TIME TABLE

TIME	Monday September 3	Tuesday September 4	Wednesday September 5	Thursday September 6	Friday September 7
9.00 - 9.45	Irschik	Irschik	Irschik	Sarro	Ferrari
9.45 - 10.30	Jakoby	Jakoby	Jakoby	Ferrari	Sarro
11.00 - 11.45	Lerch	Lerch	Lerch	Sarro	Ferrari
11.45 - 12.30	Vellekoop	Vellekoop	Vellekoop	Ferrari	Sarro
14.00 - 14.45	Irschik	Irschik	Irschik	Sarro	Ferrari
14.45 - 15.30	Jakoby	Jakoby	Jakoby	Ferrari	Sarro
16.00 - 16.45	Lerch	Lerch	Lerch		
16.45 - 17.30	Vellekoop	Vellekoop	Vellekoop		
18.00	Welcome Aperitif				

ADMISSION AND ACCOMMODATION

The registration fee is 600.00 Euro + VAT*, where applicable (bank charges are not included). The registration fee includes a complimentary bag, four fixed menu buffet lunches (on Friday upon request), hot beverages, downloadable lecture notes and wi-fi internet access.

Applicants must apply at least one month before the beginning of the course. Application forms should be sent on-line through the following web site: http://www.cism.it. A message of confirmation will be sent to accepted participants. Applicants requiring assistance with the registration should contact the secretariat at the following email address cism@cism.it.

Applicants may cancel their course registration and receive a full refund by notifying CISM Secretariat in writing (by email to cism@cism.it) no later than two weeks prior to the start of the course.

Cancellation requests received during the two weeks prior to the start of the course will be charged a 50.00 Euro handling fee. Incorrect payments are also subject to a 50.00 Euro handling fee.

A limited number of participants from universities and research centres who are not supported by their own institutions can be offered lodging and/or board, if available, in a reasonably priced hotel or student guest house.

Requests should be sent to CISM Secretariat by **July 3**, **2018** along with the applicant's curriculum and a letter of recommendation by the head of the department or a supervisor confirming that the institute cannot provide funding. Preference will be given to applicants from countries that sponsor CISM.

Information about travel and accommodation is available on the web site www.cism.it, or can be mailed upon request.

* Italian VAT is 22%.

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ELECTROMECHANICAL TRANSDUCERS: PRINCIPLES AND TECHNOLOGIES

Advanced School
coordinated by

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Udine *September 3 - 7* 2018

ELECTROMECHANICAL TANSDUCERS: PRINCIPLES AND TECHNOLOGIES

Current developments in mechatronics lead to (and often require) the integration of sensors and actuators in mechanical structures. This trend is represented by research topics as for instance "smart structures" and "structural health monitoring". The associated technologies connect mechanics with neighboring disciplines such as electrical engineering and microtechnology.

Prof. Reinhard Lerch will address the Finite Element (FE) modeling of piezoelectric, electrostatic and magnetomechanical transducers, the characterization of material data for piezoelectric and magnetic materials using inverse methods, the modeling and measurement of hysteresis properties, ultrasound transducer technologies (air coupled transducers for distance measurement and object identification, sonar Transducers, and imaging transducers), transducers for energy harvesting and associated electronic circuits. The design of audio electrodynamic loudspeakers will serve as an example for a particular application treating the FE-modeling of the devices, their verification by prototypes, and their application as loudspeakers in cars.

For the realization of embedded transducers, microtechnologies are particularly useful which will be introduced by Prof. Lina Sarro. Microsystems or MicroElectroMechanical Systems (MEMS) technology covers design, technology and fabrication efforts aimed at combining electronic functions with mechanical, optical, thermal and others and that employ miniaturization in order to achieve high complexity in a small space. The core technologies, silicon bulk micromachining and surface micromachining, will be introduced to illustrate the potential of 3D micro structuring in the development of Microsystems. Advances in dry etching technology and thin films deposition and the added value the introduction of other materials in silicon-based technology offer, will be discussed as well.

When implementing autonomous sensor nodes, energy harvesting technologies are essential to power these nodes, which will be discussed by Prof. Vittorio Ferrari. Energy harvesting to power sensors from the surroundings, making them autonomous nodes, or passive sensors with energy supplied on demand from an external interrogation module, are two attractive options, each with specific features. Both options can be enabled by piezoelectric elements embedded in miniaturized devices. The lectures will introduce the piezoelectric effect as a cross-domain energy conversion mechanism and offer an overview of principles and applications in stand-alone sensors.

Prof. Michiel Vellekoop will discuss microfluidic components and systems. The investigation and analysis of fluids in microchips should, compared to macro devices, yield advantages such as very small sample volumes, high speed testing, integration of multiple functions, and monitoring of fast reaction dynamics. In the course, some fundamentals of fluid behavior are used to discuss basic design considerations for microfluidic devices. Technologies for the realization of microfluidic devices, which are partly very different from standard sensor technology will be presented. In addition, some attention will be given to the "chip to world" connection, as it is an important aspect that is often underexposed. Finally, a series of examples of Lab on a Chip devices will be conferred.

Prof. Bernhard Jakoby will provide general considerations when considering interaction of vibrating systems with liquids. First, some fundamental principles regarding microacoustic devices will be reviewed and selected microacoustic sensors will be discussed as examples. Many of these devices require special analysis approaches to allow for efficient modeling. To understand and model the interaction with fluids, the behavior of potentially non-Newtonian fluids will be considered including a discussion on the first and second coefficient of viscosity. The interaction with fluids will be considered for piezoelectrically and electromagnetically actuated devices and device performance and modeling will be discussed for selected examples.

Finally, the sensing and control of deformations and stresses in structures will be addressed by Prof. Hans Irschik. Particular emphasis will be given to dense, specially weighted piezoelectric sensor networks that can measure, e.g., discrete displacements or slopes. The use of so called nil-potent sensor networks for structural health monitoring will be discussed. Complementary to the discussion on sensors, weighted piezoelectric actuator networks that can track desired displacement fields, as well as nil-potent actuator networks and their usage for minimizing the actuator input energy will be presented. As a quite new research field, structural control of stresses by dense piezoelectric sensor and actuator networks will be systematically addressed also in the lectures.

PRELIMINARY SUGGESTED READINGS

G. Hairer, M.J. Vellekoop, An integrated flow-cell for full sample stream control, Microfluid Nanofluid, 7:647-658, 2009, DOI 10.1007/s10404-009-0425-6.

M. Krommer, H. Irschik, Sensor and actuator design for displacement control of continuous systems,

Smart Structures and Systems, Vol. 3, No. 2, 147-172, 2007.

R. Lerch, G. Sessler, D. Wolf, Technische Akustik Grundlagen und Anwendungen, Springer-Verlag Berlin Heidelberg, 1st ed. 2009, ISBN: 978-3-540-23430-2.

P.P.L. Regtien, Piezoelectric sensors in Sensors for Mechatronics, Elsevier, Amsterdam (NL), Ch. 8, 219-239, 2012, ISBN: 978-0-12-391497-2.

M. Madou, Fundamentals of Microfabrication and Nanotechnology, 3rd ed., CRC Press, 2011.

F. Herrmann, B. Jakoby, J. Rabe, and S. Büttgenbach, Microacoustic sensors for liquid monitoring, Sensors Update, 9(1), 105-160, 2001.

Additional readings at: http://www.cism.it/courses/C1813/readings/

INVITED LECTURERS

Vittorio Ferrari - University of Brescia, Italy
6 lectures on:
Piezoelectric transducers and energy harvesting: fundamentals of piezoelectric transducers, readout electronics for transducers, electromechanical transducers for energy harvesting.

Hans Irschik - Johannes Kepler University Linz, Austria
6 lectures on:
Feed-forward control of stresses and deformations in structures by piezoelectric transducers: fundamentals of structural shape control, displacement and stress tracking, nilpotent sensors and actuators, health monitoring by distributed sensors.

Bernhard Jakoby - Johannes Kepler University Linz, Austria
6 lectures on:
Fluidic Sensors and Actuators: fundamentals of fluidic sensors, physical fluid properties, physical chemosensors, sensors for rheological, thermal and electric fluid properties, sensor design and fabrication.

Reinhard Lerch - University of Erlangen, Germany
6 lectures on:
Numerical modeling of electromechanical transducers: fundamentals of electromechanical transducers, piezoelectric transducers, Finite Element modeling of coupled field problems, material characterization.

Pasqualina M. Sarro - TU Delft, The Netherlands
6 lectures on:
Micromechanical transducers and systems: introduction to micromachining of miniaturized mechatronic systems (MEMS), fabrication technologies, design rules, device and application examples.

Michiel Vellekoop - University of Bremen, Germany
6 lectures on:
Microfluidic components and systems: fundamentals of microfluidics, Lab on a Chip devices, opto-fluidic concepts and structures, technology for integrated fluidic devices.

LECTURES

All lectures will be given in English. Lecture notes can be downloaded from the CISM web site. Instructions will be sent to accepted participants.