



UNIVERSITÀ DI PISA
DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE
Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

**“Electromagnetic Metasurfaces for Next Generation
4.0 Industry and Future Networks”**

Prof. Ing. Agostino Monorchio – Dott. Ing. Danilo Brizi

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Short Abstract:

In the last decades, electromagnetic metamaterials and metasurfaces have raised a huge amount of interest both in academic and industrial environments. The possibility to achieve unnatural and exotic properties confers to these solutions an unprecedented capability to shape, control and exploit the electromagnetic radiation for advanced applications. In the last years, the use of electromagnetic metamaterials and metasurfaces have been diffused also in 4.0 industry, increasing the diffusion and the development of innovative devices, sensors and productive processes.

The first part of the course will be directed to present the general theoretical aspects and modelization of metamaterials and metasurfaces, with a particular emphasis on the transversality among the different sectors where they found application. In the second part, practical test-cases of metasurfaces in advanced scenarios will be reported and discussed, along with design guidelines and tips to correctly dimension these tools. In details, sensing and imaging applications, useful for industrial, telecommunications and biomedical applications, and some examples about electromagnetic field manipulation will be described, as for instance absorption for lowering external disturbances at RF and microwaves, novel sensors and antennas, field filtering capability.

Course Contents in brief:

- Electromagnetic modelization of metamaterials and metasurfaces
- Derivation of practical design guidelines for 4.0 industry applications
- Practical test-case: sensing and imaging for industrial and biomedical applications;
- Practical test-case: radiation absorption/reflection for RF and MW coupling reduction and electromagnetic waves manipulation for stealth applications and next generation networks.

Total # of hours of lecture: 20

References:

- [1] Munk, Ben A. Frequency selective surfaces: theory and design. John Wiley & Sons, 2005.
[2] F. Costa, A. Monorchio and G. Manara, "Analysis and Design of Ultra Thin Electromagnetic Absorbers Comprising Resistively Loaded High Impedance Surfaces," in IEEE Transactions on

Antennas and Propagation, vol. 58, no. 5, pp. 1551-1558, May 2010, doi: 10.1109/TAP.2010.2044329.

[3] D. Brizi et al., "Design of Distributed Spiral Resonators for the Decoupling of MRI Double-Tuned RF Coils," in IEEE Transactions on Biomedical Engineering, vol. 67, no. 10, pp. 2806-2816, Oct. 2020, doi: 10.1109/TBME.2020.2971843.

CV of the Teachers

Agostino Monorchio is Full Professor at the University of Pisa. He spent several research periods at the Electromagnetic Communication Laboratory at Pennsylvania State University (USA), both as a recipient of a scholarship (Fellowship Award) of the Summa Foundation, New Mexico (USA), and in the framework of CNR-NATO Senior Fellowship programme. He has carried out a considerable research activity and technical consultancy to national, EU and U.S. industries, coordinating, as principal scientific investigator, a large number of national and European research projects. Prof. Monorchio is active in a number of areas including computational electromagnetics, microwave metamaterials, radio propagation for wireless systems, the design and miniaturization of antennas and electromagnetic compatibility, biomedical microwaves applications.

The activity is mainly carried out at the Microwave and Radiation Laboratory (www.mrlab.it) of the Department of Information Engineering, University of Pisa. His research results have been published in more than 130 journal papers and book chapters, and more than 200 communications at international and national conferences, he is co-author of 4 patents. In 2012 he has been elevated to Fellow grade by the IEEE for his contributions to computational electromagnetics and for application of frequency selective surfaces in metamaterials.

Danilo Brizi is an Assistant Professor at the University of Pisa. He received the M. Sc. degree in biomedical engineering and the Ph.D. degree in information engineering (both summa cum laude) from the University of Pisa, Italy, in 2016 and in 2020, respectively. From 2020 to 2021, he was a Post-Doctoral Researcher at the same university, Department of Information Engineering.

His research interests include: metamaterials and metasurfaces, wireless power transfer and electromagnetic biomedical imaging and sensing. His research activities have been published in several international scientific journals and in international conference proceedings. He is an IEEE and SIEM Member.

Room and Schedule

Room: Aula Riunioni del Dipartimento di Ingegneria dell'Informazione, Via G. Caruso 16, Pisa – Ground Floor for theoretical lessons; ex-B26 for hands-on design

Schedule:

Day1 – Theoretical aspects of metamaterials and metasurfaces

Day2 – Design guidelines and principles for 4.0 industry applications

Day3 – Test-case: sensing and imaging for industrial and biomedical applications;

radiation absorption/reflection for RF and MW coupling reduction and electromagnetic waves manipulation