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Bioinspired microstructures polymer surfaces with antireflective properties

Alexandre Wetzel, Ada-Ioana Bunea, Einstom Engay, Nikolaj Kofoed Mandsberg, Nuria del Castillo Iniesta, Anja Boisen, Kirstine Berg-Sørensen and Rafael Taboryski

Antireflective (AR) coatings have been around for more than a century, with the simplest form dating back to Lord Rayleigh's 1886 tarnished glass. Different approaches to obtaining AR coatings exploit index-matching, interference or absorbing phenomena. In 2002, a novel superblack surface was developed by Brown et al. at the National Physical Laboratory in UK, and soon gained significant interest among both academia and industry.[1] Since then, scientists have been competing in a race to produce the blackest material. Although extremely valuable, existing solutions usually require complicated fabrication procedures and post-application treatments.

Structural colors are ubiquitous in nature, so an interesting approach for developing AR coatings is biomimicry. Moth-eye structures are well-known for their AR properties, and they have been successfully replicated using micro- and nanofabrication methods and employed as AR coatings.[2,3] Interestingly, recent studies from Harvard highlight two types of microstructures that lead to superblack coloring in nature, i.e. barbule microstructures on birds of paradise,[4] and cuticular bumps on peacock spiders.[5] These publications provide detailed information on the shape of such natural superblack microstructures and the mechanisms behind the observed superblack effect. Although replication of such structures should prove extremely valuable, it has not yet been demonstrated.

In this paper, we present the fabrication and characterization of antireflective microarrays inspired by the peacock spiders' superblack structures encountered in nature. Fabrication is done by super-resolution 3D printing using two-photon polymerization of an acrylic resin. The optical properties of microstructure arrays with different shape design parameters are then characterized using a homemade reflectance / transmittance setup which allows wavelength-dependent investigations in the ultraviolet, visible and near-infrared range. The influence of the shape design parameters on the optical properties of the microarrays is then explained through experimental measurements, as well as simulations.

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