



ERASMUS MUNDUS



# PHOTONICS - EUROPHOTONICS MASTER COURSE

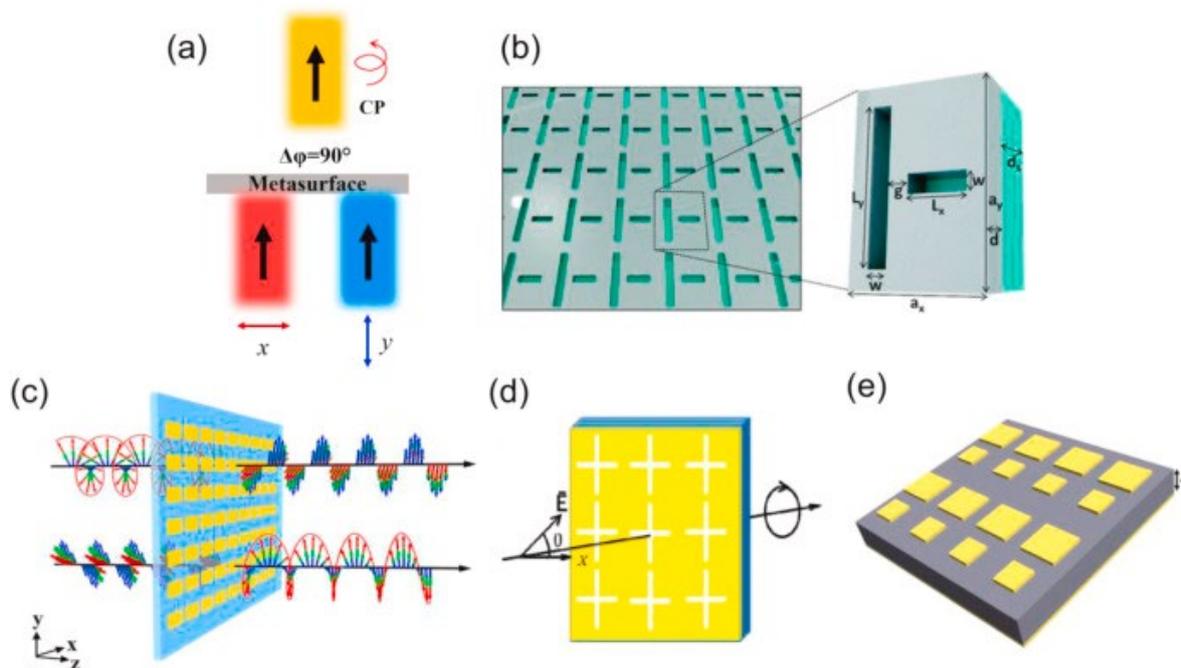
## PROPOSAL FOR A MASTER THESIS

Dates: February 1<sup>st</sup>, 2025 – September 30<sup>th</sup>, 2025

Laboratory: Centre for Sensors, Instrumentation and systems Development (UPC-CD6)  
City, Country: Terrassa, Spain

Title of the master thesis:

**EXPLORING METAMATERIALS THROUGH MUELLER MATRIX POLARIMETRY**



[Shen, Z., & Lin, X. (2023). A review of metasurface polarization devices. *Optical Materials*, 146, 114567.]

Name of the tutor of the master thesis: **Santiago Royo and Maria Ballesta**

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## Summary of the subject (maximum 1 page):

Metamaterials are artificially engineered structures designed to exhibit electromagnetic properties not commonly found in nature. Their unique interaction with light enables novel optical behaviors such as negative refractive index, polarization control, and enhanced scattering or absorption effects, which are of great interest for advanced photonic devices, sensors, and imaging technologies. To fully exploit these capabilities, it is essential to accurately characterize the optical response of metamaterials under various polarization conditions.

Mueller Matrix Polarimetry (MMP) is a powerful technique that provides a complete description of how a sample modifies the polarization state of incident light. By measuring the 16 elements of the Mueller matrix, one can extract rich information about the sample's diattenuation, retardance, and depolarization properties, leading to a deeper understanding of its micro- and nano-structural features.

The CD6 research center has recently acquired a new Mueller polarimeter that enables precise and versatile polarization measurements across a broad spectral range. This master's thesis will focus on exploring metamaterials using this new system, with the main objectives being the preparation, validation, and optimization of the experimental setup, followed by the characterization of several metamaterial samples provided by collaborators. The results will contribute to understanding their optical behavior and potential applications in polarization-based optical systems.

The student will join our multidisciplinary research group, with expertise in optical metrology, system design, photonics, and materials characterization. Support will be provided throughout the setup configuration, measurement process, data analysis, and interpretation of results.

The thesis will focus on four main areas:

- 1) **Technology background:** Understanding the working principles of Mueller Matrix Polarimetry and its implementation in the newly acquired instrument at CD6.
- 2) **State-of-the-Art Review:** Reviewing current literature on metamaterial optical characterization and Mueller polarimetry to define relevant parameters and analysis methods.
- 3) **Experimental setup and validation:** Preparing the measurement setup, aligning and calibrating the polarimeter, and validating its performance with reference samples.
- 4) **Sample characterization and analysis:** Measuring and analyzing different metamaterial samples to extract their optical parameters and interpret the underlying physical phenomena.

This project will establish a strong foundation for future research on advanced material characterization at CD6 and contribute to ongoing efforts in photonic and optical metrology. Basic programming skills (fluent Matlab or Python) and basic knowledge of electronics and optical system design are desirable, but not strictly required.

**Keywords:** Metamaterials, Mueller matrix, polarimetry, optical characterization, photonics, polarization, optical metrology

**Additional information :**

\* Amount of the monthly allowance (if it is the case):  
To be discussed depending on the value of candidate.

\* Required skills:

Interest in experimental, application-oriented research in optical metrology.

Basic concepts in optics, polarization, and photonic materials.

Programming skills (Python or Matlab) and experience with scientific data processing

Search of resources, both scientific and technical

Self-motivated, objective-driven, capable of autonomous working within a multidisciplinary team.

\* Miscellaneous:

Multidisciplinary environment with electronics and mechanics workshops, and specialists and technicians in metrology, optics, mechatronics, and electronics.

Possibility of joining the Centre for a PhD/Project Manager career in case of common interest.

Early incorporation welcome.