EUPROMETA – 33rd Doctoral School on Metamaterials, 3-6 April 2017, University of Bordeaux, France

Centre de Recherche Paul Pascal
115 Avenue Schweitzer, 33600 – Pessac, France

Metasurfaces

School Program

3 April – Monday

Hour	Topic	Lecturer
09:00 – 10:30	**Participant registration - Welcome Coffee**	
10:30 – 10:40	**Opening and introductory information**	
10:40 – 11:30	**Basics of metamaterials – Part I** - definition of metamaterials. - complex material responses in electromagnetics - anisotropy and bi-isotropy - chirality and magnetoelectric coupling - reciprocity and non-reciprocity - general bianisotropy: principal, skewon, axion parts of medium response	**Prof. Ari Sihvola**
11:30 – 12:20	**Basics of metamaterials – Part II** - radial anisotropy: systropic, bulbic, and porcupic metamaterials - basic dispersion models for material response - classical mixing and homogenization principles - electromagnetic boundary conditions from simple to complex - impedance boundaries, PEC, PMC, PEMS, SH, DB, SHDB, and GSHDB conditions	**Prof. Ari Sihvola**
12:30 – 13:50	**Lunch**	

14:00 – 14:50	**Introduction to Metasurfaces – Part I** 1. Prehistory of MS: 1.1 Microwave analogues: 1.1.1. Frequency-selective surfaces, 1.1.2. EBG structures, 1.1.3. Transmit-arrays and reflect-arrays 1.2 Holograms in optics 2. From optically substantial to subwavelength patterning: 2.1 Electric current sheets 2.2 Magneto-dielectric current sheets 2.3 Bianisotropic MS 3. Perfectly absorbing MS 3.1 General operation principles 3.2 Optical models 4. Polarization transformers 4.1. Optical activity in thin sheets 4.2 Polarization sensitivity 5. Non-uniform MS 5.1 Generalized refraction law 5.1 General methods of wavefront manipulation 5.2 Tunable wavefront manipulation 6. Other types of MS (leaky-wave MS, metalenses, etc) 7. Concluding remarks	**Prof. Constantin Simovski**
14:50 – 15:40	**Introduction to Metasurfaces – Part II**	**Prof. Constantin Simovski**
15:40 – 18:00	**Coffee break and poster session** **Followed by wine and cheese**	

4 April – Tuesday

Hour	Topic	Lecturer
09:00 – 9:50	**Microwave Metasurfaces – Part I** **1. Microwave MSs as High-Impedance Surfaces** **1.1 Surface and grid impedances** **1.2 Transmission-line model** **1.3 Capacitive, inductive and self-resonant grids** **1.4 Metal-backed dielectric layer** **1.4 Fakir's bed of nails** **1.5 Mushroom HIS** **2. Functional HIS** **2.1 Antenna substrates** **2.2 Absorbers** **2.3 Reconfigurable HIS**	**Prof. Constantin Simovski**

	2.4 Exotic HIS: **2.4.1 Bianisotropic HIS** **2.4.2 HIS of SRRs** **3. Surface waves in microwave MSs** **3.1 Simplistic approach** **3.2 Dispersion diagram** **3.3 Spoof plasmon** **3.4 Two-mode regime** **3.5 Backward-wave regime** **Concluding remarks**	
9:50 – 10:20	**Coffee break**	
10:20 – 11:10	**Microwave Metasurfaces – Part II**	**Prof. Constantin Simovski**
11:10 – 12:00	**TeraHertz Metasurfaces – Part I**	**Prof. Willie Padilla**
12:15 – 13:45	**Lunch**	
13:50 – 14:40	**TeraHertz Metasurfaces – Part II**	**Prof. Willie Padilla**
15:00 – 17:30	**Social event** **Visit and wine tasting at "Chateau Larrivet Haut-Brion "**	
19:30 – 21:30	**School dinner in Bordeaux city**	

5 April – Wednesday

Hour	Topic	Lecturer
9:00 – 9:50	**Nano-optics with Metasurfaces – Part I**	**Dr Philippe Lalanne**
9:50 – 10:20	**Coffee break**	
10:20 – 11:10	**Nano-optics with Metasurfaces – Part II**	**Dr Philippe Lalanne**
11:10 – 12:00	**All Dielectric Metasurfaces – Part I** This lecture will overview the state of the art of research into metasurfaces consisting of two-dimensional arrangements of high-refractive-index dielectric nanoresonators. It will start by providing the motivations for this research area and by putting it into context with research focussing on plasmonic metasurfaces. Next, fundamental concepts regarding the optical properties of	**Dr Isabelle Staude**

	subwavelength dielectric nanoresonators will be established. To this end, I will discuss Mie-resonances in dielectric nanoparticles and analyse how they are influenced by the nanoparticle shape, size, material composition, and coupling to other nanoparticles. I will then turn to homogeneous dielectric metasurfaces, before focussing on graded Mie-resonant dielectric metasurfaces for wavefront control applications in more detail. Following this, I will provide an overview of the recent progress in active, tunable and nonlinear dielectric and semiconductor metasurfaces. Finally, potential applications of dielectric metasurfaces and the respective challenges are discussed. **Covered topics** ➢ Optical properties of high-index dielectric nanoparticles ➢ Fundamentals of resonant dielectric metasurfaces ➢ Electric and magnetic mirrors without metals ➢ Fano resonant dielectric metasurfaces ➢ Wavefront control with dielectric metasurfaces ➢ Active control of dielectric metasurfaces ➢ Nonlinear dielectric metasurfaces ➢ Light emission from dielectric metasurfaces ➢ Application prospects and challenges of dielectric metasurfaces	
12:15 – 13:45	**Lunch**	
14:00 – 14:50	**All Dielectric Metasurfaces – Part II**	**Dr Isabelle Staude**
14:50 – 15:40	**Plasmonic Metasurfaces– Part I: Far-Field applications** - Introduction - Modelling of plasmonic antennas - Birefringent interfaces - reflect-arrays - applications (phase plates, holograms and polarization plates)	**Dr Patrice Genevet**
15:40 – 16:00	**Coffee Break**	
16:00 – 16:50	**Plasmonic Metasurfaces – Part II: Near-field applications** - Surface holography - Cherenkov excitation of directional plasmons - Non diffracting plasmons - Conclusion and discussion on boundary conditions at arbitrary interfaces.	**Dr Patrice Genevet**

6 April – Thursday

Hour	Topic	Lecturer

09:00 – 9:50	**Free-form Surfaces** In transformation optics, coordinate transformations are usually mapped onto equivalent (meta-)material parameter distributions. In 2015, we introduced an alternative approach mapping coordinate transformations onto dielectric free-form surfaces. We presented model experiments on cloaking of otherwise shadowing contact fingers on solar cells. More recently, we have fabricated masters by 3D laser lithography used for soft imprinting – opening the door to mass fabrication. For prototype silicon heterojunction solar cells investigated under 1-sun illumination, we find the predicted 9% relative efficiency increase. We additionally show that our approach is adaptable to Lambertian sources, thereby cloaking contacts on diffusively light-emitting diodes (e.g., on OLEDs) to achieve spatially homogeneous (white-light) emission.	**Prof. Martin Wegener** **Karlsruhe Institute of Technology, Karlsruhe, Germany**
9:50 – 10:20	**Coffee break**	
10:20 – 11:10	**Examples of optical characterization of Metasurfaces**	**Dr. Alexandre Baron**
11:10 – 12:00	**Bottom-up fabrication of Metasurfaces**	**Dr. Virginie Ponsinet**
12:00 – 13:30	**Lunch and end of School**	