Neural implants nanocomposite coatings with antibacterial action towards nosocomial pathogens

A.P. Piedade[1], J.Nunes[1], P.V.Morais[2], C.B.Duarte[2,3]

[1]CEMUC – Department of Mechanical Engineering, Polo II, University of Coimbra, Coimbra, Portugal
[2]Department of Life Sciences, University of Coimbra, Coimbra, Portugal
[3]CNC Center Neurosciences & Cell Biology, University of Coimbra, Portugal
ana.piedade@dem.uc.pt

Abstract

The use of biomaterials in the neuroscience field comprises the monitoring of intracranial pressure, matrix for drug release and probes of the neural system. The latest includes devices for the increase or decrease of a specific neurologic function[1]. One of the most described devices is the use of implants to reduce or even cancel the involuntary spontaneous movements that characterize Parkinson's disease[2]. Many of the obstacles in this area of biomedicine is the lack of compatibility of materials with the biological system. In fact, the material usually used in neural implants processing is silicon (inheritance of the microelectronics industry), although other materials emerge as potential candidates [3,4]. The corrosion problems associated with their implantation in a biological environment has been corrected by the modification of the surface with biomolecules [5], conductive polymers [6,7], metal alloy films [4,8] or silicone-based gels [3].

Currently, it is believed that the mechanism of instability and degradation of implanted materials is due to their "encapsulation" by reactive astrocytes that isolate the implant and induce the increase of the distance between adjacent neurons, inhibiting synapsis [9]. Moreover, the decrease in the density of neurons has also been recently associated with an adverse reaction to the implantation of systems based on silicon [10].

In this work we have developed hybrid nanocomposite thin films based on silica (SiO_2) in order to improve the biological performance of Si neural implants. The aim also included the ability of the modified surfaces to present antibacterial action against common pathogens associated with nosocomial infections. The use of silica allows a chemical compatibility with the underlying Si substrate thus allowing that substrate and coating form a continuum instead of the sum of two different materials which can induce stresses at the interface. The nanocomposite was obtained by doping the SiO_2 with silver (Ag) and gold (Au) (Figure 1). The introduction of silver is related to is known antibacterial properties and the presence of Au allows serving two purposes: ensuring the electric conductivity of the coating after silver release as well as an enhancer of cells adhesion and spreading as described in the literature[11].

The antimicrobial activity was assessed by determining the growth inhibition on Gram-negative (*Acinetobacter lwoffii* and *Pseudomonas aeruginosa*) and Gram-positive (*Enterococcus faecalis*) bacterial strains. The results highlight that SiO_2/Ag/Au nanocomposite thin films present good antibacterial activity against the three studied microorganisms (Figure 2). The preliminary results of in vitro cell tests also indicate that these coatings present better biological performance regarding neural cell proliferation and viability than bare Si substrates (Figure 3).

References

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Figures

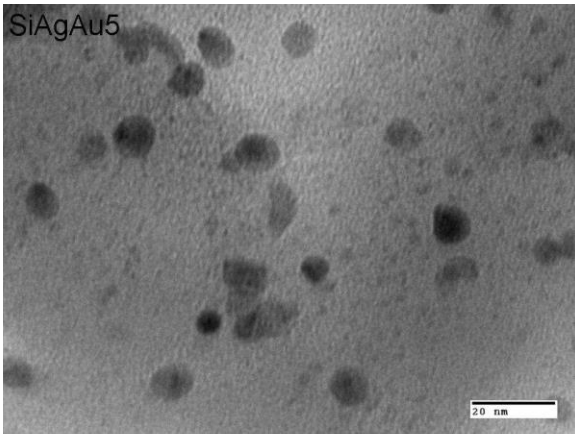

Figure 1 – TEM bright field micrograph of a nanocomposite hybrid SiO_2/Ag/Au thin film.

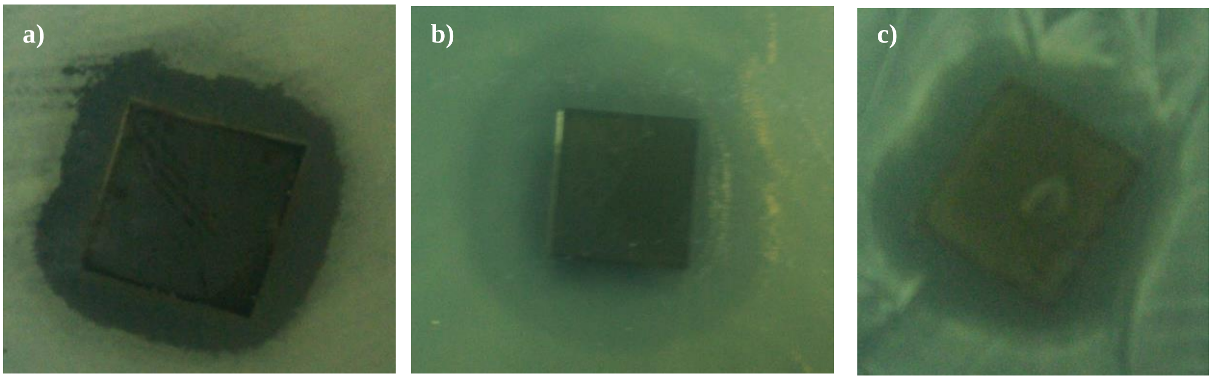

Figure 2 – Growth inhibition test of nanocomposite hybrid SiO_2/Ag/Au thin film with *A.lwoffii* (a) P. *aeruginosa* (b) and *E. faecalis* (c)

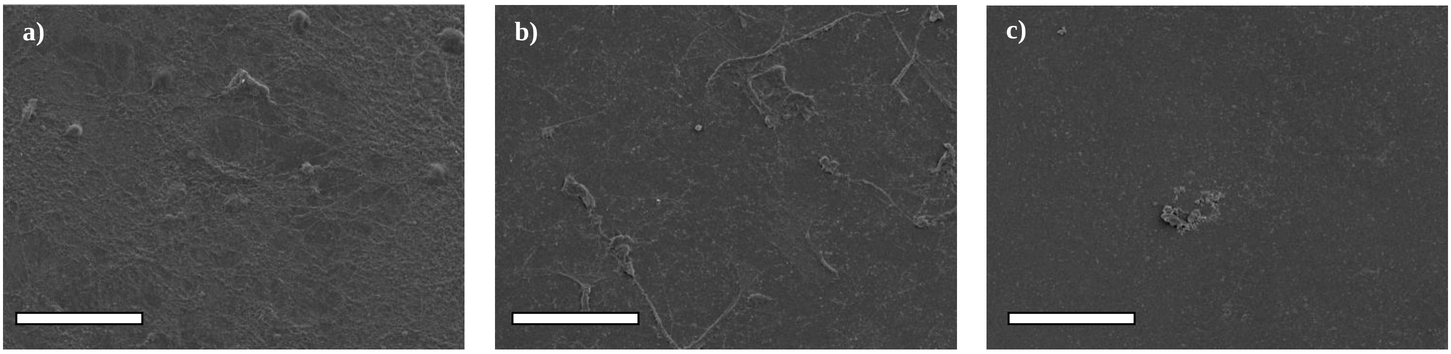

Figure 3 – SEM micrographs of the surface of control (a), SiO2/Ag/Au thin film (b) and Si (c) after 14 days with cortex rat embryo cells culture.