

Si nanostructures induced by ion-beam impact on SiO₂

C. F. Codeço *¹, S. L. A. Mello[†], G. M. Penello^{**}, K. S. F. M. Araújo*, A. C. F. Santos*, M. M. Sant'Anna*²

* Instituto de Física, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brasil

[†] Departamento de Física, Universidade Federal de Viçosa, Minas Gerais, Brasil

^{**} Departamento de Eletrônica e Telecomunicações, Universidade do Estado do Rio de Janeiro, Brasil

Summary. In this work we study the formation of silicon nanostructures based on impact of ions of low energy. A SiO₂ thin film is bombarded and progressively transformed in SiO_x, with $x < 2$. At sufficiently high beam fluences there is a transition in the sample leading to the formation of Si nanoclusters. The surface of the sample is studied with a technique that combines the use of synchrotron radiation and atomic force microscopy.

Silicon oxide films are useful in various fields owing to its optical and electrical properties. One of its main applications includes the microelectronics industry. In this case, the silicon suboxide (SiO_x) emerges as an important material, and can be used as a precursor for synthesis of silicon nanocrystals [1]. The present study aims to explore a synthesis route for these nanocrystals based on the impact of low energy ions in thin films of silicon dioxide.

As the development of techniques for synthesis of nanostructures is continuous, it also becomes necessary to develop, in parallel, nanoscale characterization techniques compatible with nanometric spatial resolution. The combination of synchrotron radiation and Atomic Force Microscopy allows topographic imaging combined with nanometric infrared imaging and the measurement of IR spectra on chosen points on the images [2]. Those spectra provide information about the vibrational modes of the solid (by infrared spectroscopy).

Our starting point in this work is a 50 nm thick silicon dioxide layer grown on top of a Si bulk. The synthesis of nanostructures is explored in two different ways, both involving the interaction of ions with matter. In the first case we irradiate the thin film with a beam of F⁻ fluorine ions. It is possible to study the introduction of defects and disorder in the film by analyzing the changes in the normal modes of vibration of Si-O-Si in the film. In a second

case, the film is irradiated by a beam of Cs⁺ ions. Again it is possible to study the introduction of defects, and (for a range of beam fluencies) to observe the nanostructure synthesis of Si nanocrystals with heights of the order of 70 nm.

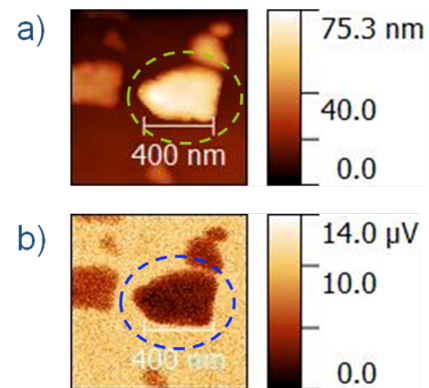


Figure 1. Example of Si nanostructure synthesized in this work: a) topographic image and b) infrared image.

In order to probe a possible preferential sputtering of O (compared to Si) mass spectra of secondary ions are also measured in situ while the initial SiO₂ is bombarded by F⁻ ions.

References

- [1] M. Gunde 2000, Plasmonics Vibrational modes in amorphous silicon dioxide, *Physica B*. **292** 286.
- [2] H. Bechtel, E. Muller, R. Olmon, M. Martin 2014, *PNAS*, **111**, 7191.

¹ E-mail: camilla@if.ufrj.br

^{**} E-mail: mms@if.ufrj.br