



Training Course

Basics and Applications of Solid State Electrochemistry (BASE) May 7-11, 2007, University of Patras, Greece

Sunday, 06.5.2007

18-21 Welcome, informal presentation of the lecturers and of the participants

Monday, 7.5.2007: *Ionic conduction in solids, mechanism of conduction*

9-11 J. Irvine, University of St. Andrews, Scotland

11-13 I. Riess, Technion, Haifa, Israel

15-19 Practical course: Conductivity measurements, S. Brosda

Thursday, 8.5.2007: *Thermodynamics and kinetics of solid electrolyte cells*

9-11 C.G. Vayenas, University of Patras, Greece

11-13 P. Vernoux, University Claude Bernard, Lyon, France

15-19 Practical course: Current-voltage measurements in PEM fuel cells, A. Katsaounis

Wednesday, 9.5.2007: *Experimental techniques*

9-11 S. Neophytides, ICEHT/FORTH Patras, Greece

11-13 D. Tsiplakides, CPERI Thessaloniki, Greece

15-19 Excursion and Dinner

Thursday, 10.5.2007: *Characterization techniques for electrode applications in sensors, fuel cells and electropromoted reactors*

9-11 J. Janek, Justus-Liebig-University, Giessen, Germany

11-13 A. Katsaounis, University of Chania, Greece

15-19 Practical course: Cyclic voltammetry, Kelvin probe, D. Tsiplakides
TPD, XPS, S. Neophytides

Friday, 11.5.2007: *Electrochemical reactors*

9-11 G. Foti, EPFL Lausanne, Switzerland

11-13 S. Bebelis, University of Patras, Greece

15-19 Practical course: Monolithic Electropromoted Reactor (MEPR), A. Hammad



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Monday, 7.5.2007

Ionic conduction in solids, mechanism of conduction **J. Irvine and I. Riess**

9:15-10:45 J. Irvine

10:45-11:15 Coffee break

11:15-12:45 I. Riess "The current density equations under low and high driving forces" (the way the current density equation is obtained, the concept of local equilibrium, driving forces, and present solutions of the I-V relations and defect distribution for certain defect models)

12:45-15:00 Lunch break

15:00-19:00 Practical course: Conductivity measurements, S. Brosda

Theory:

- Oxygen ion, proton and mixed conductors (YSZ, CeO₂, Nafion, perovskites) - classification
- Defects and transport, Frenkel and Schottky defects, notation of defects
- Diffusion, migration and permeation
- Nernst-Einstein equation
- Transfer number
- Kroger-Vink-diagramm
- Temperature and partial pressure dependence of conductivity

Praxis:

- Bulk conductivity of YSZ as a function of temperature, (AC impedance technique, current interruption technique, four point measurements)



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Thursday, 8.5.2007

Thermodynamics and kinetics of solid electrolyte cells
C.G. Vayenas and P. Vernoux

9:15-10:45 C.G. Vayenas

10:45-11:15 Coffee break

11:15-12:45 P. Vernoux

12:45-15:00 Lunch break

15:00-19:00 Practical course: Current-voltage measurements in PEM fuel cells, A. Katsaounis

Theory:

- Catalysis-Electrocatalysis
- Electrode-gas interface
- Electrolyte-electrode-gas interface (three phase boundary)
- Electrochemical double layer
- Adsorption, Langmuir isotherms
- Catalyst work function
- Tafel diagramm
- Overpotentials and Butler-Volmer equation
- Electrochemical Promotion of Catalysis (EPOC, NEMCA)

Praxis:

- Current-voltage characteristics of PEM fuel cells as a function of gas composition at the anode and cathode, I-U curves as a function of loading



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Wednesday, 9.5.2007

Experimental techniques

S. Neophytides and D. Tsiplakides

9:15-10:45 S. Neophytides

10:45-11:15 Coffee break

11:15-12:45 D. Tsiplakides: "Investigation of the Origin of Electrochemical Promotion Using Cyclic Voltammetry and Work Function Measurements"

12:45-15:00 Lunch break

15:00-19:00 Excursion and dinner

Theory:

- Electrochemical oriented techniques
Cyclic voltammetry, AC impedance spectroscopy
- Surface science oriented techniques
Thermal programmed desorption (TPD), X-ray photoelectron spectroscopy (XPS),
Scanning tunneling spectroscopy (STM)
- Discussion of NEMCA transients
- Determination of active catalyst surface area (Isothermal titration of the catalyst surface)



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Thursday, 10.5.2007

Characterization techniques for electrode applications in sensors, fuel cells and electropromoted reactors

J. Janek and A. Katsaounis

9:15-10:45 J. Janek

10:45-11:15 Coffee break

11:15-12:45 A. Katsaounis "Characterization techniques for electrode applications in electropromoted reactors"

12:45-15:00 Lunch break

15:00-19:00 Practical course: Cyclic voltammetry, Kelvin probe, D. Tsiplakides

Theory:

- Preparation and design of electro-catalysts
- Galvanic-electrolytic cells
- Current potential curves-overpotentials
- Sensors: potentiometric/resistive/amperometric
- Fuel cells: SOFC, PEM
- Discussion of examples
- Pt, Rh as catalysts for NO reduction – TPD
- Pt-Ru electrodes in PEM fuel cells (CO poisoning)-I-U curves, surface science techniques

Praxis:

- Cyclic voltammetry, Kelvin Probe, TPD, STM, XPS



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Friday, 11.5.2007

Electrochemical reactors

G. Foti and S. Bebelis

9:00-11:00 G. Foti, EPFL Lausanne, Switzerland

12:45-15:00 Lunch break

11:00-13:00 S. Bebelis, University of Patras, Greece

15:00-19:00 Practical course: Monolithic Electropromoted Reactor (MEPR), A. Hammad

Theory:

- Engineering aspects of electrochemical reactors
- Tubular and planar SOFC operation
- Discussion of important reactions
- Anodic oxidation of volatile organic components (VOCs)
- NO reduction in excess of oxygen
- Methane and higher hydrocarbon oxidation on Ni-YSZ cermets

Praxis:

- NEMCA experiments under CSTR conditions and in the Monolithic Electropromoted Reactor (MEPR)