11th International Conference
on Advanced Materials

Rio de Janeiro Brazil
September 20 - 25

ICAM2009

Nanostructured hydroxyapataite coating on monocrystalline silicon for BioMEMS

L. C. O. Vercik(1)*, E. C. S. Rigo(2), A. Vercik(2) and C. A. C. Zavaglia(1)

(1) Departamento de Engenharia de Materiais - Faculdade de Engenharia Mecânica - Universidade Estadual de Campinas, FEM – UNICAMP Caixa Postal 6122, CEP 13083-970, Campinas – SP, Brasil, e-mail: lucivercik@yahoo.com.br

(2) Departamento de Ciências Básicas - Faculdade de Zootecnia e Engenharia de Alimentos - Universidade de São Paulo. Av. Duque de Caxias Norte, 225, CEP 13635-000, Pirassununga – SP, Brasil.

* Corresponding author.

Abstract – The Hydroxyapatite, the predominant inorganic component of human bones, can be used as a matrix for immobilization of enzymes, DNA and other bio-recognition elements in biosensors. Samples of crystalline silicon cut from a p-type wafer were coated with HA by immersion in SBF solution, incubated at (37 ± 1) °C for 24h, 3d and 7d. The analysis of the samples allows confirming the formation of HA, as can be seen by SEM micrographs (Fig 1a and 1b). The morphology is homogeneous and non-uniform with large discrete islands of 50- to 100-nm crystals. The HA phase was confirmed by energy-dispersive x-ray spectrometry (EDS).

Si-based devices have been used in vitro (outside the body) biosensing applications, such as smart sensors, BIOMEMS and biochips [1]. However, devices based on silicon technologies require a biocompatible protective coating in order to be implanted in human bodies. Thus, in order to make them able to be used in or linked to living tissues, silicon-based biosensors had to be packaged in a biocompatible material. The hydroxyapatite ($Ca_{10}(PO_4)_6(OH)_2$, HA) is predominant inorganic component of human bones, and it has been widely used in implants and as carriers for genes and enzyme. The biocompatibility and bio-activeness of HA allows tissue growth on this material and helps device fixing inside the body. Beyond this, the use of HA coatings on Si has been proposed as a matrix for immobilization of bio-receptors, such as enzymes or DNA, due to its porous structure [2]. Samples cut from p-type Si were cleaned and treated in a solution of NaOH 3mol/L, to activate the surface by creating silanol groups. Then the samples were immersed in a SBF (Simulated Body Fluid) where they were incubated at (37 ± 1) °C for 24h, 3d and 7d. The samples were removed, washed by immersion in distilled and deionized water and dried at room temperature [3]. The specimens were analyzed in a scanning electron microscope (SEM-FEG/Philips). Scanning electron microscopy measurements were used to investigate the surface morphology of the coating. Figure 1a is the SEM image of a surface with treatment deposits after 7 days. The SEM image shows that the HA-coating obtained on Si/SiO_2 surface is homogeneous, highly non-uniform and contained large and discrete islands. The SEM image of the HA coating with higher magnification reveals many granular HA crystals with diameters ranging from 50 to 100 nm, shown in Figure 1b. The typical structure of the SiO_2 surface can be seen in the uncoated region in this figure. The shape of this crystals are characteristic of the HA structure. The energy-dispersive x-ray spectrometry (EDS) shows intense Ca and P peaks, confirming the assumption of the formation of HÁ phase (Figure 2). Even when spots of HA were deposited, the activation sites were not enough to render a uniform coating and other methods for surface activation will be needed.

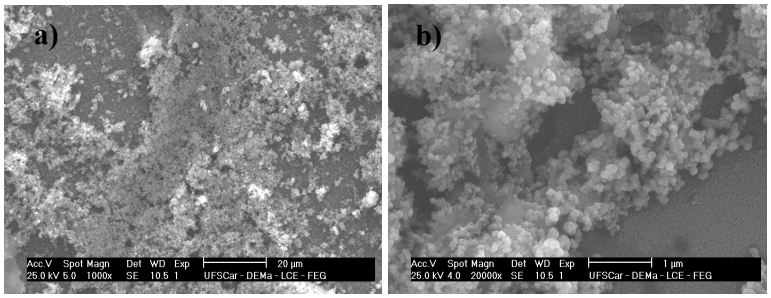

Figure 1: SEM image of the HA coating: **a)** 1000x and **b)** 20000x magnification The HA-coating Si/SiO_2 surface is highly inhomogeneous and contained large and discrete islands. With higher magnification the nanostructure can be resolved.

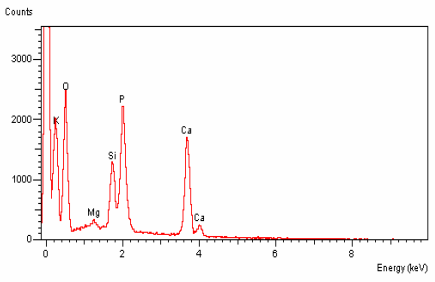

Figure 2: The EDS spectrum shows intense Ca and P peaks, confirming the formation of HÁ phase.

[1] Richards Grayson, A. C., Shawgo, R. S., Johnson, A. M., Flynn, N. T., Li, Y., Cima, M. J. and Langer, R. Proceedings of the IEEE 92 (2004) 6.
[2] Wanga, B., Zhanga, J. –J., Pana, Z. –Y., Taob, X. –Q. and Wang, H. –S. Biosensors and Bioelectronics 24 (2009) 1141.
[3] Vercik, L.C.O., Rigo, E.C.S. and Vercik, A. Key Engineering Materials 396-398 (2009) 337-340.