

Hierarchical design optimizes transparency and haze factor of holey metal films

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Colloidal lithography is a key feature to fabricate thin metal coatings with regularly arranged nanoholes [1]. These nanohole arrays find application for instance as optically transparent electron conductive coatings and serve as ideal model structures to study the relation between optoelectronic properties and structural design. An important but less systematically studied property of transparent conductors is the amount of scattered light passing through the coating, described by the haze factor. We investigated systematically the influence of structural parameters of metal nanohole array coatings on the optical performance. The transmission, transparency and haze factor are highly dependent on each other and cannot be controlled individually. Generally, the percolation threshold sets an upper limit for the transparency of such metal nanohole array coatings. Here, we propose a new fabrication method to optimize the optoelectronic properties and maximize the transparency up to 84%. A hierarchical design of metal micro/nanohole arrays combines precisely controlled and highly regular features at two length scales and simultaneously provides low haze factors. Further, finite elements and ray optic computer simulations are in close agreement with the experimental results. They reveal that the reduced haze factor results from a drastic decrease of grating efficiency in the hierarchical films [2].

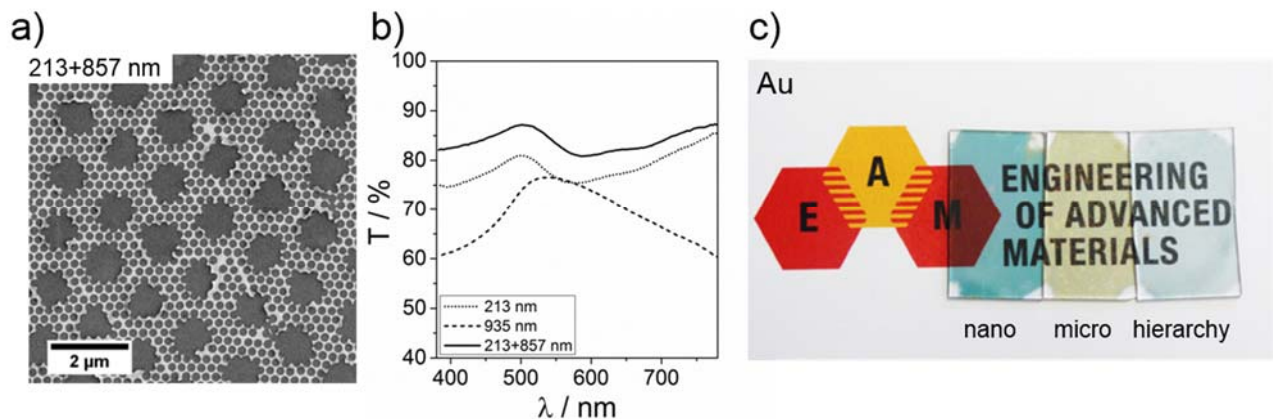


Figure 1. Optimized optical performance of hierarchical gold micro/nanohole arrays. 15 nm gold film with small hole diameter $D_{\text{small}} = 213$ nm (periodicity: $a = 245$ nm; ratio $D/a = 0.87$) and large holes with $D_{\text{large}} = 857$ nm (periodicity: $a = 1500$ nm). (a) scanning electron micrograph of the regular micro/nanohole structure, (b) transmission spectra of small (dotted line), large (dashed line) and hierarchical array (compact line), (c) photograph single hole size nano-, microhole, and hierarchical micro/nanohole array coating.

[1] K. Cheng, *Nanotechnology* **2012**, 23, 425303.

[2] K. Bley, *Adv. Funct. Mater.* **2018**, 1706965.

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