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

JUAN ROMBAUT SEGARRA

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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 use materials for optoelectronic devices. Chapter 3 presents a nanopillar structure created o glass substrates, which provides high anti-reflective properties, enhanced transmission superhydrophobicity, and high mechanical resistance against external agents. The propose manufacturing method permits moderate tunability to adapt the structure to th requirements of different applications. The design and optimisation of the fabricatio 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 biomimeti nanostructures (NS). The classical ML coating, relying on destructive interference fro multiple reflections at layer interfaces is capable of providing excellent AR properties, bu with a limited wavelength range and angular acceptance. In addition, it has limite hydrophobicity and self-cleaning properties due to its flat surface. The NS coating ca provide broad wavelength and angular AR properties, as well as superhydrophobicity However, it suffers from mechanical durability issues. In this work, the combination of bot methods is presented as an innovative solution, combining greater anti-reflective operationa wavelength and angular acceptance, self-cleaning properties, and high mechanica durability

A nanostructured design for transparent oleophobic surfaces is investigated an experimentally demonstrated in Chapter 5. Two new fabrication techniques to creat nanocavities on glass are presented. The nanohole structure can repel oil and other lo surface tension liquids, and a new wetting model is developed to theoretically explain th mechanism. The porous structure modifies the effective refractive index of th nanostructured layer between the air and the glass, creating an AR effect. The sample present higher transmission, as well as low scattering due to the subwavelength size of th cavities. In addition, the geometry of the surface offers higher mechanical resistanc 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 i presented. Nanostructured thin polyimide films on top of glass surfaces can act as a anti-reflective coating, while adding protection and hydrophobicity. A practical example i demonstrated with transparent electrodes made of Indium Tin Oxide. By covering a surfac with nanostructured polyimide, the overall optical response can be improved while it electric properties are protected by the polymeric film

Thesis Director: Prof Dr. Valerio Pruneri

Hosted by: Prof. Dr. Valerio Pruneri