# 2024 ELEDIA@ICAM PhD Schools

# Surface Electromagnetics for Wireless Communications and Sensing

Artificial surfaces, metasurfaces, and Electromagnetic Skins are artificial sheet materials with sub-wavelength thickness that enable to control the properties of the transmitted / reflected waves according to the designer's specifications. Thanks to their electromagnetic and geometrical properties, these are among the most important technologies for the development of next generation wireless communications and sensing applications.

**The course aims at providing the fundamentals of Surface Electromagnetics theory and concepts, along with an overview of the most effective analysis/synthesis techniques and their most appealing/emerging applications in advanced engineering fields. Applicative examples including CAD exercises will corroborate the theoretical concepts.**

**Course Topics**

- Introduction and fundamentals of electromagnetic wireless systems.
- Recalls to the principles of electromagnetic fields, wireless propagation of plane waves, and EM wave scattering phenomena.
- Surface equivalence theorem and the concept of Surface Electromagnetics.
- Electromagnetic propagation through surface structures and 2D boundary conditions.
- Uniform surfaces, periodic and aperiodic boundary conditions and devices.
- The Generalized Snell's laws for reflection and refraction
- Electromagnetic wave manipulation using static/dynamic 2D artificial skins in transmission and in reflection.
- Applications for 6G communications and next-generation sensing systems.

**Teaching Activities**

- Theoretical Lessons
- e-Xam Self Assessment (each teaching class or periodically)
- MATLAB Hands-On
- e-Xam Final Assessment

**Lecturers**

- Prof. OLIVERI Giacomo (https://www.eledia.org/eledia-unitn/people/oliveri-giacomo/)
- Dr. SALUCCI Marco (https://www.eledia.org/eledia-unitn/people/salucci-marco/)
- Dr. SALAS SÁNCHEZ Aarón Ángel (https://www.eledia.org/eledia-unitn/people/salas-sanchez-aaron-angel/)

**References**


[1] F. Yang, Y. Rahmat-Samii, Surface Electromagnetics with Applications in Antenna, Microwave, and Optical Engineering, Cambridge University Press, 2019.

[2] N. Yu, P. Genevet, M. A. Kats, F. Aieta, J.-P. Tetienne, F. Capasso, and Z. Gaburro, "Light Propagation with Phase Discontinuities: Generalized Laws of Reflection and Refraction," Science, vol. 334, no. 6054, pp. 333-337, 2011.

[3] G. Oliveri, F. Zardi, P. Rocca, M. Salucci and A. Massa, "Building a Smart EM Environment - AI-Enhanced Aperiodic Micro-Scale Design of Passive EM Skins," in IEEE Transactions on Antennas and Propagation, vol. 70, no. 10, pp. 8757-8770, Oct. 2022.

[4] G. Oliveri, P. Rocca, M. Salucci and A. Massa, "Holographic Smart EM Skins for Advanced Beam Power Shaping in Next Generation Wireless Environments," in IEEE Journal on Multiscale and Multiphysics Computational Techniques, vol. 6, pp. 171-182, 2021.


**Dates:** July 1-5, 2024

**Location**

- *In presence*: Room 1H, Polo di Mesiano, Via Mesiano 77, 38123 Trento, Italy
- *Online*: Zoom Platform (video registrations will be available for 2 weeks after the event)

**Lessons**

- 32 h total (including exam – not mandatory)
- 12 h hands-on (in Matlab)

**Prerequisites:** Basics of Maths

**ECTS:** 4

**Registration Fees (*)**

- Free for UniTN Students
- 200 Euro - online attendance
- 400 Euro - in presence attendance

Registration is mandatory

**Course Coordination**

- Prof. Giacomo Oliveri
- Prof. Andrea Massa

**Further Information**

- summer-schools@eledia.org

(*) The fees include the course teaching and the slides/material

**Register at: https://edu.eledia.org/courses/phd-school-2024-surface-electromagnetics**


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