NETPORE

Network on porous semiconductors and oxides

1st NETPORE Training School
University of Aveiro, Portugal
5th to 8th July 2022

Introduction to porous materials: From design to Fabrication and Characterization Techniques

Organized by:

Paula Ferreira | University of Aveiro, PT

Hélder Almeida Santos | University of Groningen, NL

university of aveiro
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aveiro institute of materials

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EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Funded by the Horizon 2020 Framework Programme of the European Union

DAY 1 Tuesday, 5th July 2022

12:30 LUNCH (Department of Materials and Ceramics Engineering-DEMaC)

13:30 REGISTRATION

14:00 WELCOME (NETPORE meeting room)

- **Paula Ferreira** | University of Aveiro, PT - Organizer
- **Hélder Almeida Santos** | University of Groningen, NL- Organizer
- **Rui Silva** | Director of Department of Materials and Ceramics Engineering - DEMaC, University of Aveiro, PT
- **João Coutinho** | Director of Associate Laboratory CICECO – Aveiro Institute of Materials, University of Aveiro, PT
- **Frederique Cunin** | Cost Action Vice-Chair & Institut Charles Gerhardt Montpellier, CNRS, FR

14:20 PRACTICAL MATTERS & INTRODUCTION OF SPEAKERS

Paula Ferreira | University of Aveiro, PT

14:30 THE IMPORTANCE OF BEING POROUS: METAL ORGANIC FRAMEWORKS AND SILICATES

João Rocha | University of Aveiro, PT

16:00 REFRESHMENTS & SNACK

16:30 3 MINUTES RESEARCH PITCH / TRAINEES INTRODUCTION

19:00 DINNER (Students' Restaurant)

9:00 INDUSTRIAL TRANSLATION OF NANOPOROUS SILICON

Leigh Canham | University of Birmingham, UK

10:30 REFRESHMENTS & SNACK

11:00 BIOMEDICAL APPLICATIONS OF POROUS SILICON

Nicolas Voelcker | Monash University, AUS

12:30 LUNCH BREAK (Department of Materials and Ceramics Engineering- DEMaC)

14:30 GAS ADSORPTION BY POROUS MATERIALS

Moisés L. Pinto | University of Lisbon, PT

José R.B. Gomes | University of Aveiro, PT

16:30 PROJECT BASED LEARNING MOMENT

17:30 POSTER SESSION & REFRESHMENT (Department of Materials and Ceramics Engineering- DEMaC)

19:00 DINNER (Students' Restaurant)

DAY 3 Thursday, 7th July 2022

9:00 ELECTROCHEMICALLY ENGINEERED MACROPOROUS SILICON AND NANOPOROUS ANODIC ALUMINA STRUCTURES

Lluis Marsal | University Rovira i Virgili, ES

10:30 REFRESHMENTS & SNACK

11:00 INTERFACE CHEMISTRY IN POROUS MATERIALS

Hatice Duran | TOBB University of Economics and Technology, TR

12:30 LUNCH BREAK (Department of Materials and Ceramics Engineering- DEMaC)

14:30 ANODISING OF ALUMINIUM

Alexandre Bastos | University of Aveiro, PT

João Tedim | University of Aveiro, PT

17:30 POSTER SESSION & REFRESHMENT (Department of Materials and Ceramics Engineering- DEMaC)

19:00 DINNER (Students' Restaurant)

9:00 INTRODUCTION TO OPTICAL BIOSENSORS BASED ON POROUS SEMICONDUCTORS

Ester Segal | Technion – Israel Institute of Technology, IL

10:30 REFRESHMENTS & SNACK

11:00 AN INDUSTRIAL PERSPECTIVE ON POROUS BIOSENSING DEVICES

Gerard Maciel Sotuela | Macias Sensors Ltd., UK

12:30 LUNCH BREAK (Department of Materials and Ceramics Engineering- DEMaC)

14:30 SOCIAL PROGRAM

19:30 BANQUET DINNER - Meliá Ria Hotel & Spa

Agenda

	5th July	6th July	7th July	8th July
9h00		Leigh Canham, U. Birmingham	Lluis Marsal, U. Rovira i Virgili	Ester Segal, Israel Institute of Technology
9h30				
10h00				
10h30		coffee	coffee	coffee
11h00		Nicolas Voelcker, U. Monash	Hatice Duran Durmuş, TOBB U.	Gerard Maciel Sotuela, Macias Sensors Ltd.
11h30				
12h00				
12h30	Lunch	Lunch & posters	Lunch & posters	Lunch & posters
13h00				
13h30				
14h00	Welcome			
14h30	João Rocha, U.Aveiro	Moisés Pinto, U.Lisboa - IST & José Gomes, U. Aveiro Project-based learning	João Tedim & Alexandre Bastos, U. Aveiro Project-based learning	Sun and fun
15h00				
15h30				
16h00	coffee			
16h30	3 minutes PhD Pitch	Poster session & Refreshment	Poster session & Refreshment	
17h00				
17h30				
18h00				
18h30				
19h00	Dinner	Dinner	Dinner	Farewell dinner
20h00				
20h30				
21h00				
21h30				
22h00				

Lecture 1

The Importance of Being Porous: Metal Organic Frameworks and Silicates

João Rocha
Department of Chemistry, CICECO – Aveiro Institute of Materials, University of Aveiro, 3810-193 Aveiro, Portugal

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Zeolites (aluminosilicates) are the archetypal microporous materials with well-established applications (among other) in catalysis, ion exchange and gas storage and separation. In the last two decades, or so, other classes of inorganic and organic-inorganic hybrid microporous materials have emerged.

This lecture highlights some of the work carried out in Aveiro on microporous transition-metal and lanthanide (Ln) silicates and on Ln-bearing coordination polymers (or metal organic frameworks, MOFs). The focus will be on the design of lanthanide-bearing nanomaterials for sensing temperature via light emission, and nanosystems for health-related applications, such as drug delivery and treating bone tissue disorders. Another outstanding example is the use of zirconium silicates as pharmaceuticals for treating hyperkalemia (excess K+ in serum), providing an intriguing case study of a real translation from the bench to the bedside. A final example of health-related and sustainability applications is provided by the anti-mosquito activity of a titanium-based metal–organic framework supported on textile fibres.

While nanoporous (zeolite-like) silicates are highly robust (thermal and chemical) systems, allowing applications in relatively harsh conditions, it is very challenging to synthesise the desired architectures and modify them post-synthesis. In contrast, MOFs operate in milder conditions and often lack robustness, but they are much more amenable to rational synthesis and post-synthetic modification. Thus, together, metal silicates and MOFs provide a wonderful playground for chemists and a toll box for engineering applications.

Lecture 2

Industrial Translation of Nanoporous Silicon

Leigh Canham
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Highlight the differences between academic research and industrial R&D.

Survey different types of companies, their different roles and why they need you.

Detail the steps via which early-stage research can move steadily towards a product ("translation").

Talk about the progress made and the challenges faced by selected nanoporous silicon companies.

Lecture 3

Biomedical applications of porous silicon

Nicolas Voelcker
Victorian Node of the Australian National Fabrication Facility
Melbourne Centre for Nanofabrication
151 Wellington Road, Clayton 3168, Australia

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This tutorial will highlight important biomedical applications of porous silicon.

First, the talk will summarise relevant materials properties and fabrication techniques. Then it will introduce important concepts in drug and gene delivery, and nanomedicine; and provide examples how porous silicon nanoparticles are used in this field.

Then the talk will highlight key examples of porous silicon nanoparticles are used in bioimaging across the different microscopy and tomography contrast modalities.

Following this, the talk will touch on recent examples of using porous silicon in wearable biosensing.

Finally, the tutorial will give an insight on using porous silicon as a biomaterial, in regenerative medicine and tissue engineering.

Lecture 4

Gas Adsorption by Porous Materials

Moisés L. Pinto
CERENA, Department Chemistry Engineering, Instituto Superior Técnico, Universidade de Lisboa, 1049-001, Lisboa, Portugal

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José R.B. Gomes
CICECO - Aveiro Institut of Materials, Department of Chemistry, University of Aveiro, Campus Universitário de Santiago, 3810-193, Aveiro, Portugal

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This session will be devoted to introducing the fundamental aspects of gas adsorption by porous materials, from the experimental and computational perspectives. It will be highlighted several methods based on the analysis of gas adsorption data that are used to extract textural and morphological information about the porous structure of the materials.
A short hands-on project will be offered to demonstrate the applications of some of these methods to real data and consolidate the knowledge of the students on this topic.

Lecture 5

Electrochemically Engineered Macroporous Silicon and Nanoporous Anodic Alumina Structures

Lluis Marsal
Departament d'Enginyeria Electrònica, Elèctrica i Automàtica, Escola Tècnica Superior d'Enginyeria, Universitat Rovira i Virgili, Tarragona, Spain

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Lecture 6

Interface Chemistry in Porous Materials

Hatice Duran
Department of Materials Science and Nanotechnology Engineering
TOBB University of Economics and Technology
Ankara, TURKEY

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Course content

Surface Forces:

- van der Waals Forces: (Microscopic (Hamaker) Approach and Macroscopic Lifhitz Theory), Derjaguin approximation
- The Electric Double Layer Forces and DLVO forces
- Structural Forces (non-DLVO Forces): solvation forces, hydration forces, hydrophobic forces and steric forces

will be covered between colloidal solid particles, particle-flat surfaces, flat surface- flat surface, liquid- gas interfaces and liquid-solid interfaces.

The Aim of the Course

The increasing importance of studies on soft matter and their impact on new technologies, including those associated with nanotechnology, has brought intermolecular and surface forces to the forefront of physics and materials science, for these are the prevailing forces in micro and nanosystems. These subjects are significantly less pronounced in our education system and interface science has become an interdisciplinary field of research including, for example, materials, mechanical and electric-electronic as well as chemical engineering and biology. This development motivated us to include this lecture in NETPORE training school and I will teach a general introduction to surface and interface science during NETPORE training school.

Textbook and / or References

Physics and Chemistry of Interfaces, 3rd Edition, Hans-Jurgen Butt, Karlheinz Graf, Michael Kappl, Wiley-VCH Verlag GmbH & Co.

Surface and Interfacial Forces, Hans-Jurgen Butt, Michael Kappl, Wiley-VCH Verlag GmbH & Co. 2009.

Intermolecular and Surface Forces, Revised 3rd Edition by Jacob N. Israelachvili, Academic Press. 2011.

Lecture 7

Anodising of aluminium

Alexandre Bastos
CICECO - Aveiro Institut of Materials, Department of Materials and Ceramics Engineering, University of Aveiro, Campus Universitário de Santiago, 3810-193, Aveiro, Portugal

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João Tedim
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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

Introduction to Optical Biosensors Based on Porous Semiconductors

Ester Segal
Department of Biotechnology and Food Engineering
Technion - Israel Institute of Technology
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Since its first demonstration as a promising material for molecular detection, more than two decades ago, porous silicon (and other porous semiconductors) has attracted significant research interests and progress is being made towards commercially viable optical biosensor platforms.

In general, optical biosensors detect the presence of molecules based on utilization of light to monitor changes in absorption, reflection, transmission, or emission, and they are well-suited to provide a highly scalable solution for molecular detection applications with a need for simple readout, versatility in the types of molecules to be detected, and relatively rapid results.

This talk will focus on recent progress in porous semiconductors-based optical biosensors, starting from the main types of porous structures utilized as optical biosensors and the characteristic transducing mechanisms for each structure.

The use of porous semiconductors as host substrates for various nanomaterial and molecule guests will be discussed, as well as the sensitivity of different classes of optical biosensors and strategies to improve their sensitivity will be presented.

Lecture 9

An Industrial Perspective on Porous Biosensing Devices

Gerard Maciel Sotuela
Macias Sensors, 1 Market Hill, Royston,
SG8 9JL, United Kingdom

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Research on biosensing applications of nanoporous silicon, as well as nanoporous metal oxides, has been ongoing for several years. However, commercial applications are limited.
In this lecture we will discuss how the industry views biosensors and how it differs from the academic view. We will also talk about the preferred measurement techniques for developing biosensors within an industrial environment and why. Finally, we will talk about what features make porous materials attractive to develop biosensors from an industrial perspective and show examples of commercially available porous biosensors.