



## **PhD THESIS DEFENSE: "Multifunctional optical surfaces for optoelectronic devices"**

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Highly transparent optical surfaces with anti-reflection (AR) and self-cleaning properties have the potential to increase performance in a wide range of applications, such as display screens, photovoltaic cells or sensors. Nature has provided numerous examples of biological systems with interesting functionalities that have high commercial interest, from the broadband and omnidirectional anti-reflection effect created by the tiny nanopillars found on the corneas of moths' eyes, to the self-cleaning behaviour of lotus leaves generated by micro-and nanoprotuberances. However, despite intense academic research, replicating such elaborate nanostructures for mass-production remains a major challenge due to the limitations of the existing nanofabrication techniques based on classical optical and e-beam lithography processes.

This thesis is devoted to the study of bio-inspired multifunctional nanostructured surfaces with enhanced optical and wetting properties for use in optoelectronic devices. Novel and reliable manufacturing techniques are proposed for patterning organic and inorganic materials with high precision and throughput, aiming to bring this technology out of the laboratory and making it industrially viable.?

The first part of this study has been centred on glass, as it is one of the most widely used materials for optoelectronic devices. Chapter 3 presents a nanopillar structure created on glass substrates, which provides high anti-reflective properties, enhanced transmission, superhydrophobicity, and high mechanical resistance against external agents. The proposed manufacturing method permits moderate tunability to adapt the structure to the requirements of different applications. The design and optimisation of the fabrication process and a full characterisation of the samples are reported.

Chapter 4 describes the combination of two different anti-reflective approaches: state-of-the-art multilayer (ML) anti-reflective coatings and self-cleaning biomimetic nanostructures (NS). The classical ML coating, relying on destructive interference from multiple reflections at layer interfaces, is capable of providing excellent AR properties, but with a limited wavelength range and angular acceptance. In addition, it has limited hydrophobicity and self-cleaning properties due to its flat surface. The NS coating can provide broad wavelength and angular AR properties, as well as superhydrophobicity. However, it suffers from mechanical durability issues. In this work, the combination of both methods is presented as an innovative solution, combining greater anti-reflective operational wavelength and angular acceptance, self-cleaning properties, and high mechanical durability.

A nanostructured design for transparent oleophobic surfaces is investigated and experimentally demonstrated in Chapter 5. Two new fabrication techniques to create nanocavities on glass are presented. The nanohole structure can repel oil and other low surface tension liquids, and a new wetting model is developed to theoretically explain the mechanism. The porous structure modifies the effective refractive index of the nanostructured layer between the air and the glass, creating an AR effect. The samples present higher transmission, as well as low scattering due to the subwavelength size of the cavities. In addition, the geometry of the surface offers higher mechanical resistance compared to nanopillars, widening the potential applications where it could be used.

Finally, in Chapter 6, a new method to nanostructure organic materials with high resolution is presented. Nanostructured thin polyimide films on top of glass surfaces can act as an anti-reflective coating, while adding protection and hydrophobicity. A practical example is demonstrated with transparent electrodes made of Indium Tin Oxide. By covering a surface with nanostructured polyimide, the overall optical response can be improved while its electric properties are protected by the polymeric film.



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