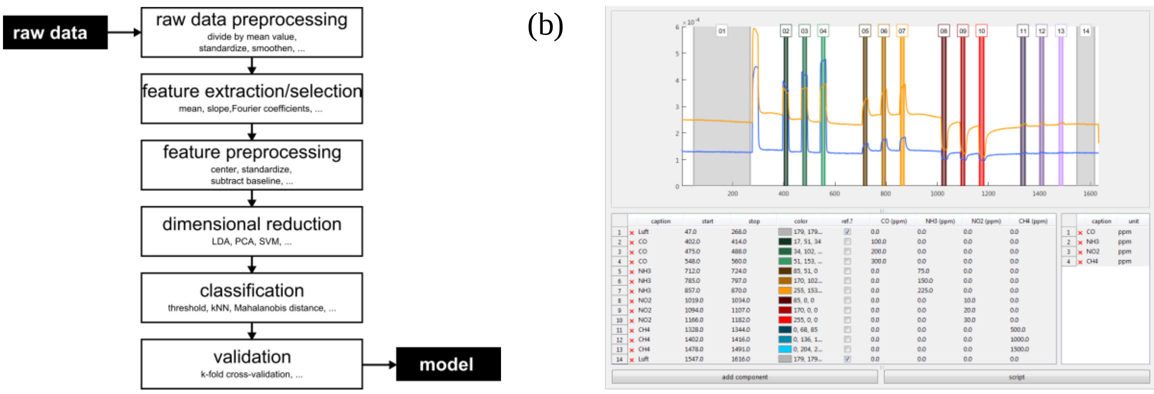

Figure 1. (a) Steps in the model-building process. (b) View of a DAV³E module for target vector definition.

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Poster Presentation

GAS SENSITIVE SIC-FET SENSORS FOR INDOOR AIR QUALITY CONTROL

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Abstract

According to the U.S. Environmental Protection Agency (EPA), indoor air pollution is two to five times higher than outdoor air pollution, and it could be even 100 times higher in the worst cases [1]. Volatile organic compounds (VOCs) are considered major air pollutants in several indoor environments. Among these, formaldehyde (CH_2O), naphthalene ($C_{10}H_8$), and benzene (C_6H_6) are classified as probable, possible, and known human carcinogens.

In this work, we present highly sensitive, selective, and low cost gas sensors based on silicon carbide field effect transistor (SiC-FET) technology for detection of the three mentioned hazardous VOCs in the low parts per billion (ppb) concentration range. We compare the sensor performance of pure metal-gated (Ir) and a combination of metal/metal-oxide (Ir/WO_3) gated SiC-FETs at different operating temperatures and electrical operating points of the device, i.e., linear, onset of saturation, and saturation regions. Operating the sensor at the saturation region of the transistor gives a sensor response up to 52 % higher than that at the linear region [2].

Pure Ir-gated SiC-FET shows the highest sensitivity to formaldehyde (Fig. 1a), whereas the combined Ir/WO_3-gated SiC-FET shows enhanced selectivity to naphthalene (Fig. 1b).

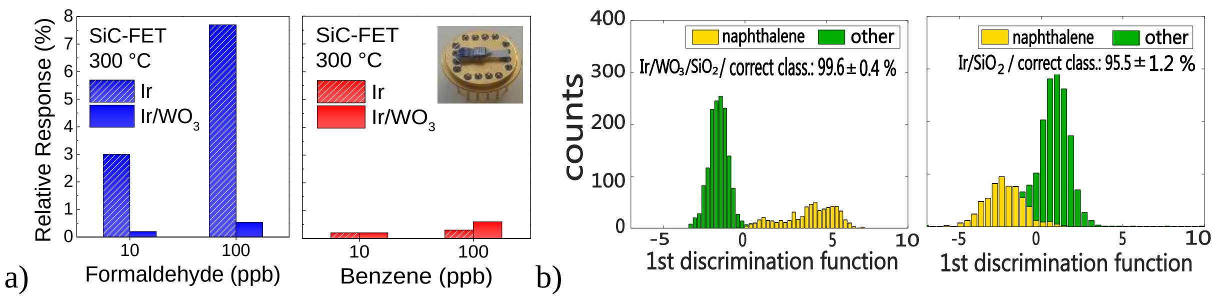

Figure 1. a) Relative response to CH_2O and C_6H_6 with Ir- and Ir/WO_3-gate SiC-FETs. Inset on top right: mounted sensor chip [3], b) Discrimination of $C_{10}H_8$ independent of ethanol's presence by linear discriminant analysis (LDA) [4].

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Poster Presentation

IMPEDANCE SPECTROSCOPY OF MOLECULAR MATERIAL – BASED HETEROJUNCTIONS FOR A BETTER DISCRIMINATION BETWEEN AMMONIA AND WATER

M. Bouvet[1]*, T. Sauerwald[2], M. Schüler[2], J.-M. Suisse[1], A. Wannebroucq[1], P. Gaudillat[1], A. Kumar[1], A. Schütze[2]*

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Abstract

We investigated MSDI (molecular semiconductor-doped insulator) ammonia sensors using impedance spectroscopy. MSDI sensors use a heterojunction between a molecular semiconductor (MS) and a doped insulator (DI). The interface of fluorinated and non-fluorinated phthalocyanines appears to be a determining factor for the electronic charge transport in the two-component thin film and ultimately deciding the nature of gas sensing. The impedance measurements showed that the Schottky contact between the sublayer and the electrodes also plays a key role. In MSDIs, the semiconducting layer completely covers the doped insulator and is not in contact with the electrodes. The MSDIs exhibit unique current-voltage characteristics, compared to resistors, diodes or field-effect transistors. MSDIs are used as conductometric transducers for the detection of ammonia (NH_3). Even though the only material in contact with atmosphere is $LuPc_2$, the response depends on the nature of the sub-layer. Thus, n-type MSDIs like $Cu(F_{16}Pc)/LuPc_2$ exhibit a positive response to NH_3 whereas p-type-MSDIs prepared with a p-type sub-layer exhibit a negative response to NH_3. More interesting, this response is only slightly affected by the presence of humidity, in a broad range of relative humidity, and the sensors operate at room temperature.

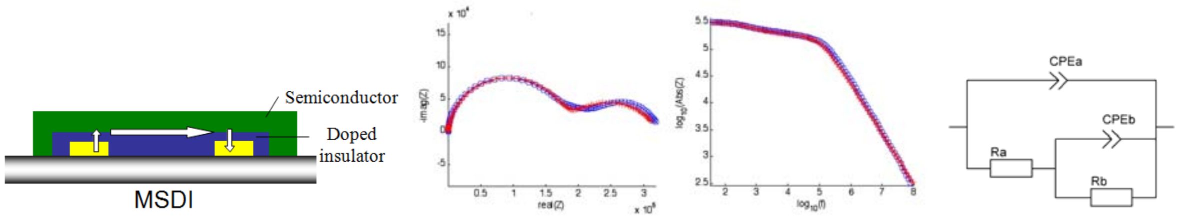

Figure 1. Schematic view of MSDIs, Nyquist and Bode plots of a $Cu(F_{16}Pc)/LuPc_2$ MSDI, using the equivalent circuit on the right hand side.

We also carried out impedance measurements at humidity levels of 30, 50 and 70 % RH. At each level, we exposed the sensor to ammonia concentrations of 30, 20 and 10 ppm. From a linear discriminant *analysis (LDA)*, we calculated the Q and α values of the CPEs, as well as the R values of the resistors of the equivalent circuit, from impedance spectra acquired using the Agilent 4294A spectroscope. Then, the influence of humidity and ammonia on the electrical properties was separated using LDA. The result indicates that this approach is rewarding; it enables a discrimination of different humidities, which can further improve the ammonia quantification.

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Poster Presentation

MOLECULAR SEMICONDUCTORS – DOPED INSULATOR (MSDI) HETEROJUNCTIONS AS NEW CONDUCTOMETRIC DEVICES FOR CHEMOSENSING

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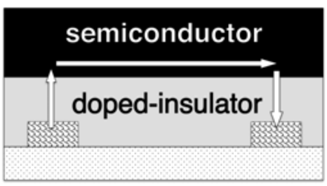
Abstract

Molecular Semiconductor-Doped Insulator (MSDI) heterojunctions are built around a heterojunction between a molecular semiconductor (MS) and a doped-insulator (DI). The MS must be more conductive than the sub-layer to take advantage of the heterojunction. In most cases, the lutetium *bis*phthalocyanine ($LuPc_2$) is used as MS. DI may be an n-type-material, such as fluorinated Pc (ex.: $Cu(F_{16}Pc)$) or a perylene derivative. The energy barrier at the interface depends on the difference in energy levels of the two materials. In contrast to resistors, the MSDI exhibit non-linear but symmetrical I(V) characteristics as a result of the energy barrier at the interface between the two layers. Even though the only material in contact with the atmosphere is a p-type material ($LuPc_2$), the current across MSDI increases when exposed to a donating species like NH_3. Due to the particular redox properties of $LuPc_2$, the MSDIs are very sensitive. Here we studied a MSDI made of an n-type material, the 2,2,3,3,4,4,4-heptafluorobutyl-perylene-bisimide (C_4F_7-PTCDI), 50 nm, as DI and $LuPc_2$, 50 nm, as MS. We exposed the MSDI to ammonia in the 10-90 ppm range. This MSDI exhibits an increase of I, with a relative response $RR = (I_{on}-I_{off})/I_{off}$ of 33 % at 90 ppm. At 10 ppm, the RR is still of 6 %. The RR variation as a function of the NH_3 concentration is not linear but may be fitted by a polynomial.



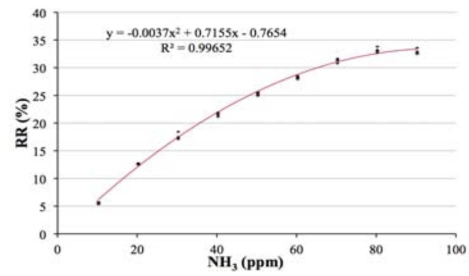


Figure 1. Schematic view of a MSDI heterojunction, the arrows indicate the conduction path of charge carriers; and the relative response of a C_4F_7-PTCDI / $LuPc_2$ MSDI exposed to 10 – 90 ppm of ammonia under 50 % rh.

The better stability towards humidity was obtained with $Cu(F_{16}Pc)$ as n-type sub-layer. Thus, for $Cu(F_{16}Pc)/LuPc_2$ MSDI (50 nm/50 nm), the relative response to NH_3 remains unaffected by the variation of relative humidity in the 20-80 % range. Moreover, this response has proved to be stable over time (several years).

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Poster Presentation

THE IMPLEMENTATION OF THE HEALTH IMPACT ASSESSMENT (HIA) IN VAL D'AGRI (ITALY) AND THE DIRECT INVOLVEMENT OF CITIZENS IN MONITORING ACTIVITIES

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Abstract
Health Impact Assessment (HIA) is a practical tool, which can be used for evaluating the health impact of a proposed program, project, policy, strategy and initiative in sectors that indirectly affect health and well-being and inform decision-makers of these potential outcomes before the decision is made, supporting the identification of appropriate policy options.The HIA is strongly reliant on inter-sectorial collaboration, both across various sectors, but also across policymaking and practice [1,2].

The ‘Project for the construction of a health impact assessment in the municipalities of Grumento Nova and Viggiano in Val d'Agri was in fact launched by a multidisciplinary research team: it has been defined and developed by the Environmental Epidemiology and disease registries Unity - Institute of Clinical Physiology, National Research Council (CNR), in collaboration with researchers from the Department of Biology of the University of Bari, the Institute for Atmospheric Sciences and Climate of the National Research Council, the Institute for the Study of Ecosystems of the CNR, the Consorzio Mario Negri Sud, and the Department of Epidemiology of the Lazio Region.

The project proposes the realization of an HIA in Val d’Agri (Basilicata - South of Italy); the interest for its implementation in this area is due to the presence of the largest Italian gas and oil pre-treatment plant, called the "Centro Oli Val d'Agri" (COVA), which performs a first processing of the crude oil extracted from the various wells on the surrounding territory.

In this project the task of the research group of the University of Bari is to monitor conventional and non-conventional pollutants at the high spatial-temporal resolution, performed by standard and innovative methodological approaches and integrated technologies that are able to provide real time information about the emissive situation and the impacts on the territory. In particular, the project involves the activity of odour monitoring both by means of electronic noses and dynamic olfactometry according to UNI EN 13725. Odour annoyance represents one of the most emerging aspects related to odour emissions, produced by industrial plants and constitutes an indicator of an unhealthy environment, strongly felt by population.

The odour impact assessment will also be carried out by involving citizens by means of an experimental methodology for the detection and evaluation of olfactory annoyance. Citizens play a key role to alert the public authority by means of a phone switchboard, communicating in real time the perception of odor events and their intensity. The warnings are displayed on a map together with the meteorological data in order to associate the emissions to the sources on the territory. According to a chosen routine, remote automatic sampling systems, located in particular sites on the territory, are activated in real time in order to collect a representative sample, analyzed through dynamic olfactometry.

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Poster Presentation

THIN FILM SENSORS BASED ON 10% ZrO_2 - 90% TiO_2 MATERIAL FOR THE DETECTION OF OXYGEN: EFFECT OF CRYSTALLIZATION CONDITIONS

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Abstract

The target of this research was to develop low power consuming oxygen sensors with low operation temperature, development of materials for these sensors and of the sol-gel method of synthesis and deposition of thin nanostructured films of 10 mol. % ZrO_2 - 90 mol.% TiO_2. For the fabrication of 2D-materials with different nanostructure, particle size, and phase composition, we used various conditions of thermal treatment. The effect of these parameters to the oxygen sensitivity was studied.

Heteroligand complexes related to the class of alcoxyacetylacetonate of appropriate metal having required hydrolytic activity were synthesized as precursors [1]. The thin films were deposited on ceramic substrate with platinum interdigitated electrodes and heater meander using dip-coating method; the rate of substrate extraction was of 1 mm/s. The precursor was hydrolyzed using humidity of air. After this, the substrates were stepwise dried at temperature of 20 - 100ºC. This process led to the formation of xerogel.

Crystallization of oxide films was performed by thermal treatment at different temperatures (500, 750ºC) during 1 and 5 hour in air. To get high-porosity oxide films, some samples were preliminarily treated in inert atmosphere at 750ºC. This treatment leads to the formation of “oxide nanoparticles in carbon matrix”; further removal of carbon matrix was carried out by calcinations in oxygen containing atmosphere at 500ºC. Average size of 10 mol.% ZrO_2 - 90 mol.% TiO_2 crystallites was in a range 5 - 20 nm. Microstructure of ceramic nanostructured films was studied using SEM and AFM methods, increase in annealing temperature and annealing duration leads to growth of particles. Phase composition and crystallite size were investigated using XRD method. It was shown that temperature, duration of thermal treatment, and composition of gas phase during annealing affect considerably phase composition of the film. For example, an increase in crystallization temperature from 500 to 750°C leads to appearance of reflex corresponding to rutile phase, which predominates over anatase phase. On the other hand, the sample containing thin nanostructured films of 10 mol.% ZrO_2 - 90 mol.% TiO_2, which were treated in two stages (first stage - treatment in argon, then treatment in air) were x-ray-amorphous.

It was shown that thermal treatment affects the response of 2D nanomaterials to oxygen. An increase in temperature and duration of annealing leads to a decrease in sensor response $\Delta R/R_0$ to oxygen (working temperature of 350°C) from 95 to 70% (when crystallization temperature increases from 500 to 750°C, at annealing time of 1 h) and from 95 to 75% (when crystallization temperature increases from 500 to 750°C, and annealing time increases from of 1 to 5 h).

It was found that the introduction of 10 mol.% of ZrO_2 improves the stability of semiconductor sensor compared to pure titanium dioxide, but does not lead to increase in working temperature equal to 300-350ºC. For the most porous sample, sensor response $\Delta R/R_0$ is of 50-60 %. The sensors based on these materials are prospective as well for the detection of ethanol.

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Poster Presentation

A COMPARISON OF SPECTROMETRIC METHODS AND METHODS BASED ON ELECTROCHEMICAL PRINCIPLES

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Abstract

Gas detection systems are an important tool for the prevention of accidents, and mitigation of their impact on human life and health. The ideal sensor is selective and has fast, stable and repeatable response to a particular analyt. Over the time it has been shown that various detection principles have led only to partial fulfillment of this ideal. Compromises have to be made according to desierd application of the sensor and resulting demands on the sensor parameters, including its price.

In this study, the static and dynamic properties of semiconductor, electrochemical and tunable diode laser based sensors are evaluated and compared. These parameters includes the selectivity, sensitivity and the response time. The sensors are tested with selected chemicals (VOC - volatile organic compounds – toluene and xylenes). The advantages and disadvantages are summarized and the possibilities of their use are discussed.

Spectrometry based detection techniques are rapidly expanding along with the emerging technical capabilities. The progress in Tunable Diode Laser Absorption Spectroscopy (TDLAS) leads to the development of detection system with good reliability, superior response time, high accuracy even at very low concentrations of gases (ppb) and reasonable price. Electrochemical sensors are used primarily in the measurement of oxygen and low concentrations of toxic gases. They are characterized by very good selectivity relatively to semiconductor sensors. The disadvantage is limited lifetime, cross-interference and the possibility of damage due to the high concentration of gas. Semiconductor sensors detect a broad spectrum of gases. They have very long lifetime, they can detect both low and high concentrations of gases, the key advantage is its very low price. Their disadvantage is particularly strong dependence on humidity, temperature and flow, as well as poor selectivity. However with proper mathematical analysis of required signals, the selectivity can be significantly enhanced. These mathematical methods use all possible information from the signal, including its time profile. We envision, that the combination of spectroscopy based sensor with cheap semiconductor or electrochemical sensors can lead to further selectivity enhancement with negligable increasement of the sensor system´s price.

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Poster Presentation

GAS DETECTION BY QUARTZ ENHANCED PHOTOACOUSTIC SPECTROSCOPY

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Abstract
Photoacoustic spectroscopy (PAS) is a detection method in which the light source energy is converted to sound,[1] subsequently the sound captured by microphone. This method can be used for quantitative chemical analysis at ultra-low concentrations of gaseous species or samples with low absorption coefficient.
Quartz enhanced photoacoustic spectroscopy (QEPAS) replaces the classical conventional microphone and enables rapid and highly sensitive detection of trace gas concentrations, when using quartz tuning fork (QTF) with a high Quality factor.[2] Tunable quantum cascade laser (QCL) partly covering acetonitrile infrared spectra[5] was employed in this study as an excitation source for QEPAS.

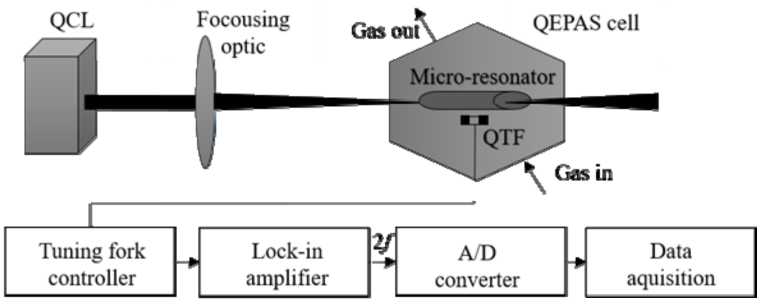

Figure 1 experimental setup

Vapor of acetonitrile was used as measuring gas. From the practical point of view this gas is of importance as a marker of explosive compounds such as trinitrotoluene (TNT) and hexogen (RDX)[3], or it can be released into the atmosphere during combustion of biomass[3]. Case specific design of the photoacoustic cell and experimental setup for the purposes of QCL-QEPAS detection is finally reported within this work.

The authors are grateful for the financial support from Project No. 14-14696S funded by the Czech Science Foundation and Project No. LD14022 within the COST action TD 1105 funded by the Ministry of Education, Youth and Sports of the Czech Republic.

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Poster Presentation

MEASUREMENT OF PM2.5 CONCENTRATIONS IN INDOOR AIR USING THE LOW-COST SENSORS AND ARDUINO PLATFORMS

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Abstract

The aim of this research was to investigate the comparability between the indoor $PM_{2.5}$ mass concentrations measured simultaneously with the Sharp GP2Y1010AU0F [1] sensors that are attached to Arduino platforms and light scattering monitoring instrument OSIRIS (Turnkey Instruments, Model 2315) [2]. The research was conducted in the period from 1 May to 31 August 2016 in the laboratory at the Mining and Metallurgy Institute Bor, Serbia. Two independent measurement systems were formed. They consisted of the Sharp GP2Y1010AU0F sensors and Arduino microcontroller platforms. The temperature in the laboratory was maintained in the range of 24-29 °C and relative air humidity within the limits of 50-60% in order to reduce the influences of these parameters on measurements. The results of Sharp sensor measurement (simultaneous measurement of 3 Sharp sensors connected on two Arduino platforms) were compared with the readings of OSIRIS monitor. OSIRIS monitor has been calibrated weekly with the reference gravimetric method (LVS3 gravimetric sampler with $PM_{2.5}$ sampling head was used). We have compared $PM_{2.5}$ concentrations over the whole period of the measurements (15-min averages, Osiris vs Sharp).

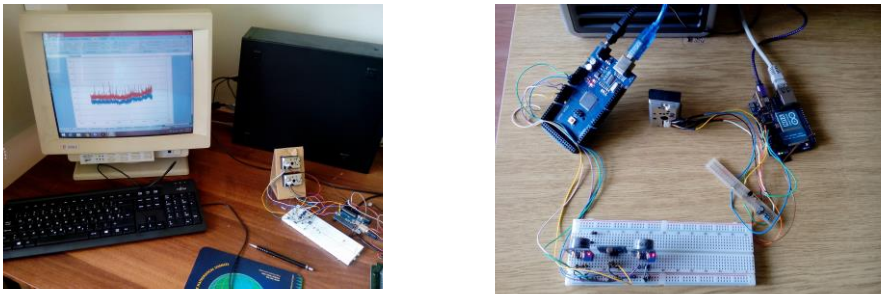

Figure 1. Sharp $PM_{2.5}$ sensors connected on Arduino platforms (S1 and S3 on the left, S2 on the right)

Table 1. The regression equations and coefficients of determination (Y-Sharp, X-Osiris)

Sensor	Regression equation	Coefficient of determination (R^2)
S1	Y=0.233*X+5.01	0.71
S3	Y=0.237*X+4.58	0.58
S2	Y=1.230*X+2.09	0.90

Analysis of the results shows that there is a strong positive correlation between the averaged 15-minute $PM_{2.5}$ concentrations obtained with Sharp sensors and Osiris monitor. Arduino platform has demonstrated remarkable stability during the experiment. Further work will be focused on examining the effect of temperature and air humidity on the measurement results.

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Poster Presentation

NOVEL GRAPHENE CANTILEVERS EMPLOYED IN PHOTOACOUSTIC SPECTROSCOPY FOR MULTICOMPONENT ANALYSIS OF ACETIC ACID

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Abstract

The detection and spectroscopy of acetic acid is of great importance in many fields, including breath analysis, catalysis, atmosphere monitoring and astrophysical research[1,2,3,4]. Herein, we present the attempt of spectral multicomponent analysis of acetic acid in the mixture of acetone and methanol.

Two different approaches are presented and compared – photoacoustic spectroscopy with discretely tunable CO2 laser emitting at rotation-vibration transitions of CO2 in the spectral range of 9-11 μm, and tunable diode laser absorption spectroscopy (TDLAS) using mid infrared Quantum Cascade Lasers (QCL) emitting around 10,6 μm. The results are compared. The measurements were carried at room temperature, where the acetic acid is known to be mixture of monomers and dimers. The -OH bending of acetic acid dimer centered around 10,5 μm have been used for its detection[5].

Photoacoustic spectroscopy is a powerful technique for the detection of trace concentrations of gases especially with combination with high power laser sources like CO2 lasers. Graphene cantilevers have been employed in photoacoustic spectroscopy as a part of an optical microphone in order to enhance the sensitivity of this method and we have managed to overcome the sensitivity of a commercial top class microphone with a potential low cost detector. The photoacoustic spectroscopy with the developed detector has been used for the multicomponent analysis. Although the photoacoustic spectroscopy in combination with CO2 laser yields good sensitivity, the experimental arrangement is quite bulky and not suitable for field measurements. On the other hand, QCL lasers have the potential to be incorporated into compact, easy to use analyzer with high selectivity and sensitivity.

The authors are grateful for the financial support from Project No. 14-14696S funded by the Czech Science Foundation and Project No. LD14022 within the COST action TD 1105 funded by the Ministry of Education, Youth and Sports of the Czech Republic.

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Poster Presentation

SIC-FET BASED NO_X SENSOR FOR AUTOMOTIVE APPLICATIONS

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Abstract

We have investigated the sensing properties of gas sensitive silicon carbide based field effect transistors (SiC-FET) for monitoring the concentration of nitrogen oxides (NO, NO_2) in combustion engine exhausts[1]. Due to their NO_x storage properties, catalytic thin films consisting of strontium titanate ($SrTiO_3$) were chosen. $SrTiO_3$ was deposited by pulsed laser deposition (PLD) at 600°C . Gas exposures to NO, NO_2, and interference gases NH_3, and CO were performed and it was found that NO_2 could be detected with good accuracy and repeatability in the single digit ppm range over a sensor temperature span from 540°C to 600°C, which are temperatures suitable for the intended application. The sensor response is affected by operating temperature, with higher temperature producing larger response.. Suppression of interfering gases (mainly NH_3) is possible at around 530°C sensor surface temperature.

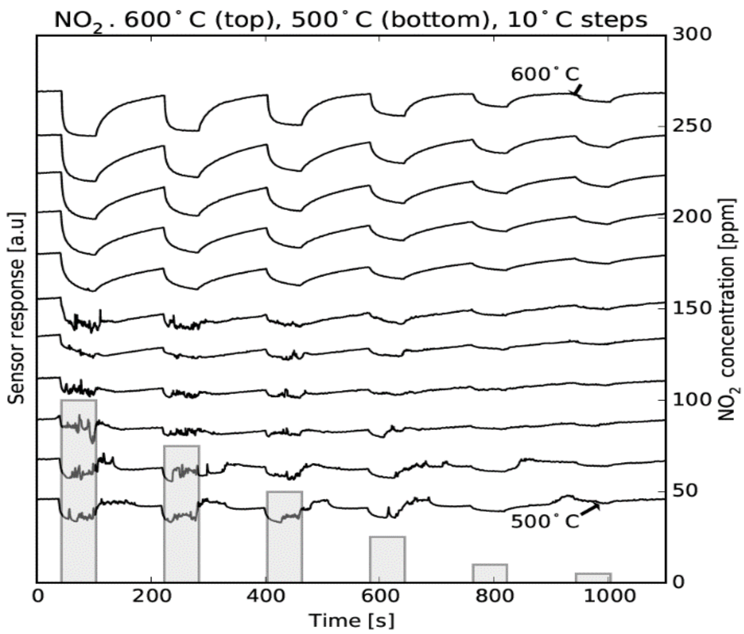

Figure 1. Sensor response to NO_2 at temperatures ranging fromt T = 500 °C – 600 °C

References

P. Möller, M. Andersson, A. Lloyd Spetz Jarkko Puustinen, Jyrki Lappalainen, and J. Eriksson, *Materials Science Forum* **858** (2016) 997-1000

Poster Presentation

THE DYNAMICS OF VISCOELASTIC LAYERED SYSTEMS STUDIED BY SURFACE ACOUSTIC WAVE (SAW) SENSORS

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Abstract
Acoustic sensors have been used for bio-sensing in liquid conditions. A typical application is the probing of biological layers formed by the deposition of e.g., proteins, lipid vesicles, or cells, from a liquid onto a sensing surface. For a quartz crystal microbalance (QCM), there is a shift in the resonance frequency and, for viscous deposits, a dissipation of vibrational energy [1]. Analogously, for a surface acoustic wave (SAW) sensor, the phase velocity of the waves is shifted and the waves might attenuate due to viscous losses. Measuring the velocity shift and the attenuation can provide information about the nature of the deposited mass, allowing for ultra-sensitive mass measurements or determination of material parameters, such as shear modulus or viscosity. However, a correct interpretation of the measurement data rests on a theoretical basis, and e.g., operating an acoustic sensor in a liquid and neglecting the viscoelastic coupling of the liquid and the deposit softness (viscoelasticity) can lead to an underestimation of the deposited mass, a “missing mass” effect [1,2]. We consider a theoretical model of a SAW sensor consisting of two viscoelastic layers on top of an infinitely deep elastic substrate (fig. 1; the SAWs are shear horizontally polarized). We use continuum viscoelasticity theory to derive a dispersion equation, and using this we can numerically calculate and plot the phase velocity shift and wave attenuation for different cases, as well as present analytical expressions for these quantities in a limiting case.

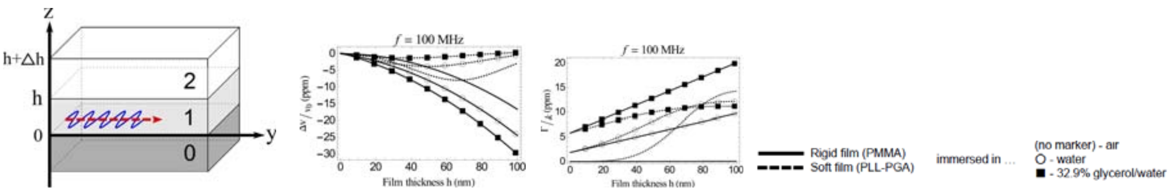

Figure 1. A theoretical model of a SAW sensor, consisting of three layers, each of infinite extent in the xy-plane. The substrate layer (0) is infinitely deep. The red arrow indicates the direction of wave propagation and the blue sinusoidal line the shear displacement. Numerically calculated phase velocity shift Δv/v (left) and scaled attenuation coefficient Γ (right) for quartz covered by two different films in different fluids, vs film thickness.

We perform numerical calculations for a range of film thicknesses, comparing rigid (elastic) and soft (viscoelastic) films immersed in different fluids (see plots, fig. 1). We found that for acoustic sensors with soft films in viscous/viscoelastic fluids, it is necessary to account for the viscoelastic coupling between the layers.

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