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## Ink-free color decoration

Anders Kristensen<sup>\*1</sup>, Emil Højlund-Nielsen<sup>1</sup>, Cristian Lavieta<sup>1</sup>, Xiaolong Zhu<sup>1</sup>, N. Asger Mortensen<sup>2</sup>

1: DTU Nanotech; 2: DTU Fotonik

\*Corresponding author email: anders.kristensen@nanotech.dtu.dk

This paper describes plasmonic colors based on the concept of localized surface plasmon resonances (LSPR) for decoration of high volume manufactured plastic products [1]. A palette of bright and angle-insensitive colors, spanning the entire visible spectrum, is realized by utilizing the hybridization between LSPR modes in aluminium nano-disks, and nano-holes. Research grade, clean-room fabricated plasmonic metasurfaces are transferred to industrial production of plastic consumer products. Plastic components are embossed or injection moulded with a nano-textured surface, comprising an array of nano-scale pillars. The master-original for the square-centimeter nano-texture is realized by means fast e-beam writing or colloidal lithography. The nano-disk/nano-hole plasmonic metasurface is formed when a thin film of aluminium is deposited on top of the nanopillar array. The nanotextured plasmonic metasurface is covered with a transparent protective coating, which can withstand the daily life handling. This approach also supports a cradle-to-cradle production philosophy: Plastic products can be injection moulded using a single plastic base material, where the color decoration is realized by the as-injection-moulded nano-textured surface, covered by a thin (10-20 nm) metal film plus a 1-20  $\mu\text{m}$  protective coating. After use, the product can be grinded, where the thin film coatings, which are the same for all products, represents a contamination level in the sub ppm level of the base material granulate – which is thereby directly re-usable.



Flexible plastic foil with embedded plasmonic color meta-surface decoration. The color appears from a thin film of aluminium deposited on top of a nanotextured surface.

1. Jeppe S. Clausen et al., Nano Letters, **14**, 4499-4504 (2014)