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## Investigation of hyperfine interaction in the nanostructured HfO<sub>2</sub> by PAC spectroscopy

Hafnium oxide is one of the new dielectric materials that is likely to replace silicon dioxide in semiconductor industry because of its excellent physical and chemical properties. Obtaining detailed information about this material, such as defects in the crystal lattice is quite important because they can alter its macroscopic characteristics thus changing it from a dielectric in to a semiconductor material with magnetic properties. In the present study we have used PAC technique to measure the hyperfine interactions in nanostructured samples of HfO<sub>2</sub> using <sup>181</sup>Hf-<sup>181</sup>Ta nuclear probe. Samples of HfO<sub>2</sub> were prepared by the well known sol-gel method to obtain nanostructured material. After gel formation, samples were calcined at 320°C in air. The samples were characterized by x-ray diffraction (XRD), scanning electron microscopy (SEM) and energy dispersive x-ray spectroscopy (EDS), where the crystal structure, morphology and grain size were determined. The results showed a unique phase with monoclinic structure of HfO<sub>2</sub>. The particle diameter was found to be in the range 30-40 nm. The samples were irradiated at the IEA-R1 reactor at IPEN with thermal neutron flux  $\Phi = 5 \times 10^{13} \text{ n.cm}^{-2}.\text{s}^{-1}$  during 10 hours to produce <sup>181</sup>Hf through (n,  $\gamma$ ) reaction on <sup>180</sup>Hf. After neutron irradiation the samples were annealed at temperatures which varied between 400°C and 900°C in vacuum, in air and in nitrogen atmosphere. PAC measurements were performed at room temperature after each annealing procedure. The results show the presence of two different electric quadrupole interactions. One of these interactions, with a well-defined frequency  $\nu_q \sim 780 \text{ MHz}$  and  $\eta \sim 0.4$  was assigned to the probe nuclei substituting regular Hf sites in the HfO<sub>2</sub> structure. The other interaction with highly distributed frequency  $\nu_q \sim 1000 \text{ MHz}$  and a smaller fraction, which varied with the annealing temperature, was associated with the probe nuclei occupying sites with structural defects near the surface of the nanoparticles.

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poster contribution

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