EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY

EuNetAir COST Action TD1105

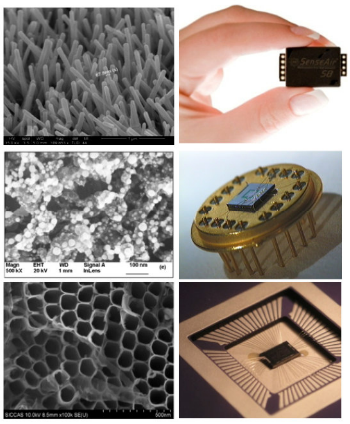
European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability

The main objective of the Action is to develop new sensing technologies for Air Quality Control (AQC) 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.

Abstract

This Action will focus on a new detection paradigm based on sensing technologies at low cost for Air Quality Control and set up an interdisciplinary top-level coordinated network to define innovative approaches in sensor nanomaterials, gas sensors and devices, wireless sensor-systems, distributed computing, methods, models, standards and protocols for environmental sustainability within the European Research Area (ERA). State-of-the-art 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 intensive coordination efforts to boost new sensing paradigms for research and innovation.

Only a close multidisciplinary cooperation will ensure cleaner air in Europe as well as 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. The objective 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 practises and to move towards global sustainability via monitoring climate change and outdoor/indoor energy efficiency. Establishment of such a network, involving COST country participants as well as non-COST key-experts, will enable Europe to develop world capabilities in urban sensor technology based on cost-effective nanomaterials, to form a critical mass of researchers suitable for cooperation in science and technology, to give training and education, to coordinate outstanding R&D, to promote innovation towards industry, and to support policy-makers.



Keywords:

- Sensor functional materials
- Nanomaterials and sensing nanostructures
- Gas sensors and wireless sensor-systems with distributed computing
- Air quality control/monitoring and environmental measurements/modelling
- Protocols and standardisation methods for environmental sustainability and chemical weather forecasting

Working Groups

WG1: Sensor materials & nanotechnology
WG2: Sensors, devices & systems for AQC
WG3: Environmental measurements & air-pollution modelling
WG4: Protocols & standardisation methods

Participating COST Countries and Institutions:

A: *Materials Center Loeben Forschung GmbH*
BE: *University de Liège; VITO; Odometric SA; University Catholique de Louvain*
BG: *Bulgarian Academy of Sciences; Mircosystems LTD*
CH: *Ecole Polytechnique Federale de Lausanne; ETH; EnvEve SA; EMPA Swiss Federal Laboratories for Materials Science and Technology; SGX Sensortech*
CZ: *Academy of Sciences of Czech Republic; Institute of Photonics and Electronics*
DE: *IUTA; Alfred Becker GmbH; 3S GmbH; Saarland University; University of Bayreuth; University of Paderborn; UST GmbH; MPI for Biogeochemistry; Eurice GmbH; WHO CC; Siemens; University of Stuttgart; Heidelberg University; BAM; DLR*
DK: *Aarhus University; Technical University of Denmark; National Research Center for Working Environment*
EL: *Aristotle University; FORTH; ISI-ATHENA; University of Piraeus; University of Patras; University of West Macedonia*
ES: *IREC; CSIC; University Rovira i Virgili; University of Barcelona; Worldsensing SL; Public University de Navarra; University de Santiago de Compostela*
EST: *University of Tartu*
FI: *University of Oulu; University of Helsinki; Tampere University of Technology*
FR: *University de Bourgogne; University Blaise Pascal; Ecole des Mines de Douai; CEA-CNRS; ETHERA; Nano-Sense*
HR: *Rudjer Boskovic Institute; University of Zagreb*
HU: *Hungarian Meteorological Service; Szechenvi Istvan University*
IE: *Trinity College Dublin; University College Cork*
IL: *AirBase Systems: Technion Institute of Israel*
IS: *Agricultural University of Iceland*
IT: *ENEA; ELETTRA; University of Bari; Lenviros srl; Sensichips srl; University of Brescia; University of Trieste; ARPA-Puglia; RED srl; NOVASIS srl; ARIANET srl; CNR*
L: *Luxembourg Institute for Science and Technology*
LV: *University of Latvia; Riga Technical University*
MK: *Ministry of Environmental and Physical Planning; University St. Kliment Ohridski*
NL: *IMEC; ECN*
NO: *NILU Norwegian Institute for Air Research*
PL: *Silesian University of Technology; Warsaw University of Life Science; Czestochowa University of Technology*
PT: *University of Coimbra; IDAD Institute of Environment and Development; National Health Institute; University of Lisbon; University of Aveiro; University of Porto; LNEG*
RO: *National R&D Institute for Nonferrous and Rare; SC IPA SA*
SE: *Chalmers University of Technology; Linkoping University; SenseAir AB; SenSiC AB*
SI: *Aerosol doo; University of Ljubljana*
SRB: *Institute of Public Health of Belgrade; VINCA Institute*
TR: *GEBZE Institute of Technology; Middle East Technical University of Ankara; Nidge University; Bahcesehir University*
UK: *Alphasense Ltd; Cambridge CMOS Sensors Ltd; Imperial College London; Newcastle University; University of Manchester; University of Warwick; University of Cambridge; University of Edinburgh; Worcester University*

Non-COST Participants:

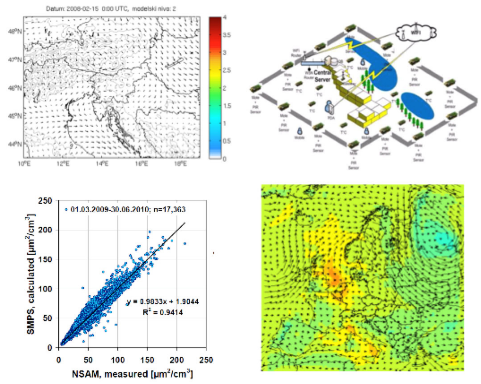
Australia: *CSIRO*
Canada: *University of Waterloo*
China: *Chinese Academy of Sciences*
Morocco: *University of Agadir IBN Zohr*
Russia: *National Research Center Kurchatov-Institute*
Ukraine: *O.M. Marzeiev Institute for Hygiene and Medical Ecology of Academy of Science of Ukraine*
USA: *NASA Ames Nano Research Center; Southern Illinois University Carbondale*

Objectives

The aim of the Action is to form a European-wide science and technology knowledge platform by a multidisciplinary coordinated network at international level on the new sensing technologies for Air Quality Control including sensor nanomaterials, portable wireless sensor-systems and distributed computing, air-quality modelling and chemical weather forecasting, standards, methods and protocols for environmental measurements in order to advance R&D and innovation in the European green-economy by strengthening the sustainable development in smart cities, outdoor air-pollution control and indoor energy efficiency in buildings and to foster the technology transfer of the new sensing paradigm of the cost-effective chemical sensors in the European countries with a special focus on SMEs.

Action Details – Action Fact Sheet:

Memorandum of Understanding (MoU)	oc-2011-1-9706
CSO Approval date	01 December 2011
Kick-off Meeting of Action TD1105	16 May 2012
Start of Action	1 July 2012
Entry into force	09 January 2012
End of Action	15 May 2016
Extension of Action	15 November 2016
Period of Action	4 years



Participants of COST Action EuNetAir

At the moment of approval of the Action, 51 big institutions from **17 European Countries** (*Belgium, Bulgaria, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Lithuania (pending), Netherlands, Poland, Slovenia, Spain, Sweden, Switzerland and United Kingdom*) participated in the preparation of the proposal. The Action spans largely across the European Union including a wide geographical coverage and other Countries, such as Norway, Iceland, Latvia, Romania, and Turkey, that signed MoU after its approval from CSO.

At the Kick-off Meeting (May 16th, 2012), **21 COST countries** were participants in the COST Action TD1105 by involving 60 research teams from COST area (Europe-zone).

At the 6th MC Meeting (Istanbul, December 5th, 2014), **29 COST Countries** were participants in the COST Action TD1105 by involving 90 research teams from COST Countries, Near Neighbour Countries (Morocco, Russia, Ukraine) and International Partner Countries (Australia, Canada, China, USA).

At the date of November 2016, **31 COST Countries** (*Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Luxembourg, Former Yugoslav Republic of Macedonia, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom*) with 123 partner institutions are involved in EuNetAir. The Action participants are from *55 universities (44%)*, *39 research centres (32%)*, *4 environmental agencies* (*3%*) and *25 SMEs* (*21%*) including *9 spin-offs (8%)*. Additional eight top-level institutions from **7 Non-COST Countries** (Australia, Canada, China, Morocco, Russia, Ukraine, USA) are involved in the Action.

Non-COST participation

CSIRO Materials Science and Engineering (Australia)

CSIRO focuses on the application of carbon nanotube structures in the form of forests, webs and spun yarns as potential robust and cost effective gas sensing elements and the optimization of these sensors by functionalization. The exchange of knowledge on in the area of nanotechnology and the development of highly sensitive gas sensors are the benefits for CSIRO and TD1105.

University of Waterloo (Canada)

The research trust is to develop nanotechnology based solid-state sensors that are well-suited for harsh environment. The expertise is on the understanding / modeling / designing of all aspects of functional micro/nanosystems with integrated nanomaterials and assembled circuits for AQC sensor application. An additional benefit is the access to a novel Nano/Quantum facility with clean room.

Chinese Academy of Sciences (China)

The expertise is based on nanomaterials and 1D oxide nanostructures for gas sensors, LTCC materials and devices for miniaturized wireless sensing systems. The goal is the development of innovative chemical sensors and sensor systems for AQC with high performance at low power consumption and low cost combining nanostructures, low power consuming nanosensors and wireless gas sensors.

University of Agadir IBN Zohr (Morocco)

We we are working on pollution monitoring based on the inventory of different measured greenhouse gases within the regional government of Souss Massa in the south of Morocco. Our objective is to build an environmental and air pollution model to predict local pollution scenarios. The measurement for the moment is performed by a set of physico-chemical analyzers of a mobile laboratory in specific hot-spots and in the large of the region. In the same time, we aim to have fixed stations on specific points using gas sensors based on new nanomaterials. We are open for the exchange of knowledge and the development of such areas, which would be of great benefit for the EuNetAir project.

National Research Center Kurchatov Institute (Russia)
The benefit of the cooperation is the development of new types of instruments for air quality control on basis of the knowledge on nanostructures and nanomaterials for gas and chemical sensors. The experience is on the kinetics of heterogeneous processes on the interface between nano-particles and gas to develop new approaches for selective sensors including ceramic MEMS platforms for fast heating.

O.M. Marzeiev Institute for Hygiene and Medical Ecology of Academy of Science of Ukraine (Ukraine)
The activities of the Institute focus on the emerging issues of the environmental health, medical ecology, problems of the public health protection from the hazardous effects of anthropogenic environmental factors of the various nature and control improvement over this factors. The main goals of Air Quality Unit is the development of National air quality regulations and standards; control of outdoor/indoor air quality; improvement of the National air pollution monitoring network; existent air sampling testing techniques and air pollution dispersion modelling; human health exposure and risk assessment.

NASA Ames Nano Research Center (USA)
Their experience is on system development of gas nanosensors for AQC application, on nano-micro-macro integration, sensor network and protocols, and field tests on ground and in space. Applied materials are carbon nanotubes, graphene and inorganic nanowires. The idea is to have sufficient physical / chemical variation between sensors to construct a functional electronic nose.

Southern Illinois University Carbondale (USA)
The expertise is on nanowire based gas sensors and knowledge about new principles of gas sensing with novel nanostructures and material shall be accumulated. The focus is on the fundamental interplay between surface reactions (by surface spectromicroscopy) and bulk electron transport in 1D metal oxides at macroscopic level and even in operando mode in real time.

Working Groups

WG1: Sensor materials & nanotechnology

WG1 Leader: Prof. Juan Ramon Morante, IREC Catalonia Institute for Energy Research, Spain;
WG1 Vice-Leader: Prof. Jyrki Lappalainen, Oulu University, Finland

WG1 efforts will focus on sensor materials and nanotechnology including advances and recent trends to develop and utilize sensors fabricated mainly by metal oxide (MO) polycrystalline films utilizing among others two of the most intensively studied techniques, aerosol spray pyrolysis and DC magnetron sputtering. The influence of the grain size and the surface morphology achieving sensing responses of the order of a few ppb for gases (e.g. ozone) at room temperature will be emphasized. Studies of the sensitivity of MO films towards additional harmful gases (like NO_2, H_2 and vapours of acetone) will provide a guide for further material and device development either on glass, ceramic, silicon or flexible substrates. Flexible substrates (PET/PEN) may lead to simpler, faster and inexpensive fabrication techniques targeting novel roll-to-roll and printed processing applications with obvious advantages over conventional technologies. Sensor responses will be studied by applying conventional conductometric techniques or specific low to medium frequency surface acoustic wave (SAW) devices which have shown high sensitivity towards electrical perturbations caused by the gas interaction at their active surface. Other advanced transducers (MEMS, NEMS, cantilevers, optical fibres, field effect transistor, electrochemical devices, etc.) will be studied as well. Another important class of sensor materials to be considered are carbon-based nanomaterials. They are very sensitive to different air-pollutants even at room temperature for developing wireless gas-sensors at low-power consumption. Functionalization with metal nanoclusters and surface-modifications are very challenging for addressing high sensitivity and broad selectivity.

Objectives

- Protocols for synthesis of gas-sensitive nanomaterials
- Protocols for synthesis of functionalized nanostructures for enhanced gas detection at ppb level, stability and selectivity
- Assessment on nanomaterials characterization for AQC gas sensors
- Protocols for integration of nanomaterials into micromachined devices and gas sensors
- Protocols for development of gas nanosensors, microsensors and sensors-array

WG2: Sensors, devices & systems for AQC

WG2 Leader: Prof. Andreas Schütze, Saarland University, Germany

WG2 concentrates on research for design, fabrication, testing and functional characterization of new cost-effective sensor-systems at level of proof-of-concept for enhanced air-pollutants detection up to trace levels by means of laboratory experiments and in field campaigns. Advanced transducers (chemoresistors, electrochemical, field effect transistor (FET), surface acoustic wave (SAW), quartz crystal microbalance (QCM), optical fibres, micro-electro-mechanical-systems (MEMS), nano-electro-mechanical-systems (NEMS), cantilevers, hybrid transducers, etc.) will be employed for high-performance environmental sensors with new functionalities of advanced electronic interfaces and wireless communications at low-power consumption. Smart devices with pattern recognition algorithms and artificial neural networks will be designed and developed. Microsensors and nanosensors at low-cost and low-power consumption are expected to be integrated in a distributed wireless sensor network at high spatial resolution with distributed computing in the multiple nodes for accurate measure of concentration of air-pollutants in real scenario. The usage of fully autonomous systems for gas sensing becomes a challenge from technological point of view as well as for budgetary reasons. These depicted main research tasks will be studied via qualified manpower of the COST Action partners and investigated by their operational systems.

Objectives of WG2:

- Protocols for fabrication of gas sensors
- Protocols for integration of nanostructures and nanomaterials into AQC gas sensors
- Protocols for design and implementation of new transducers for AQC gas sensors
- Assessment on device characterization for AQC gas sensors
- Assessment /Protocols for integration of portable gas sensor-systems for AQC
- Assessment on integrated intelligence of AQC gas sensors and distributed computing
- Protocols for development of wireless sensors network for AQC
- Assessment on IP Rights of gas nanosensors for AQC

WG3: Environmental measurements & air pollution modelling

WG3 Leader: Prof. Ole Hertel, Aarhus University, Denmark

WG3 will initiate and coordinate a European measure program including studies on innovative, continuous and automated environmental measurement and on air-pollution (NO_x, CO, SO_2, CO_2, O_3, BTEX, PAH, PM_{10}, $PM_{2.5}$, PM_1, etc.) modelling in specific hot-spot and large areas located in European countries. In order to meet the needs of these new air quality monitoring approaches, new measurement and analytical techniques need to be developed and tested. In a second stage, the new instruments and sensors should be subject to inter-comparison exercises which will guarantee the comparability of their results with regard to the reference methods currently in force. Such instrument tests and inter-comparison exercises should be carried out on a European scale in order to ensure the validity of the new air quality monitoring strategies in the different European regions. Harmonised air pollution monitoring in Europe will be addressed such as air quality research in urban, industrial, rural, and remote sites, including assessing of air quality plans.

Objectives

- Assessment of environmental measurements long-term campaigns by AQC gas sensors at laboratory experiments level
- Assessment of environmental measurements in field by AQC gas sensor-systems in the air quality stations
- Assessment of air-quality modelling with data assimilation from integrated AQC gas sensors
- Assessment on chemical weather forecasting at global area and hot-spot case-studies
- Evaluation of integrated air quality plans and strategies: role of low-cost AQC gas sensors
- Assessment of clean technologies and environmental management systems reducing the emission of air-pollutants, green-houses, particulate matter, aerosol, nanoparticles, etc.
- Assessment of new sensing technologies, including AQC gas sensors and wireless sensors network, for environmental management
- Assessment on harmonisation of environmental measurements in EU-zone and non-COST areas
- Assessment on IP Rights of air-quality modelling and chemical weather forecasting

WG4: Protocols & standardisation methods

WG4 Leader: Prof. Ingrid Bryntse, SenseAir AB, Sweden

WG4 will deal with procedures, protocols and pre-standardised methods for low-cost sensor-systems applied to AQC. These include:

- Performance of partner-developed and available sensors/instruments for measuring air pollutants (regulated in Air Quality Directive 2008/50/EC)
- Study and assessment of protocols and methods devoted to low-cost gas sensors for AQC with definitions of guidelines for standards
- Air quality case studies
- Benchmarking with official methods
- Round-robin of procedures and tests for AQC sensors
- Reference materials for AQC
- Assessment of gas sensors in well-characterized (industrial and natural) environmental situations
- Indoor air quality monitoring
- Assessment of physical and chemical characterization of nanomaterials and ambient particles
- Assessment of measurement and exposure metrics in view of future use in ambient air quality assessment

Originality of this COST Action consists in the definition of a new measuring paradigm of air pollution real-time pre-standardised control based on a new generation of low-cost ubiquitous smart microsensors integrating functional nanomaterials for a distributed map of urban air-pollution at high-resolution. Actually, the AQC sensors are not yet standardized in certified procedures of measurements and protocols. Currently, AQC is performed by standardised, expensive and bulky analysers.

Objectives

- Assessment of characterisation, quality assurance, quality control, property database, standardization of AQC gas sensors
- Assessment of testing, standard operation procedures, safety aspects for AQC gas sensors
- Evaluation of case-studies in round-robin testing of AQC gas sensors in odour-pollution, air pollution, indoor control, outdoor control
- Assessment /Recommendations of the new sensing AQC technologies for the future strategies in the EU research programmes of air quality monitoring and environmental management
- Assessment on scaling up, applications and commercialisation of AQC gas sensors

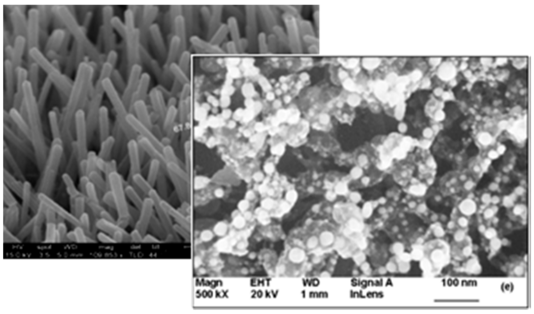
EuNetAir COST Action TD1105

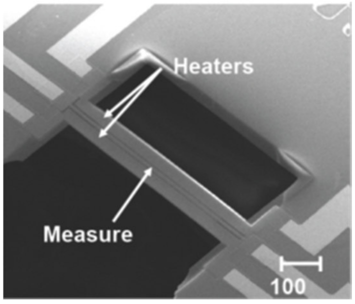
European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability

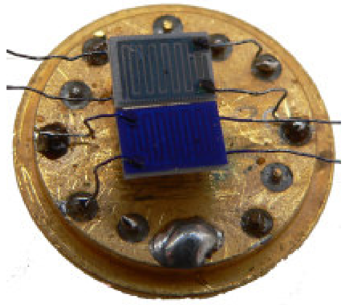
Research products from working groups

WG1: Sensor materials & nanotechnology

WG1 Leader: Prof. Juan Ramon Morante, IREC Catalonia Institute for Energy Research, Spain

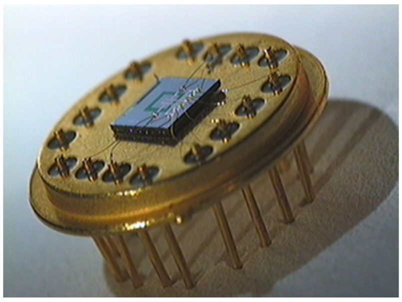


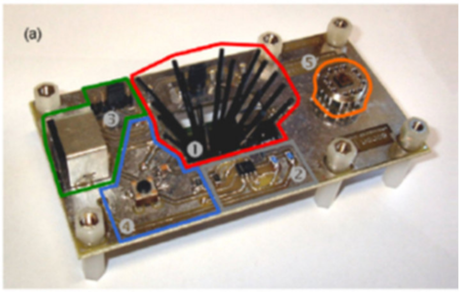




WG2: Sensors, devices & systems for AQC

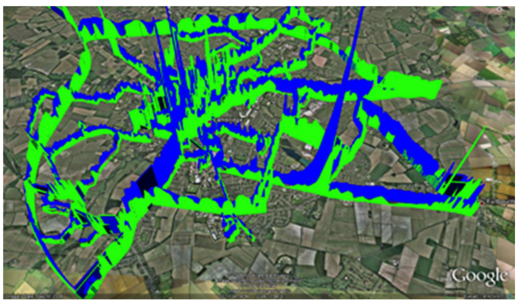
WG2 Leader: Prof. Andreas Schütze, Saarland University, Germany

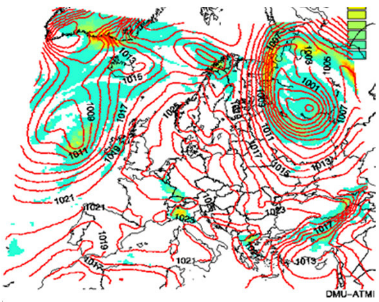


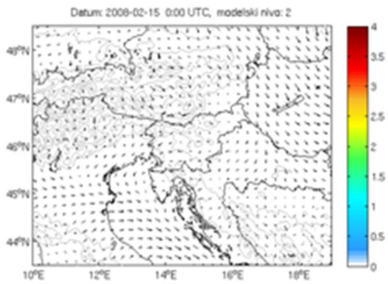


WG3: Environmental measurements & air pollution modelling

WG3 Leader: Prof. Ole Hertel, Aarhus University, Denmark

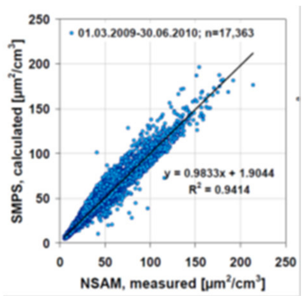


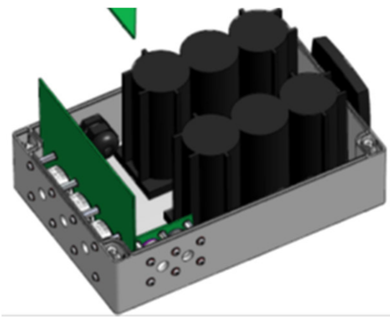




WG4: Protocols & standardisation methods

WG4 Leader: Prof. Ingrid Bryntse, SenseAir AB, Sweden





EuNetAir COST Action TD1105

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

Brochure COST Action TD1105 EuNetAir – Brochure Iss. 2/ Oct. 2016

Action Chair: Dr. Michele Penza, ENEA, IT - michele.penza@enea.it

Editor-in-Chief: Prof. Ralf Moos, University of Bayreuth, DE - functional.materials@uni-bayreuth.de

Editorial Board Manager: Dr. Daniela Schönauer-Kamin, University of Bayreuth, DE

Graphic design: Dr. Jaroslaw Kita, University of Bayreuth, DE and Dr. Fabio Galatioto, University of Newcastle, UK

COST website: **http://www.cost.eu/domains_actions/essem/Actions/TD1105?management**

Action website: **http://www.eunetair.it**