Novel approach for precise and flexible micro-nano patterning of surfaces towards enabling controlled textures on arbitrary objects

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Patterning of curved surfaces or 3D objects with micrometer and nanometer scale precision and design flexibility is a challenging issue, for which no universal solution exists. Control upon functionalities such as water and oil wetting, e.g. superhydrofobicity, oleophylicity, or light management can be obtained when texturing the surface of metals or plastics (1). Micro/nanostructured surfaces actually provide significant added value to many products in terms of performance, durability or appearance, as full control on properties such as friction, self-cleaning or mate finishing can be achieved.

Robust and very high resolution methods like photolithography or electron beam lithography routinely employed in industries such as the semiconductors are primarily applied on optically polished surfaces, e.g. Si wafers (2). Alternatively, efficient methods able to process large areas, include laser machining (3). Yet, among its limitations, truly flexible design is not made accessible. Moreover, massive manufacturing technologies such as plastic injection increasingly require molds patterned with micro/nano features. In this case, some solutions based on insertions have demonstrated certain capabilities (4), whereas an alternative method would be to micro/nanostructure directly the mold and demonstrate good replication fidelity.

In this communication, we present an original and versatile method for transferring any micro-nanopatterned structure to arbitrary surfaces, including curved surfaces, Fig.1 (5). First, the micro/nanostructures are defined by standard semiconductor processes on top of a polymer film deposited on a silicon wafer. This compound layer is delaminated and transferred to the target substrate. Our strategy can be applied, and has been demonstrated on a curved, steel mold surface, Fig. 1, and at wafer scale, Fig. 2. Their use in replication by plastic injection has also been validated for several aspect ratios, Fig. 3. These successive proofs of concept highlight, the following aspects: i) flexible, thin polymer media for transfer is appropriate, ii) transferred features keep their original form, iii) they become strongly bonded to the substrate, so that, iv) their plastic replica can be made very accurately.

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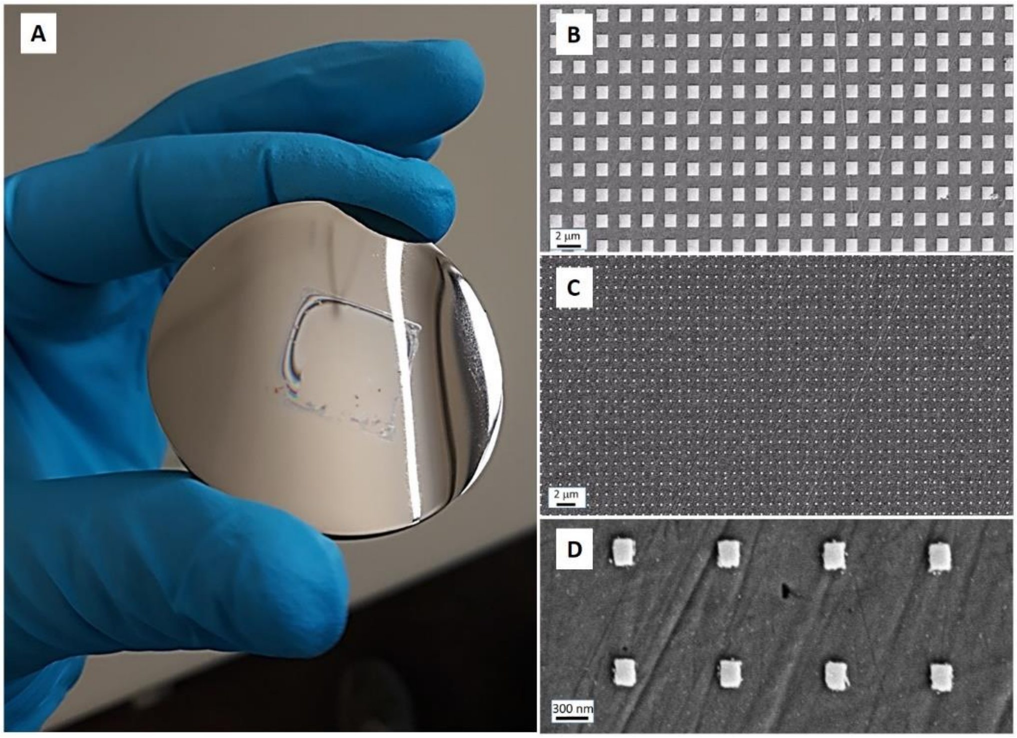

Figure 1: Thin-film metal micro/nano patterns transferred to a curved steel mold

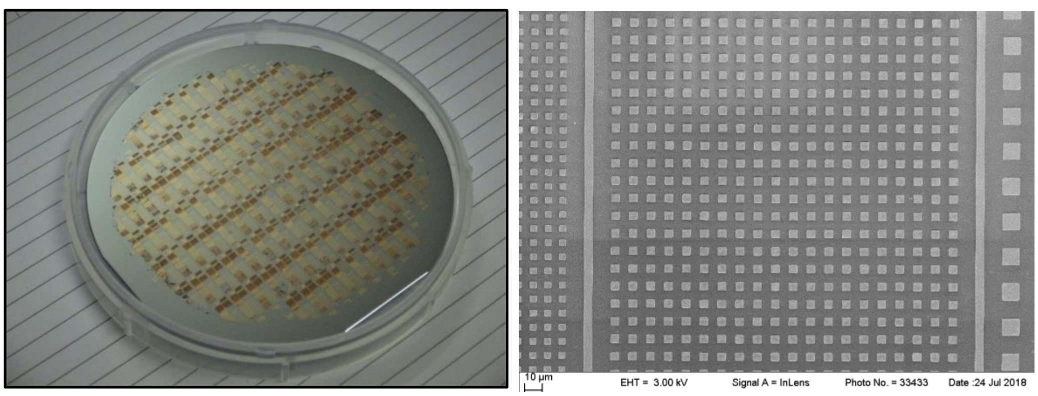

Figure 2: 4" wafer scale transfer of photolithography structures

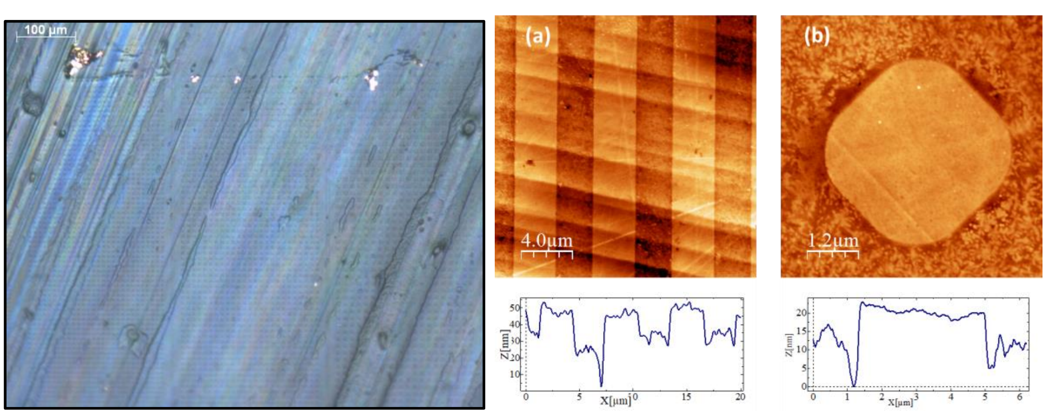

Figure 3: Transfer of microstructures. Replicated on plastic by injection molding