Nanostructured 3D shape platform for controlled selectivity applications fabricated by direct writing electron beam lithography

G.C Gomes, T. Mazon, R.R. Panepucci
Center for Information Technology Renato Archer - CTI, DMI, Rodovia D. Pedro I (SP - 65) Km 143, 6 Amarais, Campinas, SP, Brazil
gcgomes@cti.gov.br

The development of nanofabrication techniques is essential for the rapid advance of nanoscience as a whole. Innovative approaches and applications motivate further process developments to satisfy specific features and throughput requirements. Devices dedicated for biological agents recognition use molecular imprinting polymer technique to produce stamps for individual templates, such as viruses, molecules, bacteria and proteins[1] (Fig 1a). However the inherent presence of contaminants can lead to other types of molds and decrease the efficiency in selectivity and specificity of the devices.

In this work we use the direct writing properties of electron beam lithography for the development of a nanostructured surface-based platform. We present a systematic approach varying the patterned geometries and optimizing the process parameters such as the pattern diameter, pitch, beam energy, exposure factor and resist thickness (Fig. 1c). The aim of this work is to fabricate a platform of semi-spheres with high resolution in a resist surface. We used the SEM-FEG TESCAN MIRA3 system with proximity effect corrections to achieve templates with different geometries. Monte Carlo simulations were applied to optimize the beam energy and the resist thickness. In this work we will present the main aspects of the TESCAN dedicated DrawBeam software used to design the patterned geometries. Figure 1b shows results for a tri-dimensional surface designed with circles of 20 nm diameter and 80 nm of center-to-center distance fabricated in a 65 nm thickness of PMMA 495K. In this case it was achieved with 30 kV of beam energy and 250 $\mu C/cm^2$ of dose. We will present a comprehensive study of parameters.

A platform for patterned 3D shaped nanostructures containing higher density of active sites should be suitable for selectivity control applications in biosensors devices. Direct writing electron beam lithography is an alternative allowing standardization and reproducibility in manufacturing, increasing the commercial viability of imprinted polymer based biosensor devices[1,2].

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[1]Karthik, A. Margulis, K, Ren, K, Zare, R.N., Leung, L.W. *Rapid and Selective Detection of Viruses Using Virus-Imprinted Polymer Films*. Nanoscale 7 (45) (2015) 1898-9003.
[2]Shahali, H., Hasan, J., Cheng, H., Ramarishna, S., Yarlagadda, P.K. *A systematic approach towards biomimicry of nanopatterned cicada wings on titanium using electron beam lithography*. Nanotechnology 32 (2021) 065301.

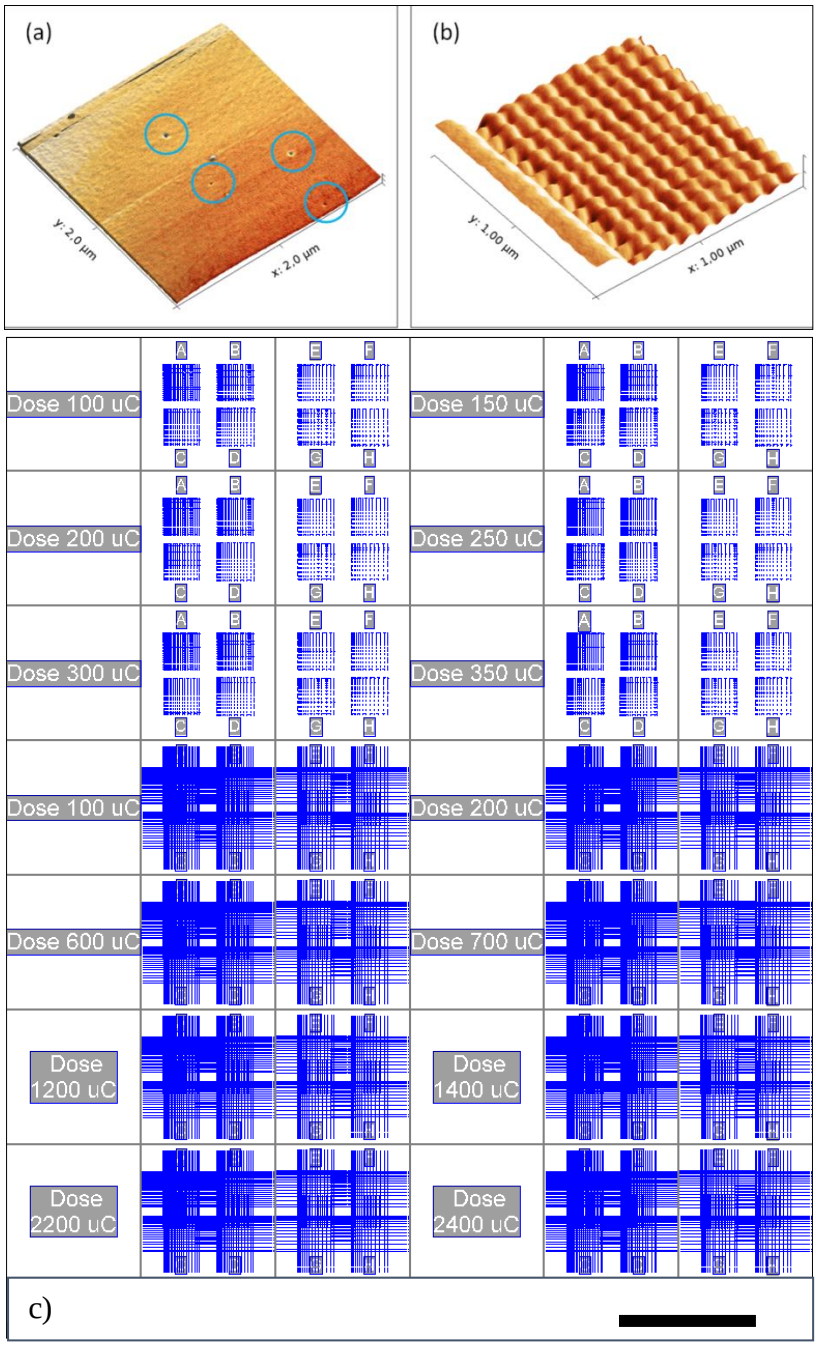

Figure 1: (a) AFM image of a polymer surface containing sparse molecularly imprinted dots (indicated by blue circles) in a 2×2 µm area, (b) a 3D nanostructured surface fabricated by direct writing electron beam lithography in 65 nm PMMA as our preliminary result and (c) CAD pattern designed to optimize process parameters. Scale bar 30 µm.