Designing nanoporous anodic alumina for nanomedicine applications

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Nanostructured porous materials have been used as versatile platforms in nanomedicine. In this context, nanoporous anodic alumina (NAA) has demonstrated to be an excellent functional platform for diagnostic, drug delivery and tissue engineering. One important characteristic of NAA is its well-defined cylindrical pores, with diameters tunable from a few to hundred nanometers and profiles that can be modulated in depth to design photonic structures [1-3]. Here, we present advances in the structural design of NAA and their application in biosensing, drug delivery and cell culture.

The fabrication of self-ordered NAA structures based on electrochemical etching process is presented and discussed as well as examples of new 2D and 3D micro and advanced nanostructures based on NAA. We analyse the dependence of some technological parameters on the geometry and the photonic properties of NAA. Also, some examples of new nanostructures are presented using NAA as a template and by filling the nanopores with metal, polymers, nanoparticles, etc.

We present and discuss the application of advanced photonic NAA structures for the detection of biomarkers such as Amyloid beta (Aβ) oligomer [4] and tumour necrosis factor alpha (TNF-alpha) [5]. We demonstrate how the pore surface can be chemically and biologically modified for successful biosensing. Furthermore, these structures are evaluated for stimuli drug delivery. Using polyelectrolytes and different shape configuration of nanopores, we can control the released of DOX by pH stimulus [6].

Finally, NAA is also applied for reproducing 3D cellular microenvironments and understanding the complex cellular interactions and behaviors. The effect of the geometry and the functionalization of NAA on cell adhesion and morphology of human aortic endothelial cells is investigated and presented [7-8]. The biocompatibility is demonstrated by analyzing the cell viability and cytotoxicity [9-10]

Results demonstrate that this kind of nanostructures open new possibilities in the diagnostic and treatment of diseases.

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References

[1] A Santos, L Vojkuvka, et al. Physica Status Solidi (A) Applications and Materials Science, (2012) 209, 2045-2048.

[2] J.T. Domagalski, E Xifre-Perez, L.F. Marsal. Nanomaterials, (2021), 11, 430.

[3] LK Acosta, F Bertó-Roselló, E Xifre-Perez, A Santos, J Ferré-Borrull, et al. ACS applied materials & interfaces (2018) 11, 3360-3371

[4] MA Tabrizi, J Ferré-Borrull, LF Marsal Biosensors and Bioelectronics (2019) 137, 279-286

[5] J G Rajeev, E Xifre-Perez, BP Simon, AJ Cowin, LF Marsal, NH Voelcker, Sensors and Actuators B: Chemical (2018) 257, 116-123

[6] M Porta-i-Batalla, C Eckstein, E Xifré-Pérez, P Formentín, J Ferré-Borrull, et al., Nanoscale research letters (2016) 11, 1-9

[7] P Formentín, Ú Catalán, L Pol, S Fernández-Castillejo, R Solà, LF Marsal, Journal of biological engineering (2018) 12, 1-9

[8] P Formentín, Ú Catalán, S Fernández-Castillejo, M Alba, M Baranowska, et al. Journal of Biomaterials Applications (2015) 30, 398-408

[9] E Xifre-Perez, S Guaita-Esteruelas, M Baranowska, J Pallares, L Masana, et al. ACS Applied Materials & Interfaces (2015) 7, 18600-18608.

[10] E Xifre-Perez, J Ferre-Borull, J Pallares, LF Marsal, Open Material Sciences (2015) 2, 13-32.

Figures

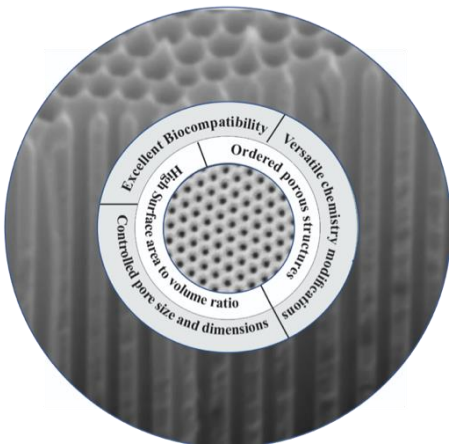

Figure 1. SEM image of an NAA cross-section and major features.