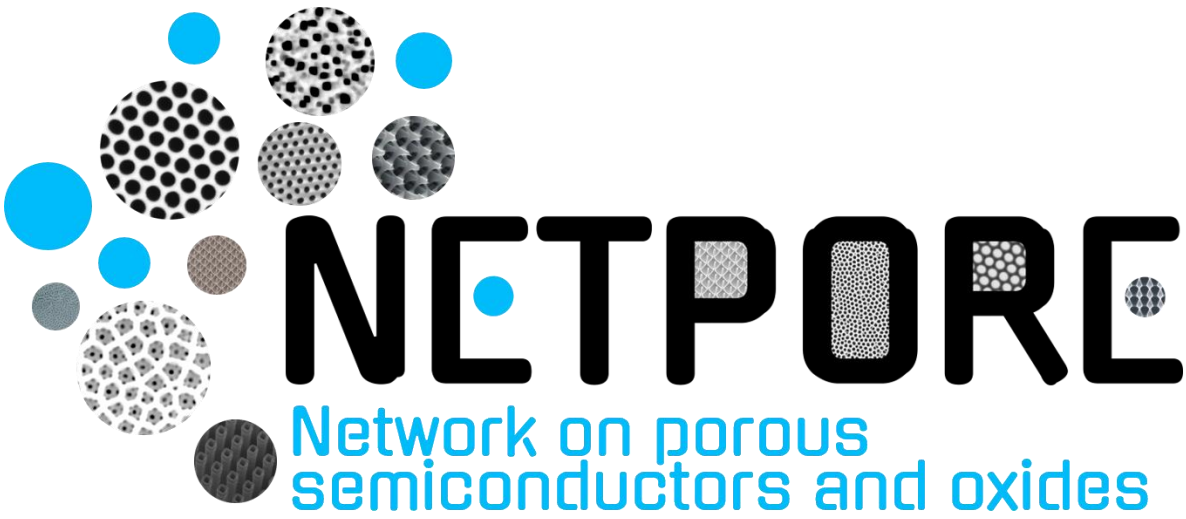


2nd NETPORE Training School Institute of Nanoscience and

Nanotechnology National Centre for Scientific Research “Demokritos”, Athens, Greece

17th to 20th July 2023

Applications of porous materials from sensing to energy and nanomedicine

Report

Organized by:

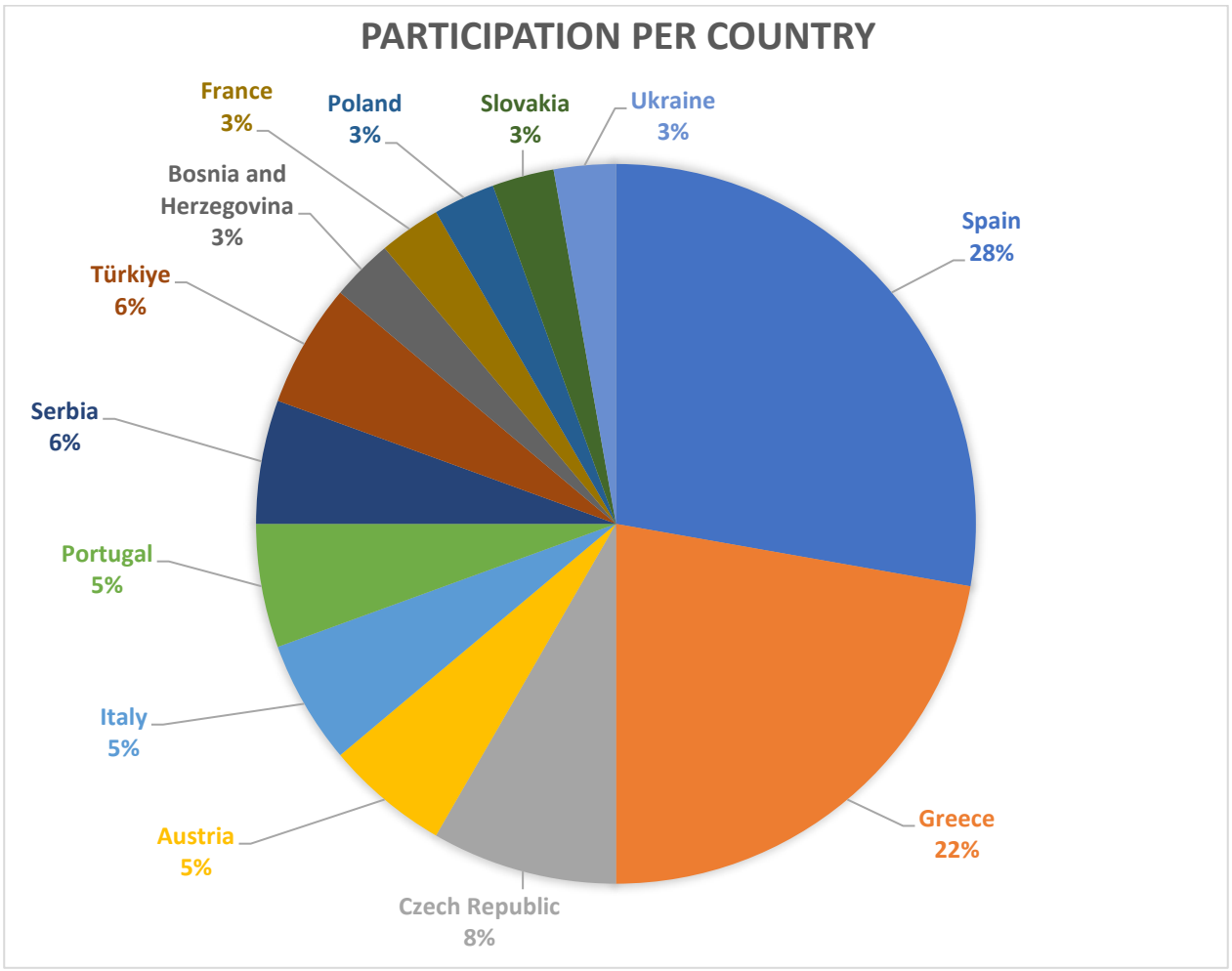
Christos Trapalis | Institute of Nanoscience and Nanotechnology National Centre for Scientific Research “Demokritos”, Athens

cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

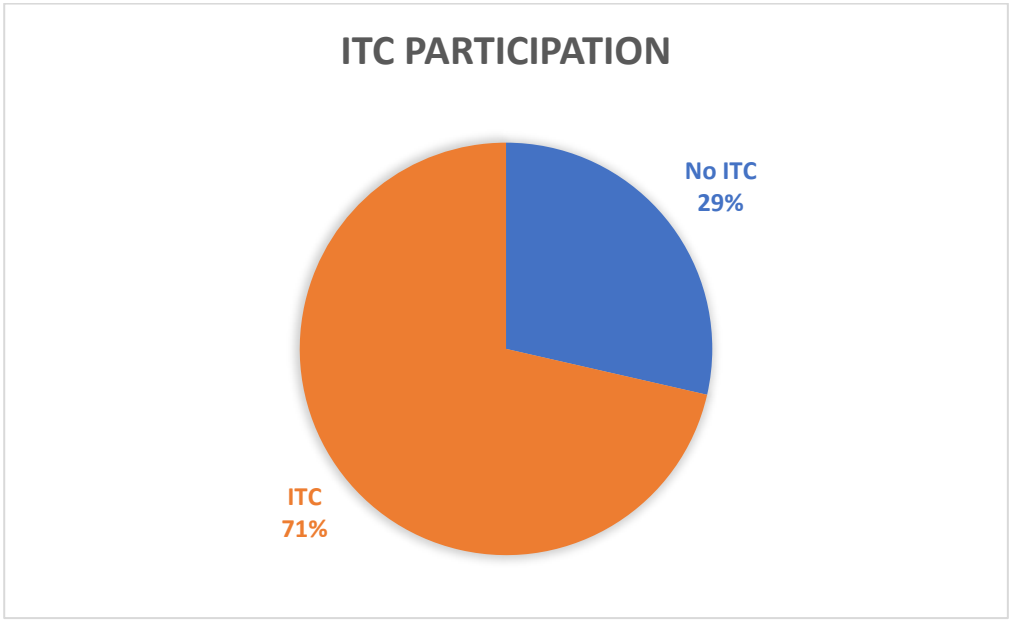
Funded by the Horizon 2020 Framework Programme of the European Union

DEMOKRITOS

Participants statistical analysis



TOTAL Participants: 35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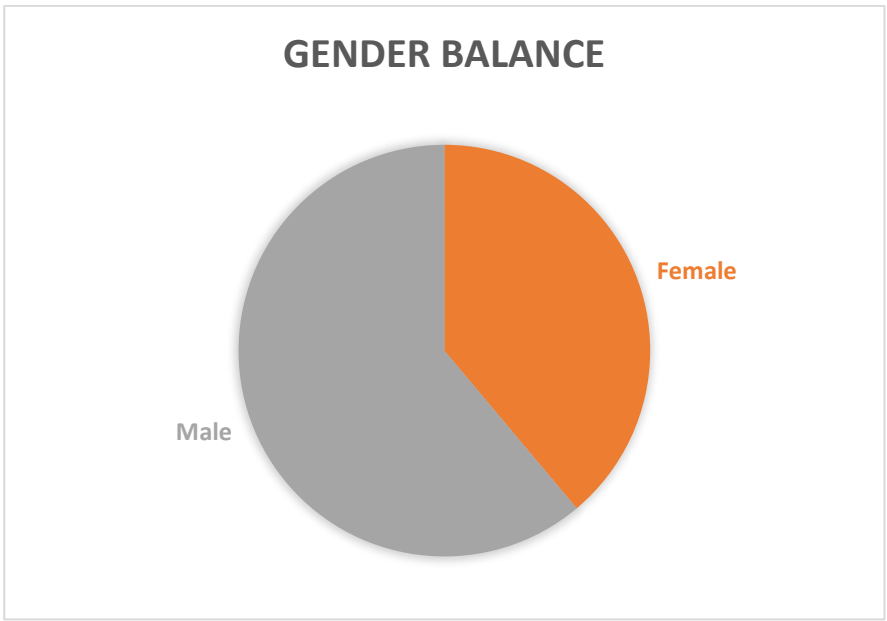
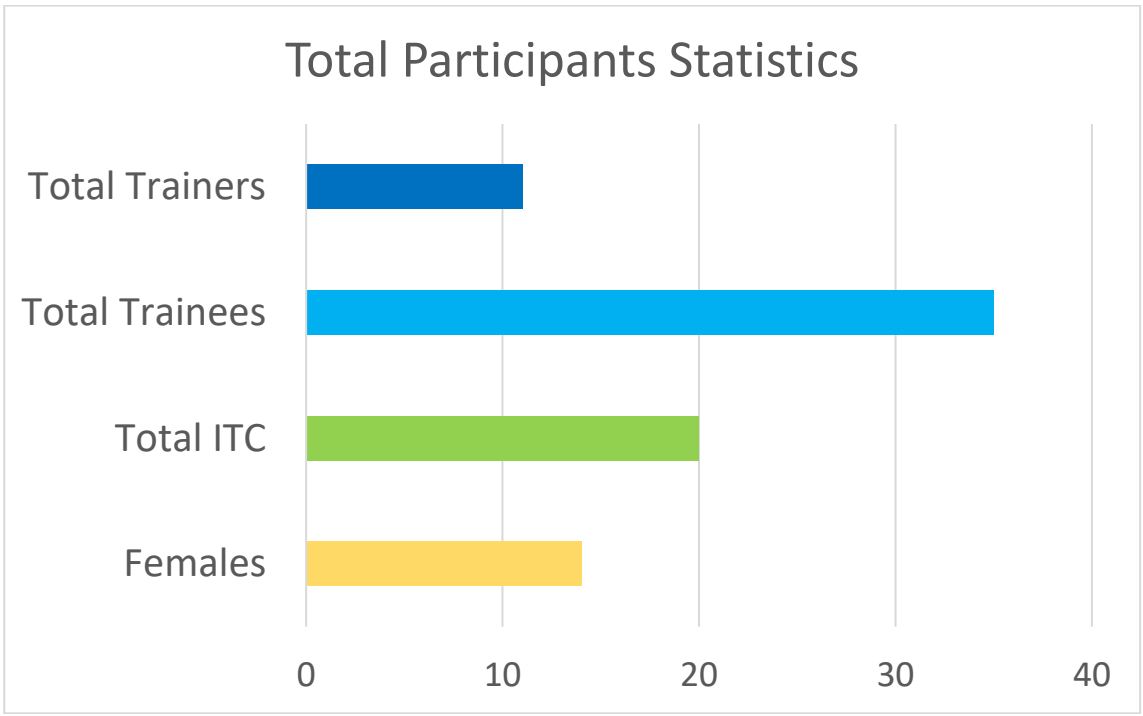
29%
ITC
71%


GENDER BALANCE
Female
Male



Program:

DAY 1 — Monday, 17th July 2023

12:30 LUNCH Congress Center (Institute of Nanoscience and Nanotechnology National Centre for Scientific Research “Demokritos”)

13:30 WELCOME (NetPore meeting room)

- **Christos Trapalis** | Institute Nanoscience and Nanotechnology (INN), Athens, Greece - Organizer
- **Lluis F. Marsal** | Universitat Rovira i Virgili, Tarragona, Spain - Cost Action Chair

15:00 Porous Anodic Alumina Preparation, Tuning of Optical Properties and Applications

Josep-Ferré Borrull | Universitat Rovira i Virgili, Tarragona, Spain.

16:30 COFFEE BREAK (Congress Center hall)

17:00 Magnetic filling of nanostructured silicon: a platform for biomedical, magnetic and optical materials (PART 1). A composite system to interlink magnetism, optics and biomedicine

Petra Granitzer | Physics Institute University of Graz, Austria.

18:00 Magnetic filling of nanostructured silicon: a platform for biomedical, magnetic and optical materials (PART 2). Mono- and bi-metal deposits to improve the magnetic performance of nanocomposites

Klemens Rumf | Physics Institute University of Graz, Austria.

19:00 DINNER

DAY 2 **Tuesday, 18th July 2023**

9:00 TiO2 nanotube layer synthesis and their utilization for sensing, biomedical and photocatalytic applications

Hanna Sopha | University of Pardubice, Czech Republic

10:30 COFFEE BREAK (Congress Center hall)

11:00 A Review of Pore configuration models. The Corrugated Pore Structure Model (CPSM) as a united theory for the interpretation of Mercury Intrusion-Extrusion and Nitrogen Adsorption-Desorption porosimetry measurements

Constantinos E. Salmas | University of Ioannina, Greece

12:30 LUNCH

14:30 Mesoporous silica nanoparticles: functionalization, characterization and applications for cancer sensing, therapy and imaging

Nikola Ž. Knežević| University of Novi Sad, Serbia

16:00 COFFEE BREAK (Congress Center hall)

16:30 PhD Students shart talks

17:30 Poster session (Congress Center garden)

20:00 SOCIAL DINNER ("Kalokerinos Tavern")

DAY 3 Wednesday, 19th July 2023

9:00 Porosimetry based on SEM image analysis: Challenges and recent advances

Vassilios Constantoudis | Institute of Nanoscience and Nanotechnology, NCSR "Demokritos", Greece

10:30 COFFEE BREAK (Congress Center hall)

11:00 From all-solid-state to stretchable Li-ion microbatteries using porous materials

Thierry Djenizian | Aix-Marseille University, France

12:30 LUNCH

14:30 Photo-activated nanostructured titanium dioxide, as a promising anticancer agent

Nefeli Lagopati | University of Athens, Greece

16:00 COFFEE BREAK (Congress Center hall)

16:30 PhD Students shart talks

17:30 Poster session (Congress Center garden)

19:00 DINNER

DAY 4 **Thursday, 20th July 2023**

9:00 Porous carbon based materials for electrochemical sensing of pesticides

Milan Z. Momčilović| University of Niš, Serbia

10:30 COFFEE BREAK (Congress Center hall)

11:00 Novel 2D Polymeric Photocatalysts for Environmental and Energy Applications

Christos Trapalis | Institute of Nanoscience and Nanotechnology, NCSR "Demokritos", Greece

12:30 CLOSING

Organizer

Christos Trapalis | NCSR Demokritos

Christos Trapalis, PhD, Chemical Engineer - Director of Research and Head of “Nanofunctional and Nanocomposite Materials Laboratory”, NCSR Demokritos. His scientific interests are focused on nanoscience and nanotechnology, carbon based materials, functionalized graphene and graphene oxide, 2D heterostructures, nanostructured powders and coatings, visible light active photocatalysts for NOx removal, water splitting, solar fuels, CO2 to nanocarbons conversion and hybrid organic–inorganic materials. Christos has taught “Physical Chemistry”, “Technology of Polymers”, “Technology of Glass and Ceramics” at HTEI Athens (1994-2004). He has been elected Prof. of “Advanced Materials” at the Department of Products Design Engineering, AEGEAN University (2004-8), but decided to continue the research activities at NCSR Demokritos. He taught also “Physical Chemistry” at the Hellenic Open University (2009-14) and “Anti-pollution Processes“(2015-now). During the last 15 years he participated in more than 20 research programs, coordinated more than 15 of them and raised for NCSR Demokritos more than 2,5 M€.

Christos is reviewer of more than 40 scientific journals with more than 140 publications in peer reviewed journals, 6100 citations, 6 patents, h-factor 41 and i10-index 84.

Invited Trainers

Josep Ferré-Borrull | University Rovira I Virgili, Spain

Josep Ferré-Borrull obtained his Physics degree in 1994, his B. Sc. in 1996 and his Ph.D in 1998, all of them at the Universitat de Barcelona. His doctoral thesis was in the field of Optical Image Processing for applications in Fourier Optics-based Optical Pattern Recognition. His postdoctoral experience was focused on the characterization of nanoroughness of surfaces in high-quality optical components in the Fraunhofer Institute in Jena, Germany and in the ENEA in Rome, Italy. The main applications of such optical components were to the 5-nm lithography systems that work in the EUV range in the microelectronic industry. Since he joined the Universitat Rovira i Virgili in 2004 he has been involved in research on the framework of the activities of the Nano-electronic and Photonics group lead by Prof. Lluis Marsal: development of technologies for the fabrication of nanoporous materials and their applications to energy, health and environment, and especially in the numerical

modeling of the interaction of light with such materials and devices. He is currently the coordinator of the Doctoral Program in Technologies for Nanosystems, Bioengineering and Energy of the Universitat Rovira i Virgili and develops its teaching activities in Physics and Electromagnetism. He has been supervisor of 10 Doctoral Thesis, 4 of them in the last 5 years. He is author of 170 papers published in international peer-reviewed journals, 67 of them in the Q1 of their corresponding JCR category. The publications have obtained 2677 Citations and have reached an h-index of 30. He has been Principal Investigator in the project with title “Estructuras micro y nanoporosas para dispositivos sensores y células solares poliméricas” with reference RTI2018-094040-B-I00 funded by the Ministerio de Ciencia, Innovación y Universidades with 110.110 Euro. He has also been member of the research team in two other projects funded by the Spanish Science Ministry and in one COST Action (CA20126, “Network for research, innovation and product development on porous semiconductors and oxides”, NETPORE).

Petra Granitzer | University of Graz, Austria

Petra Granitzer degreed in Physics at the University of Graz studying “Mesoporous Silicon as a Matrix for Ferromagnetic Nanostructures”. Then she worked 3 years at Philips in Klagenfurt, Austria before taking a PostDoc position at the Institute of Physics at the University of Graz till 2008. Afterwards she joined the FELMI (Institute for Electronmicroscopy) at the University of Technology in Graz for one year and returned to the Physics Institute at the University of Graz in 2009 as project leader. Since 2013 she holds a Senior Scientist Position there. Her work focuses on nanostructuring of silicon and the filling thereof with magnetic materials to achieve semiconducting/ferromagnetic composite systems.

Klemens Rumpf | University of Graz, Austria

Klemens Rumpf studied Physics and Mathematics and degreed at the University of Graz. In the following he worked in the semiconductor industry at Austria Microsystems in Unterpremstätten near Graz before he took a PostDoc position at the University of Technology in Graz in studying ultracold molecules till 2002. Then he returned to the Physics Institute at the University of Graz in 2002 as an Assistant Professor. Since 2009 he holds a Senior Scientist Position there. His work focuses on nanostructured semiconductors and nanomagnetism, especially the magnetic filling of nanostructured silicon and the magnetic characterization of these semiconducting/ferromagnetic composite systems.

Hanna Sopha | University of Pardubice, Czech Republic

Hanna Sopha graduated in chemistry at the University of Rostock (Germany) in 2008. After she received Ph.D. degree in analytical chemistry from the University of Ljubljana (Slovenia) in 2013, she joined the University of Pardubice (Czech Republic) as a postdoctoral research fellow in electroanalytical chemistry. Since 2015, she has been working at the Centre of Materials and Nanotechnologies of the same university. Her research is focused on the anodization of valve metals towards novel nanotubular and nanoporous structures, as well as functionalization of these structures and their utilization in various applications.

Constantinos E. Salmas | University of Ioannina, Greece

My name is Constantinos Salmas. I was born and raised in Greece in 1969. I finished high school, and I succeeded in entering to the Department of Chemical Engineering, School of Chemical Engineering, National Technical University of Athens (NTUA) in Greece via State University Entrance exams. In 1994, I obtained my first degree in Chemical Engineering (five-year studies which is equal to an MSc degree) and I got a scholarship from the Greek State Foundation of Scholarships for my PhD dissertation in the same department. Since 2004 I hold my PhD degree as a Dr. Chemical Engineer on Pore Structure of Materials. Three years before I was hired as a permanent research staff from the Chemical Process Engineering Laboratory, School of Chemical Engineering, NTUA, Greece. On 2014 I became a member of the Lab. & Teaching Staff of University of Patras in the Food Technology and the Plant Production Laboratories of the Department of Business Administration of Food and Agricultural Enterprises. On October 2017, I was elected as an Assistant Professor for the topic of "Process Engineering on Materials" in the Dept. of Materials Sci. Engineering, School of Engineering, University of Ioannina. On December 2022, I was elected as an Associate Professor in the same Department. Detailed CV-data about me could be downloaded from https://users.uoi.gr/ksalmas or http://www.materials.uoi.gr/salmas.php .

Nikola Knežević | University of Novi Sad, Serbia

Dr. Nikola Knežević is a Full Research Professor at the Center for Sensing Technologies, BioSense Institute. He graduated with PhD in Chemistry in 2009 at Iowa State University, USA; under the supervision of late Prof. Victor Shang-Yi Lin. He obtained further research experience as a Postdoctoral fellow at University of Houston (research in multistep organic synthesis), Universidad Complutense de Madrid (research in nanomaterials science), Institute Charles Gerhardt Montpellier (research in nanomaterials science), FP7 – ERA Chairs Postdoctoral researcher at Vinča Nuclear Institute and as Pole Chimie Balard Visiting professor at the University of Montpellier. Nikola's record includes over 40 peer-reviewed publications in highly ranked international journals with over 1600 citations and H index 21. Nikola is the project coordinator of one H2020 project (NANOFACTS GA 952259), three Serbian national projects (PRECAST – 6060755, Proof of concept – 5566, Transfer of Technology-1135) and two bilateral research projects (with France and Germany). His research interests include synthesis of functional bioresponsive nanomaterials and their applications in health protection and construction of biosensors.

Vassilios Constantoudis | National Kapodistrian University of Athens and Aristotle University of Thessaloniki, Greece.

Dr. Vassilios Constantoudis studied physics at the Department of Physics of the Aristotle University of Thessaloniki, where he graduated with a degree of 8.2. He then moved to Athens for postgraduate and doctoral studies at the National Hellenic Research Institute (Institute of Theoretical and Physical Chemistry) with a fellowship from the same Institute on the **non-linear chaotic dynamics of magnetic systems**. After completing his doctoral research, he served in the military in Tripoli and Lemnos.

He has worked as a postdoctoral fellow at NTUA (NTUA) and NCSR Demokritos (Institute of Microelectronics, IMEL) from 2000 to 2007, participating in many national and European programs as well as teaching postgraduate courses. In 2001-2004 he also worked as a full-time professor of Physics and Physics laboratories at ASETEM-SELETE. In 2017 he was elected Senior Researcher at the Institute of Nanoscience and Nanotechnology (INN) of NCSR Demokritos. His research work focuses mainly on **mathematical modelling and computational methods including Machine Learning techniques in nanometrology, nanoelectronics and nanotechnology**, while he has been involved in the study of **complex systems** such as **mass transfer to time dependent media** and the **mathematical description of correlations in natural language**. Also, he has supervised many post-graduate and PhD theses of Departments of NTUA, National Kapodistrian University of Athens and Aristotle University of Thessaloniki.

Thierry Djenizian | Aix-Marseille University, France

Thierry Djenizian is the head of the flexible electronics department on the George Charpak Campus. In 2002, he received his PhD degree in Materials Chemistry from the Swiss Federal Institute of Technology in Lausanne and the Friedrich Alexander University of Erlangen-Nuremberg. His research activities are mainly focussed on the nanostructuring of materials for applications in energy storage and conversion at the micrometer scale (microbatteries). He is the author of over 80 publications in international journals and 5 book chapters. He is one Conference Chair of Porous Semiconductors Science and Technology international conferences.ç

Nefeli Lagopati | University of Athens, Greece

Nefeli Lagopati is Assistant Professor in Biology-Nanomedicine at the Department of Biology, at the School of Medicine of the National & Kapodistrian University of Athens (NKUA). She performed her PhD at the Faculty of Biology of the School of Science, NKUA (Section of Animal & Human Physiology) in cooperation with the Laboratory for the Research on Cell & Matrix Biochemistry / Pathobiology of the Institute of Biosciences and Applications and the Laboratory of Nanotechnology processes for solar energy conversion and environmental protection of the Institute of Nanoscience and Nanotechnology, of the National Center for Scientific Research "Demokritos" (N.C.S.R. “D”). She has graduated from the Faculty of Physics, of the School of Science, NKUA. She has received her first MSc in Medical Physics/ Radiation Physics from the School of Medicine, NKUA and the second MSc in Advanced Materials from the Department of Materials Science and Engineering at the School of Engineering of the University of Ioannina. She is also about to finish a MSc in Technoeconomic Systems (National Technical University of Athens, School of School of Electrical and Computer Engineering/Department of Industrial Management & Technology, university of Piraeus) in parallel with continuous training and seminars, reflecting her dedication in lifelong learning. Among her research interests is the multi-disciplinary field of nanomedicine in cancer treatment. Specifically, Dr. Nefeli Lagopati focuses on the oxidative stress induced apoptotic effect and the anticancer activity of nanomaterials. She has worked as a Research Fellow in various research projects, and had the honor to receive full national scholarships as a PhD candidate, as well as Postdoc researcher (IKY, Heraclitus II), through her continuous and strategic collaborations with NTUA, NCSR “D”, and School of Medicine NKUA. In the past decade, she has focused on the development of drug delivery systems, biomaterials, hybrid materials, cellular senescence, oxidative stress molecular mechanisms, radiobiology, Monte Carlo simulation, and dosimetry in nuclear medicine, while recently she worked on projects related to SARS-CoV-2. Dr. Nefeli ‘s Lagopati work is reflected in a significant number of scientific publications. She also has numerous participations in national and international conferences, which highlights her

persistence and devotion to her research activity. She is a reviewer in various scientific journals. She has served as a Substitute board member of the Hellenic National Public Health Organization and as a scientific collaborator of the General Secretariat for Research and Innovation, of the Ministry of Development and Investment of Greece. Dr. Nefeli Lagopati teaches Biology and Genetics to undergraduate medical students, and she has supervised a significant number of junior scientists. She also teaches some aspects of Histology-Embryology to undergraduate medical and dental students while she participates at the organization and teaching of “Cancer Biology”, “Nanomedicine” and “Applications of Biology in Regenerative Medicine”. She is among the teaching staff of various postgraduate programs of NKUA.

Milan Momcilovic | University of Niš,Serbia

Milan Momcilovic holds a degree in Chemistry from the University of Niš, Serbia since 2012. His PhD thesis is related to porous carbon based materials designed for wide range of applications in water purification and electrochemistry. From 2011 until 2023, he was engaged at the “Vinča” Institute of Nuclear Sciences – National Institute of the Republic of Serbia as a researcher whose work was dedicated to synthesis of various forms of micro and mesoporous carbon based materials. At the moment, he is employed at the Faculty of Sciences and Mathematics of University of Niš as the Senior Research Associate. His scientific interest covers wide research fields with several types of carbon materials involved including MWCNTs, graphene, ordered mesoporous carbons, carbon spheres, aerogels, and biochars, mainly investigated for specific applications in sorption of metals and organic pollutants from aqueous media, electrocatalysis and electrochemical sensing.

Agenda

	17 July	18 July	19 July	20 July
9h00		Dr Hanna Sopha	Dr Vassilios Constantoudis	Dr Milan Momcilovic
9h30				
10h00				
10h30		coffee	coffee	coffee
11h00		Dr Constantinos E. Salmas	Dr Thierry Djenizian	Dr Christos Trapalis
11h30				
12h00				
12h30	Lunch	Lunch	Lunch	Lunch
13h00				
13h30				
14h00	Welcome	Dr Nikola Knezevic	Dr Nefeli Lagopati	Sun and fun VISIT TO "ACROPOLIS MUSEUM"
14h30				
15h00	Dr Josep Ferré-Borrull			
15h30				
16h00		coffee	coffee	
16h30	coffee	3 minutes Ph.D. Pitch	3 minutes Ph.D. Pitch	
17h00	Dr Petra Granitzer & Dr Klemens Rumpf			
17h30		Poster session	Poster session	
18h00				
18h30				
19h00		Social Dinner "Kalokerinos Tavern"		

Lecture 1

Porous Anodic Alumina Preparation, Tuning of Optical Properties and Applications

Josep Ferré-Borrull

NanoElectronic and PHOtonic Systems, Department: Eng. Electrònica, Elèctrica i Automàtica. Universitat Rovira i Virgili

josep.ferre@urv.cat

Lecture 2

Magnetic filling of nanostructured silicon: a platform for biomedical, magnetic and optical materials

A composite system to interlink magnetism, optics and biomedicine

P. Granitzer[1], K. Rumpf[1], R. Gonzalez-Rodriguez[2], J. Coffer[3]

[1] University of Graz, Universitaetsplatz 5, 8010 Graz, Austria
petra.granitzer@uni-graz.at
[2] Department of Physics, University of North Texas, USA
[3] Department of Chemistry, Texas Christian University, Fort Worth, USA

This presentation deals with the utilization of nanostructured silicon (porous silicon and silicon nanotubes) for deposition of various metals, especially magnetic ones, or the infiltration of readily synthesized Fe_3O_4 particles within the pores/tubes. The novel magnetic properties of the semiconducting/magnetic composites which arise due to the nanoscopic size of the used materials are investigated with respect to possible biomedical applicability or magneto-optics.
The fabrication of the different utilized types (morphologies) of porous silicon and silicon nanotubes will be discussed as well as the metal deposition process. Structural characterization of the nanocomposite systems is carried out by SEM (scanning electron microscopy), TEM (transmission electron microscopy) and EDX-spectroscopy (energy dispersive X-ray spectroscopy). Furthermore the magnetic response of the samples is investigated in using a VSM (vibrating sample magnetometer).
As one of our key topics luminescent porous silicon loaded with magnetic metals to enhance the photoluminescence will be discussed. In this regard the influence of the metal filling on the optical and magnetic properties will be shown. A further working area is the infiltration of Fe_3O_4 nanoparticles within porous silicon and silicon nanotubes in terms of biomedical applications. The samples are loaded with respect to particle size and spatial distribution within the pores to get knowledge about the magnetic coupling between the particles, since superparamagnetic behavior at room temperature is a precondition for the applicability in biomedicine.

Magnetic filling of nanostructured silicon: a platform for biomedical, magnetic and optical materials

Mono- and bi-metal deposits to improve the magnetic performance of nanocomposites

K. Rumpf[1], P. Granitzer[1], R. Gonzalez-Rodriguez[2], J. Coffer[3]

[1] University of Graz, Universitaetsplatz 5, 8010 Graz, Austria
petra.granitzer@uni-graz.at
[2] Department of Physics, University of North Texas, USA
[3] Department of Chemistry, Texas Christian University, Fort Worth, USA

This presentation deals with the deposition of mono- and bi-metal structures within nanostructured silicon (porous silicon, silicon nanotubes) and the exploitation of the properties of the soft and hard magnetic phase of the deposits.
The deposition of hard and soft magnetic materials within the nanostructures aims in the fabrication of arrays of permanent nanomagnets. The deposition process and the growth mechanism of Ni/Co structures and FePt particles within porous silicon and silicon nanotubes is discussed. Magnetic characterization of the bi-metal composites is performed with a VSM with the aim to exploit the magnetic properties of both metals and gain control of the exchange coupling between the two metals especially with respect to their volume ratio to improve the energy product. A variation of the structure size and the proximity of the metal deposits modify the exchange coupling and thus the energy product. The influence of high temperatures on the nanocomposite samples is of interest, as well as the high temperature magnetic behavior. Therefore, beside low temperature and room temperature magnetic measurements, the magnetic behavior of the samples is investigated at high temperatures up to 1270 K.
Nanocomposite systems with an energy product as high as possible should be achieved to give rise to on-chip applications using permanent nanomagnets, especially arranged in three dimensional arrays.

TiO_2 nanotube layer synthesis and their utilization for sensing, biomedical and photocatalytic applications

Hanna Sopha[a,b], Jan M. Macak[a,b]

[a] *Center of Materials and Nanotechnologies, Faculty of Chemical Technology, University of Pardubice, Nam. Cs. Legii 565, 530 02 Pardubice, Czech Republic*
[b] *Central European Institute of Technology, Brno University of Technology, Purkynova 123, 61200 Pardubice, Czech Republic*
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The synthesis of highly-ordered nanostructures of valve metal oxides has attracted huge scientific and technological interest motivated by their possible use in many applications. The most established member of this group of materials is nanoporous Al_2O_3, which has been prepared two decades ago by anodic oxidation of Al into perfectly ordered, honeycomb-like porous structures employing suitable electrochemical conditions (1). Owing to the flexibility of the pore diameter/length and the relative ease of the Al_2O_3 dissolution, its porous membranes have been since than widely used as template material of choice for a range of materials (2-4).

Over the last ~20 years, TiO_2 has received the highest attention after Al_2O_3 motivated by its range of applications, including photocatalysis, water splitting, solar cells and biomedical uses. Very significant research efforts have led to reproducible synthesis of self-organized TiO_2 nanotube layers by means of anodic oxidation, during which the starting Ti substrate is converted into a highly-ordered nanotubular layer by anodization in suitable electrolytes (5-7).

In this lecture, the synthesis of anodic TiO_2 nanotube layers will be discussed and demonstrated in detail, including the influence of anodization conditions, i.e. electrolyte composition, anodization potential and time, anodization set-up (5, 8). In a second part of the talk, the modification of the TiO_2 nanotube layers using Atomic Layer deposition and their application will be discussed with focus on sensors (9,10), biomedical applications (11,12) and photocatalysis (13,14).

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A Review of Pore configuration models. The Corrugated Pore Structure Model (CPSM) as a united theory for the interpretation of Mercury Intrusion-Extrusion and Nitrogen Adsorption-Desorption porosimetry measurements

***Constantinos E. Salmas**, Department of Materials Science Engineering, University of Ioannina, Ioannina, Greece*

Abstract

Materials' pore structure is an important factor for numerous scientific topics, technological areas, and life. The most of known solid materials such as natural stones fossil carbon, ceramics, paper, cement, insulating materials, catalysts adsorptive materials, exhibit pore structure. Many material properties such as chemical behavior, gas permeability, liquid diffusion, thermal conductivity, sound insulation, e.t.c. are strongly affected by the porosity.

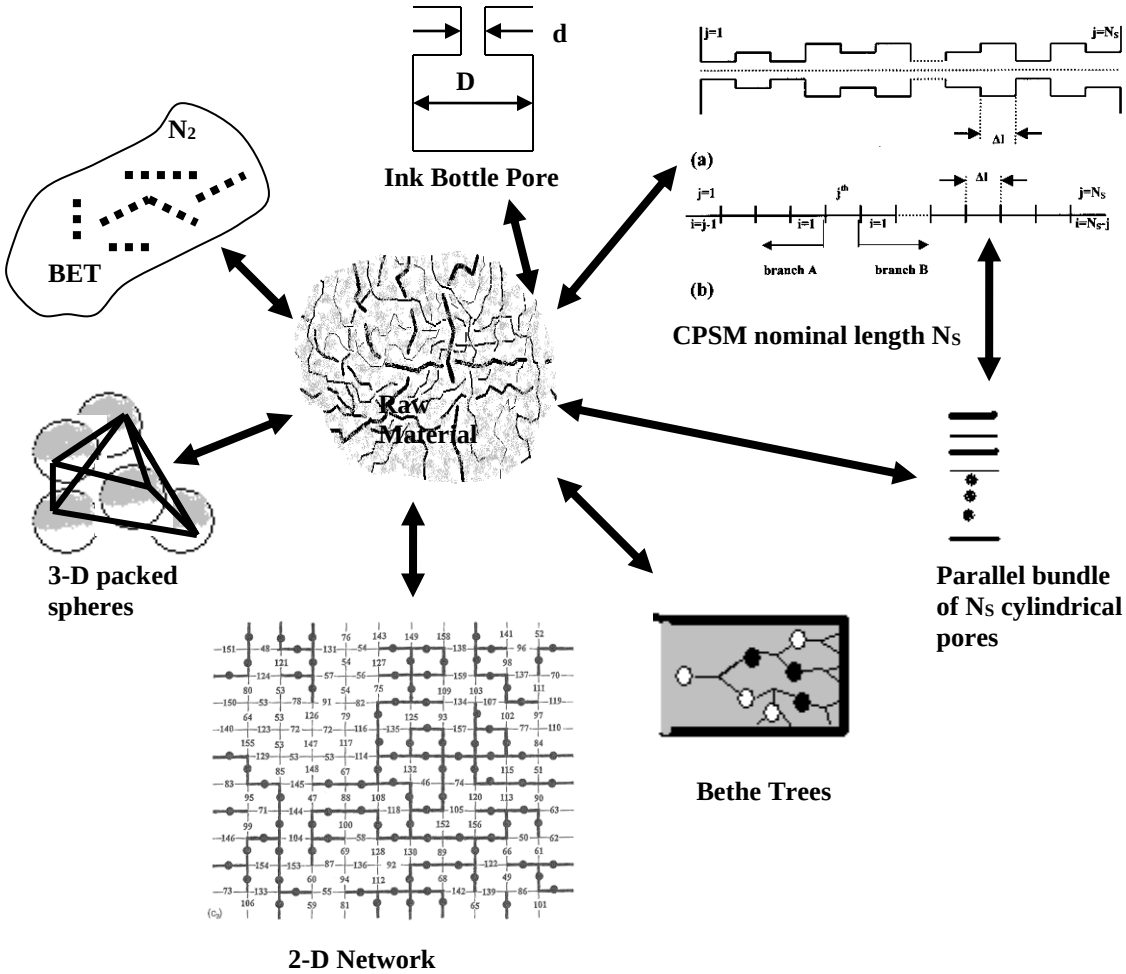

Figure 1: Applied geometrical 0-D, 1-D, 2-D, and 3-D prototypes for natural materials pore structure, and for process simulation.

Porosity is also a very important property for many processes in chemical industry. Pore structure is a significant factor for the reaction rate of several heterogeneous catalysis chemical reactions such as synthesis, pyrolysis, gasification, e.t.c. Finally, catalyst deactivation is strongly depended on pore structure due to fouling and blockage phenomena. Based on the above-mentioned arguments it is obvious that pore structure plays a key role to our life. Two major techniques are used for pore structure interpretation, the mercury and the nitrogen porosimetry. To work with these techniques, it is mandatory to assume a geometrical prototype for pore shape and size.

The search for a realistic pore model led to the development of more complex 1-D, 2-D, and 3-D models (Fig.1) aiming to a common target which was the size distribution of the pore elements. The more complex structural model the stiffer mathematical model which needs extraordinary calculation power and calculation time. Previous interpretations of experimental measurements shown that such complexity is not necessary, and the optimum choice is a model with an intermediate complexity. The most used geometrical pore structure model is the 1-D simple model of the “parallel bundle of pores with distributed diameter”. More specific, Whashburn, and Rootare & Prenzlow (Mercury Porosimetry), and BET, BJH, DFT, and CPSM models are the dominant models and the most used nowadays. All these models are 0-D or 1-D.

Lecture 6

Mesoporous silica nanoparticles: functionalization, characterization and applications for cancer sensing, therapy and imaging

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Mesoporous silica nanoparticles (MSNs) represent a versatile nanoplatform for constructing multifunctionalized particles for a variety of applications. This lecture will introduce the methodologies for synthesis, functionalization and characterization of MSNs. Furthermore, procedures and characterization methodologies for loading the mesopores of MSN with cargo molecules (dyes, drugs, imaging agents) and their entrapment inside the mesopores by the presence of pore-blocking agents (quantum dots, coordination compounds, large molecules and biomolecules) will be described. Designing nanosystems for stimuli-responsive (in response analyte biomolecules, exposure to light or change of pH) through employment of stimuli-responsive linkers between the pore-capping moieties and the MSN will be also discussed. Finally, the examples of recent research achievements in the field of pore-loaded MSNs for sensing and stimuli-responsive treatment and imaging of cancer will be described.

Lecture 7

Porosimetry based on SEM image analysis: Challenges and recent advances

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Abstract

In this talk, after a short introduction to the main porosimetry techniques, we will focus on the SEM-based method presenting its pros and cons. First, we will detail its ability to characterize the pore size distribution, pore volume, surface energy, pore complexity and spatial structure. Emphasis will be given on the statistical aspects of measurement given the local and limited information of single SEM images. Then we will proceed to recent challenges concerning the use of a) fractal and stochastic geometry to quantify scaling and random aspects of pore spatial networks and b) the first applications of Machine Learning techniques.

Finally, a systematic comparison with other techniques will be presented based mainly on literature data. The final output of this talk is intended to be a practical guide for reliable and informational SEM-based measurements of pore structure in modern materials.

1. Anodising of aluminium samples following an industrial sulfuric acid process.
2. Presentation and discussion of microscopic pictures of the surfaces (before anodizing, after anodising and after sealing). Pictures obtained previously.
3. Electrochemical impedance spectroscopy measurements of aluminium samples (cleaned, anodised, and anodised+sealing).

Lecture 8

From all-solid-state to stretchable Li-ion microbatteries using porous materials

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Lecture 9

Photo-activated nanostructured titanium dioxide, as a promising anticancer agent

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Lecture 10

Porous carbon based materials for electrochemical sensing of pesticides

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The extensive use of pesticides has resulted in their emergence in water and food products which is a growing issue. The hazardous nature of pesticides has triggered the need for their monitoring within the environment. The conceptualization of reliable electrochemical sensors for the on-site quantification of pesticide concentrations stands as an alternative to conventional chromatographic techniques, which possess characteristics of being time consuming, costly and reliant on skilled personnel. Electrochemical sensors are often designed as electrodes based on carbon materials such as MWCNTs, graphene, graphite, microspheres, etc and some notable examples are described in this presentation. Herein, two novel electrochemical sensors for pesticides fabricated through the chemical deposition of Pt and MoO_2 nanoparticles onto MWCNTs are presented in detail along with Ag- and Pt-supported carbon microspheres and Co- and Ni-dopped ordered mesoporous carbon for other electrochemical applications. Addition of metal nanoparticles is a key topic responsible for enhancement of electrode response and sensitivity. To investigate the structural characteristics of the porous carbon eletrode materials, various analytical techniques such as Raman and FT-IR spectroscopy, field emission scanning electron microscopy (FE-SEM), high-resolution transmission electron microscopy (HR-TEM), X-ray crystallography, and the others were employed and discussed. Analyzed materials evidenced excellent reproducibility, wide concentration range with robust linear relationship, and low limit of quantification when applied as specific electrodes for sensing ppb levels of pesticides.

Lecture 11

Novel 2D Polymeric Photocatalysts for Environmental and Energy Applications

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Abstract

The synthesis and use of polymeric g-C_3N_4 and g-C_3N_4/TiO_2 photocatalysts for decomposition of air pollutants and for H_2 production is discussed. The synthetic procedure includes high temperature polymerization of organic compounds like melamine for g-C_3N_4 production. In order to improve the photocatalytic activity of g-C_3N_4, it was combined with the semiconductor TiO_2, as this provides favorable valence and conduction band edges. As the effective removal of gaseous pollutants requires a high specific surface area and adsorption of the pollutants on the photocatalyst surface, exfoliation of g-C_3N_4 for enhancing the adsorption of atmospheric pollutants was applied. Likewise, for the efficient photocatalytic production of H_2, where the lack of surface defects plays an important role, thermal treatment of g-C_3N_4 has been performed in order to obtain suitable surface characteristics.

Chemical and thermal exfoliation of g-C_3N_4 was performed in order to increase the specific surface area. The chemical exfoliation of g-C_3N_4 was achieved by treatment with H_2SO_4, while for the thermal exfoliation heating at 550 ° C under air atmosphere was applied. Both methods displayed an increase in specific surface area from 9,64 m^2/g to 134,42 m^2/g. The BJH and EPR measurements showed that the chemically exfoliated g-C_3N_4 has large pore size and increased percentage amount of superoxide radicals $O_2^{\bullet-}$, whereas the XPS results showed that the thermally exfoliated g-C_3N_4 has fewer surface defects. Because of these characteristics, the chemically exfoliated g-C_3N_4 showed better behavior in NOx removal, while the thermally exfoliated g-C_3N_4 exhibited significantly improved H_2 production under visible light.

Next, g-C_3N_4/TiO_2 heterostructures were prepared by heating melamine and TiO_2 in ratios 3/1, 1/1 and 1/3 at 550 °C. It was found that the ratio significantly affects the energy band gap and the position of the valence and conduction band edges. The heterostructures with ratio 1/3 showed the best photocatalytic activity especially under visible light irradiation, which was attributed to the enhanced light absorption and oxidative capacity.

Finally, the thermally exfoliated g-C_3N_4 was used for the preparation of g-C_3N_4/TiO_2 heterostructures with ratios 9/1, 3/1, 1/1, 1/3 and 1/9. The heterostructures with 3/1 ratio showed the highest H_2 production at 48 μmol/g/h, which was attributed to the appropriate surface characteristics of g-C_3N_4 and also the efficient coupling of the semiconductors that enhances the separation of the photogenerated charge carriers.

It was demonstrated that, the novel g-C_3N_4 photocatalysts are suitable for efficient purification of air from NOx gaseous pollutants and high H_2 production under visible light radiation. Their efficiency can been maximized by optimizing factors such as the ability to adsorb gaseous pollutants and the utilization of absorbed radiation

Pictures


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