# High-Aspect-Ratio Plasma-Induced Nanotexturing of Polymers (PDMS, PMMA, PEEK, ...) for protein adsorption applications

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In the present work, we fabricate random columnar-like high-aspect ratio micro- and nano-structures based on plasma-induced roughening of commercial polymers and use them as templates for protein adsorption. Poly(dimethyl siloxane) PDMS is roughened in $SF_6$ plasmas, while Poly(methyl methacrylate) (PMMA) and Poly(ether ether ketone) (PEEK) is roughened in $O_2$ plasmas. Such polymer surfaces could also find applications as wetting controlling surfaces from super-hydrophilic to super-hydrophobic [1-3].

The height of columns varies from tens of nm to tens of μm, by increasing the duration of $SF_6$ plasma treatment as shown in Fig. 1, while their density is also affected, as aggregates of nanocolumns are created at longer treatment time. Fig. 2(a, b) illustrates PMMA and PEEK surfaces as viewed at a tilt under scanning electron microscopy, after etching with $O_2$ plasma, under conditions ensuring high etch rates 1000 and 660 nm/min respectively. Surface wettability is a critical parameter in protein adsorption and for this reason, fresh and aged nanostructured surfaces are investigated. An increase in biotinylated-BSA adsorption is observed on PDMS and PMMA nano-columnar surfaces, compared to flat untreated PDMS and PMMA surfaces, due to modified surface chemistry as well as increased surface area. Best spot morphology is obtained either for the case of fresh samples, even for long plasma treatment durations, or for the case of aged samples for short plasma treatment duration, as shown in Fig. 3. Specifically PDMS nanostructured surfaces, because of their enhanced hydrophobicity, prevent spreading of protein solution droplets and thus, there is no need for complex fabrication of micro-array platforms. Fig. 4 shows that in fresh $SF_6$-treated samples, protein adsorption increases with protein concentration and with plasma treatment time, while even larger adsorption is observed for aged samples.

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1. A. Tserepi, E. Gogolides, K. Misiakos, M. E. Vlachopoulou, and N. Vourdas, Greek Patent Application 20050100473; PCT Application Number GR2006/000011.
2. N. Vourdas, A. Tserepi, and E. Gogolides, Nanotechnology **18**, 125304 (2007).
3. A. Tserepi, M.E. Vlachopoulou, and E. Gogolides, Nanotechnology **17**, 3977 (2006).

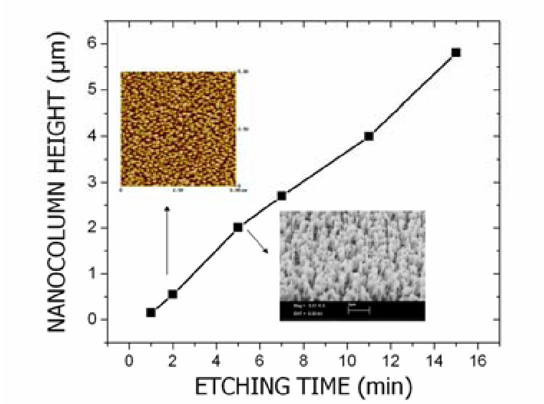


*Fig.1*: Variation of surface topography of PDMS with $SF_6$ plasma treatment time.

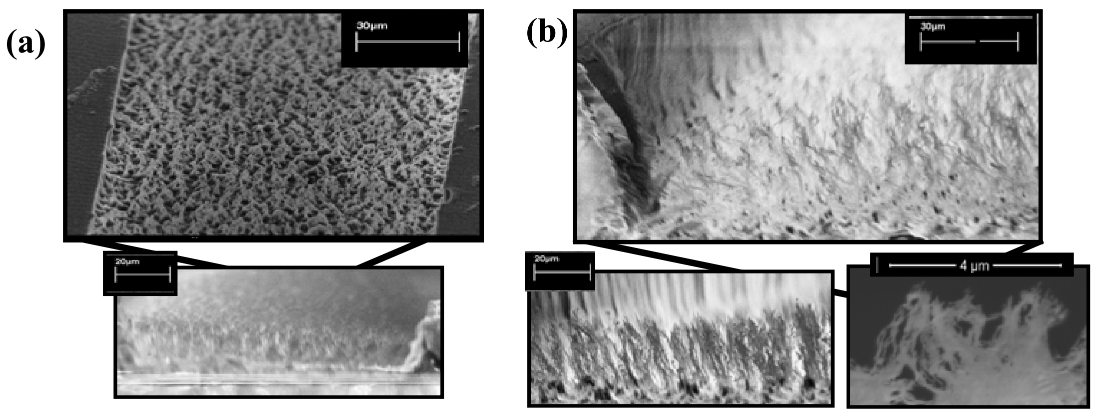


*Fig 2*: SEM images of (a) PMMA and (b) PEEK surfaces after 20 and 60 min $O_2$ plasma etching.

**(a)** **(b)** **(c)**

*Fig.3* : Protein spot on (a) a flat untreated PDMS surface, (b) a fresh 6-minute $SF_6$ plasma treated PDMS surface and (c) an aged 4-minute $SF_6$ plasma treated PDMS surface.

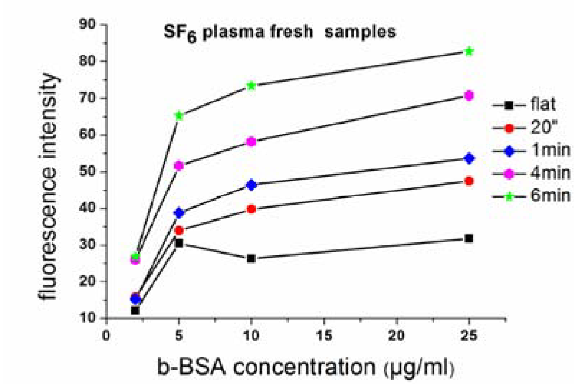


*Fig.4*: Variation of fluorescence intensity of proteins on fresh $SF_6$ plasma treated surfaces, for different plasma exposure time.