

Phd Thesis Defense: Transparent glass surfaces with functional metallic nanostructures for display applications

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15:30

ICFO Auditorium

Display technologies are ubiquitous in everyday life, generally consist of multiple functional components arranged in a stack, where each layer must satisfy specific optical, electrical, mechanical and surface requirements. In this context, nanofabrication offers the possibility to modify material properties and introduce additional functionalities without compromising the primary operation of the device. Glass represents an ideal platform because of its optical transparency, mechanical robustness, chemical stability, and compatibility with thin-film deposition and surface processing. Among the possible material approaches, ultra-thin metal films (UTMFs) are particularly attractive, as their response can be strongly tuned through

composition, thickness, morphology, and nanoscale structuring. This thesis investigates the engineering of UTMFs and derived metallic nanostructures on glass for multifunctional display-related applications, with particular emphasis on transparent antimicrobial surfaces and transparent conductors.

The first part addresses high-touch surfaces, such as public and shared touchscreens, which can contribute to microbial transmission. Ultra-thin copper films were thermally dewetted to form electrically isolated nanostructures, preserving compatibility with capacitive touch sensing while providing strong antimicrobial activity. Optimization of the thermal treatment enabled control of particle morphology and plasmonic response. Combined with a silica protective layer and an Easy-To-Clean coating, the resulting surfaces achieved bacterial reduction above 99.9%, visible transmission of approximately 70-80%, electrical insulation, and resistance to mechanical abrasion.

To further improve the optical performance of antimicrobial surface, Cu-Zn mixed films were investigated as a material-engineering strategy to increase color neutrality while maintaining the antimicrobial functionality of Cu. Co-sputtered Cu-Zn films followed by thermal dewetting produced transparent and electrically insulating nanostructured surfaces with transmission above 80% in the visible range, improved color neutrality, and bacterial reduction exceeding 99.9%. The results demonstrate how compositional engineering can tune the optical response without compromising antimicrobial efficacy.

The final part of the thesis explores UTMFs as transparent conductors. Several metals were compared in terms of transmission, sheet resistance, film growth, and percolation behavior, identifying CuZn as a promising material because of its balance between conductivity, transparency, color neutrality, film formation, and time stability. Its optoelectronic properties were further investigated as a function of thickness, thermal annealing, and aging. Compositional analysis indicated a redistribution of Zn toward the surface, associated with the formation of a protective Zn-rich oxidized region and a comparatively Cu-rich metallic layer underneath. This evolution is consistent with the experimentally observed increase in optical transmission and decrease in sheet resistance. Finally, a lithography-free colloidal patterning approach was explored to introduce openings into CuZn UTMF and further tune the trade-off between optical transmission and electrical conductivity.

Overall, this work demonstrates how composition, thickness, and nanoscale morphology can be used to engineer ultra-thin metallic systems toward markedly different functionalities. Optical modelling and experimental nanofabrication were combined throughout the work, with particular attention to fabrication routes compatible with scalable industrial processing. The results highlight the potential of UTMFs as a versatile platform for transparent glass surfaces combining optical quality with antimicrobial activity, electrical insulation, or electrical conduction for next-generation display and optoelectronic technologies.

Wednesday December 2, 15:30 h. ICFO Auditorium

Thesis Director: Prof. Dr. Valerio Pruneri and Dr. Prantik Mazumder

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Hosted by: Prof. Dr. Valerio Pruneri