

## Functionalization of silicon dioxide micropillars for biosensing and microarray technology

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### Abstract

Macroporous silicon produced by electrochemical etching has been proved to be a promising material in a broad range of applications due to its versatility and low cost technology [1-3]. One interesting structure that can be obtained from macroporous silicon is silicon dioxide ( $\text{SiO}_2$ ) micropillar arrays. The uniformity and geometry of these micropillar arrays rely on the fabrication conditions as the micropillar structure is directly related with the pore geometry of the macroporous silicon. Briefly, these structures can be fabricated from macropores produced by electrochemical etching of n or p-type silicon wafers in hydrofluoric acid (HF) solutions. After the fabrication of macroporous silicon, the samples are thermally oxidized under oxygen atmosphere to obtain a silicon dioxide layer on all the surface. The last step is to remove the silicon dioxide layer on the backside of the wafer and to etch the silicon in TMAH solution to release the micropillars. The oxide within the macropores is resistant to the TMAH etch and silicon dioxide tips begin to appear on the backside of the wafer [4-5].

If the backside of the silicon wafer is patterned by lithographic techniques, we can obtain a platform of silicon dioxide pillar arrays inside truncated micropyramids. Figure 1 shows an example of silicon dioxide micropillar arrays inside of a set of truncated inverted pyramids. The size of the mask together with the etching time determine the dimensions of the pyramid. A large number of these structures can be fabricated on a single wafer and each one of those truncated pyramids can be used for detection of different molecular binding events [6] increasing at the same time the contact area between probes and target molecules due to the presence of the micropillars.

These micropillar arrays can be used as microarchitected substrate for cell capturing and for biosensing. In all the cases the surface have to be functionalized in order to be selective to specific substances [7-8]. To demonstrate the feasibility of the chemical modification, the outer surface of the silicon dioxide micropillars was functionalized by silanization with 3-aminopropyltriethoxysilane (APTES). Subsequently, the amine group of APTES is activated by incubation in glutaraldehyde (GTA). Finally, the samples were incubated with fluorescein-labelled bovine serum albumin (BSA-FITC). Figure 2 shows a composed figure of scanning electron microscope (SEM) image of one inverted pyramid with micropillars and a schematic representation of the functionalization of the  $\text{SiO}_2$  micropillars.

The FITC fluorescent labelling of the protein is used to confirm the BSA attachment onto the functionalized  $\text{SiO}_2$  micropillars. The observation under a fluorescence microscope revealed that the FITC-BSA bounds to the  $\text{SiO}_2$  micropillars. Figure 3 shows a confocal microscopy image top view of the silicon dioxide micropillars functionalized with APTES, GTA and FITC. Green colour comes from the FITC-BSA functionalized surfaces.

In conclusion, silicon dioxide micropillar arrays are potential biosensing platforms for molecular detection in biotechnological applications such as the detection of molecular binding events, substrates for cell culture and so on.

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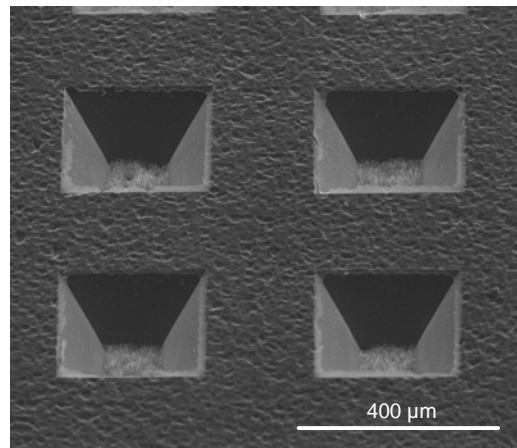


Figure 1. SEM image of a set of inverted truncated pyramids with disordered SiO<sub>2</sub> micropillars.

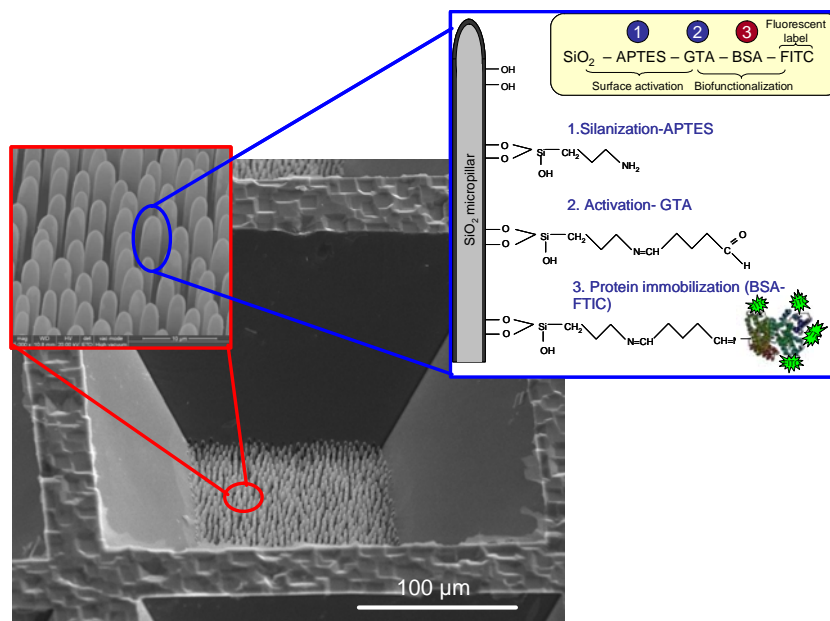


Figure 2. SEM image of an inverted truncated pyramid with disordered SiO<sub>2</sub> micropillars and schematic functionalization of micropillar.

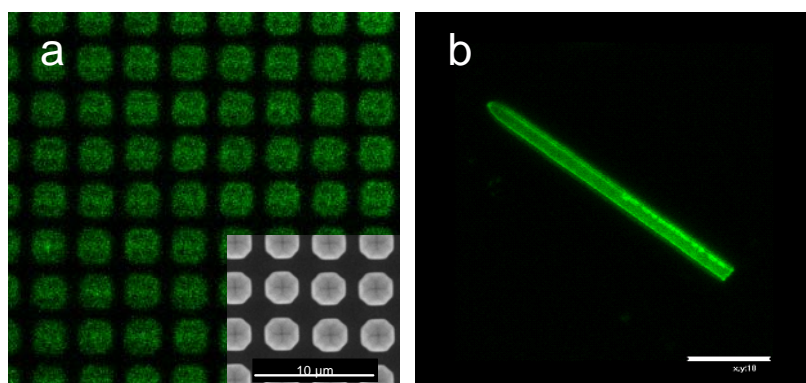


Figure 3 Confocal microscopy top view of functionalized and fluorescent labelled (APTES + FITC) a) ordered SiO<sub>2</sub> micropillars and b) single unattached SiO<sub>2</sub> micropillar. The green color indicates the fluorescence of FITC.