Characterisation of self-assembled diblock copolymers optical metasurfaces by hybrid metrology approach

Irdi Murataj [1]*, Angelo Angelini[1], Eleonora Cara[1], Samuele Porro[2], Burkhard Beckhoff [3], Philipp Hönicke [3], Christian Gollwitzer [3], Natascia De Leo [1], Luca Boarino[1], and Federico Ferrarese Lupi [1]*

[1] Istituto Nazionale di Ricerca Metrologica - INRiM, 10135 Torino, Italy
[2] DISAT, Politecnico di Torino, 10129 Torino, Italy
[3] Physikalisch-Technische Bundesanstalt - PTB, 10587, Berlin, Germany

*Corresponding authors' email: i.murataj@inrim.it, f.ferrareselupi@inrim.it

Abstract

Metasurfaces are gaining research interest due to their efficient miniaturization and novel functionalities, making them a popular choice for optical elements. Advancements in nanofabrication have reduced metasurface dimensions to nanometer scales, expanding their capabilities to cover visible wavelengths. However, large-scale metasurface manufacturing presents challenges in controlling dimensions and composition of dielectric materials. The combination of block copolymer (BCP) self-assembly and sequential infiltration synthesis (SIS) by Atomic Layer Deposition (ALD) offers an alternative for fabricating high-resolution dielectric nanostructures with tailored composition and optical functionalities, addressing these challenges. This work introduces a hybrid metrology innovative strategy that combines synchrotron-based traceable X-ray techniques to provide precise and reliable characterization of the refractive index of dielectric nanostructures, enabling comprehensive material characterization on the nanoscale. The study regards the fabrication of TiO_2 nanostructures model systems using SIS of BCPs to correlate material functionality with their chemical, compositional, and dimensional properties. Synchrotron-based analyses were integrated into physical models, validating laboratory-scale measurements for effective refractive indices of nanoscale dielectric materials.

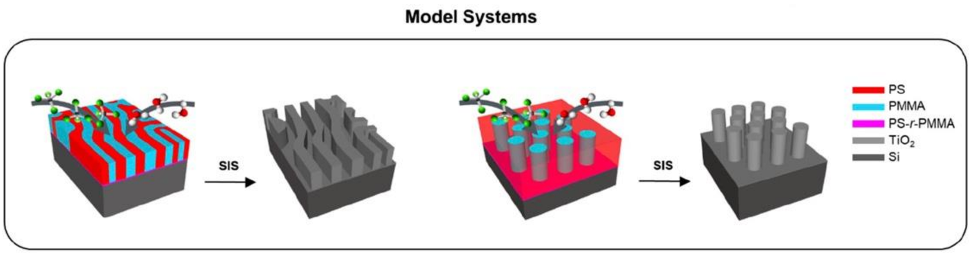

Figure 1: scheme of the block copolymer templates, (lamellar and cylinder morphologies) undergoing sequential infiltration synthesis of TiO_2 in PMMA (light-blue) nanodomains, and after the uninfiltrated PS phase removal. The dimensions of nanostructures, and substrate are exaggerated and not in scale.