THE INFLUENCE OF CONTROLLED THERMAL OXIDATION ON THE MORPHOLOGY AND PHOTOLUMINESCENCE OF POROUS SILICON

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1. Introduction

Porous silicon (PSi) is a peculiar material with structural characteristics that provides study to develop many technological applications. The photoluminescence (PL) emission at room temperature is a feature of the PSi defined by its porous structure, which is the most investigated property from both views: theoretical and experimental. The PL property is also influenced by the oxidation process that creates a surface "shell" around the silicon (Si) core and changes the surface species, which is passivated [1]. This work was to analyses the influence of thermal oxidation controlled process on the morphological and photoluminescence emission of the PSi layer before and after the oxidation process and verify the viability of the formed structures for potential applications in sensors.

2. Experimental

PSi samples were produced from the electrochemical etching of p-type boron-doped monocrystalline silicon wafer <100>, resistivity between 0.01 and 0.02 Ωcm, using different anodizing parameters. A detailed sequence for the fabrication of PSi samples is published in reference [2]. The thermal oxidation procedure used an open-quartz tube furnace with digital temperature control set at 800 °C. The samples were annealing during 1 hour in air dry by an Edwards diaphragm pump, model D-Lab 10-100. This technique was chosen because it is a simple and widely used technique in surface passivation studies for the native oxidation control of PSi. For the PL measurements, it was developed a system capable to measure, in high resolution, the emission of the PSi samples at room temperature. The system uses a 365nm LED as an excitation source and a monochromator Shamrock SR-303i connected into a CCD camera iDUO DU-401A for the detection of the spectrum. High resolution images of the PSi structures were obtained by Field Emission Scanning Electron Microscopy (FESEM) by Shimadzu, model Mira LM. Other techniques as a Raman and X-ray Spectroscopy were used to verify and compare morphologies and PL characteristics of PSi samples.

3. Results and Discussions

Analyzing the controlled thermal oxidation, it was verified that there were variations of the original structures of the PSi because of the SiO_2 layer formed during the oxidation process. This change was observed in the several characterizations performed when compared to the characteristics of the non-oxidized PSi samples. The way in which these changes were made led to changes the optical, chemical and morphological properties of PSi, such as PL, which appeared in several samples when nonexistent (Fig 1). The field emission scanning electron microscopy (FESEM) analysis of oxidized porous structures does not reveal any considerable changes compared to the non-oxidized PSi samples. Otherwise, the imagens of surface structure show some physical changes that could be responsible for the morphology changes as pore size and surface area (Fig.2).

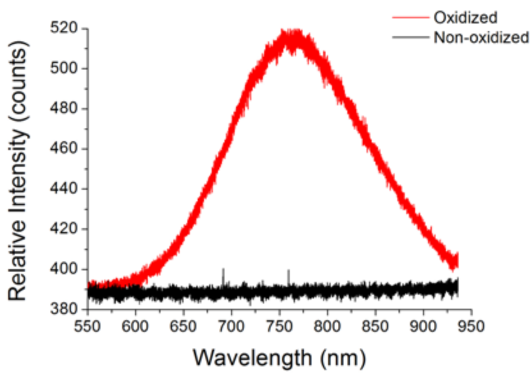

Fig. 1. *Photoluminescence spectrum of PSi Sample before and after oxidation.*

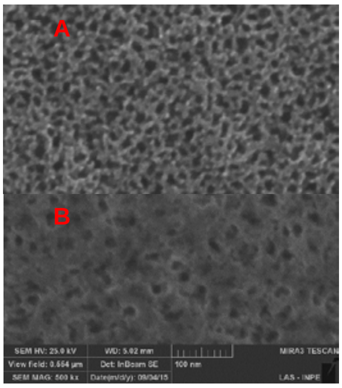

Fig. 2. *FESEM images of PSi Surface A before B after oxidation process. Magnification: 500kX.*

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Another important fact that came after the oxidation process was the passivation of the porous layer, which inhibits the continuous oxidation and guarantees the characteristics of the formed oxide [3]. Using other techniques, it also has observed the variation of the refractive indexes of PSi, which favors for applications in optical systems. The results show that the non-oxidized samples have a higher refractive index than the thermally oxidized samples. A curious point in this analysis was the finding that the oxidized samples lost the structural properties of the crystalline silicon which, unlike the non-oxidized samples, suffered different deformations, due to the temperature and the structural difference between the porous and substrate layers. This study allowed to prove the effectiveness of the use of the methods of analysis developed, as it enabled a detailed assessment of the changes occurred in the structures caused by the influence of oxidation.

4. References

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