Biomimicking natural nanopatterned topology by 3D laser lithography

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Natural nanopatterned surfaces (nNPS) present on insect wings have demonstrated bactericidal activity [1, 2]. Fabricated nanopatterned surfaces (fNPS) derived by characterization of these wings have also shown superior bactericidal activity [2]. However bactericidal NPS topologies vary in both geometry and chemical characteristics of the individual features in different insects and fabricated surfaces, rendering it difficult to ascertain the optimum geometrical parameters underling bactericidal activity. This situation calls for the adaptation of new and emerging techniques, which are capable of fabricating and characterising comparable structures to nNPS from biocompatible materials. In this research, CAD drawn nNPS representing an area of 10 µm x10 µm was fabricated on a fused silica glass by Nanoscribe photonic professional GT 3D laser lithography system using two photon polymerization lithography. The glass was cleaned with acetone and isopropyl alcohol thrice and a drop of IP-DIP photoresist from Nanoscribe GmbH was cast onto the glass slide prior to patterning. Photosensitive IP-DIP resist was polymerized with high precision to make the surface nanopatterns using a 780 nm wavelength laser. Both moving-beam fixed-sample (MBFS) and fixed-beam moving-sample (FBMS) fabrication approaches were tested during the fabrication process to determine the best approach for the precise fabrication of the required nanotopological pattern. Laser power was also optimized to fabricate the required fNPS, where this was changed from 3mW to 10mW to determine the optimum laser power for the polymerization of the photoresist for fabricating FNPS.

The power of 4 mW was the best for the fabrication of CAD drawn pattern by both fabrication approaches (see Figures 2 & 3). The Individual geometrical parameters of fabricated single nanopillars were approximately 200 nm (height), 100 nm (diam, ϕ) and 150 nm apart from each other. To fabricate 10 µm x10 µm surface area at 4 mW laser power using MBFS approach took 2 minutes while FBMS approach took 13 minutes. Defects were found in the faster MBFS-fabricated (Figure 3a) in contrast with the FBMS approach that produced defect-free features with high precision (Figure 3b); however, due to limitations in spatial resolution, its fabricate features were limited to 100 nm ϕ. The patterns were characterized by FE-SEM. We conclude that photopolymerisation technique is well suited to fabrication of nanotopological features that are aimed at the study of bactericidal activity on nanopatterned surfaces.

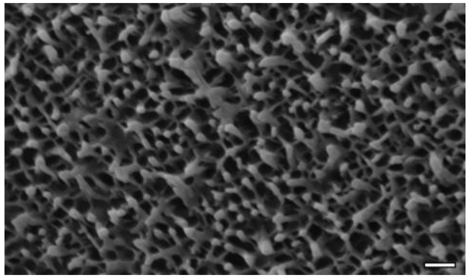

Figure 1: SEM of natural nanopatterned surface (NPS) of dragonfly wing. Dimensions: 200 nm (height) 55 nm (diameter). Scale bar: 200 nm

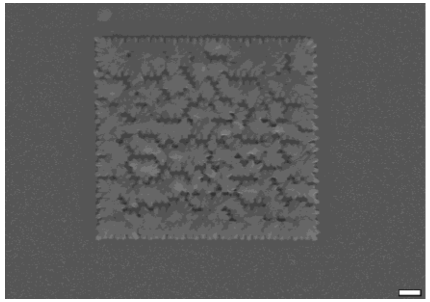

Figure 2: SEM showing failure of fabricating nanopattern using 5 mW. Scale bar: 1 µm

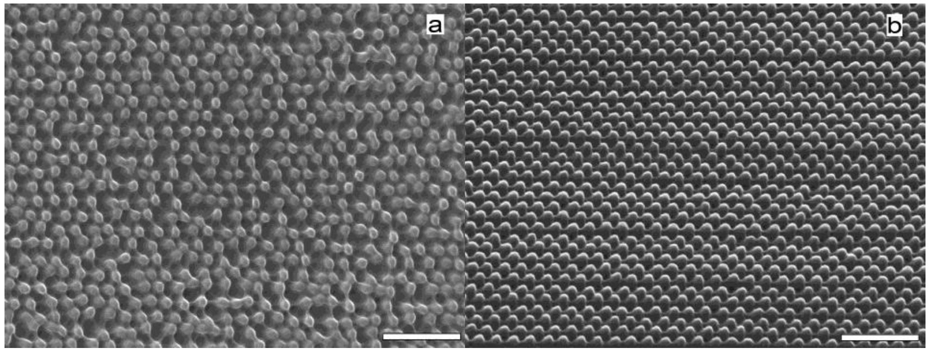

Figure 3: FE-SEM of top view of fabricated nanopatterns by Nanoscribe photonic professional GT 3D laser lithography system on glass at 4 mW laser power a) MBFS approach which resulted in deviation to the CAD drawn pattern following 2 mins of fabricating 10 µm x10 µm surface area. b) FBMS approach yielding high precision fabrication of the CAD pattern following 13 minutes of fabricating same surface area of 10 µm x10 µm. Scale bar: 1 µm.

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