Depth-profiling of Al-implanted silicon by using the high-resolution grazing emission x-ray fluorescence (GEXRF) technique

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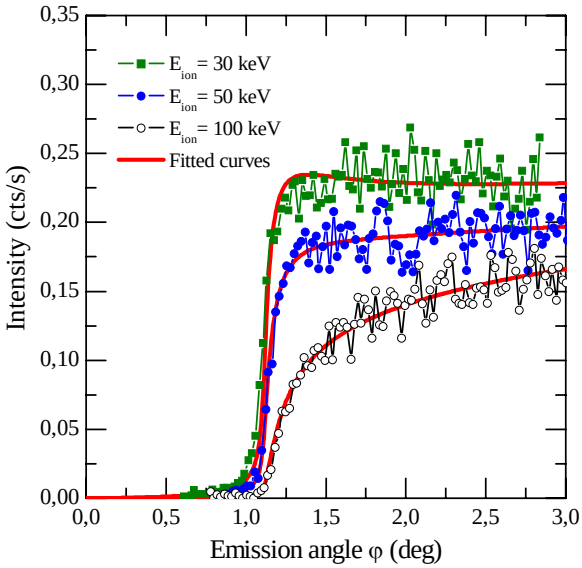
Progress in semiconductor microelectronic technology requires improved diagnostic tools for the depth profiling of doping elements in semiconductor materials. In this perspective, the high resolution grazing emission x-ray fluorescence (GEXRF) technique combined with synchrotron radiation was tested in order to develop an effective method for studying the depth profiles of Al-implanted in Si. This technique has already proven its high detection sensitivity when being used for the detection of low level concentrations of Al on Si surfaces [1]. The depth profiling is achieved by measuring the dependence of the Al x-ray fluorescence intensity on the grazing emission angle around the critical angle for Al-Kα radiation. This dependence is uniquely related to the studied concentration depth-profile.

We report on depth profiles of Al-implanted Si at energies of 30, 50 respectively 100 keV implanted with a dose of 10^{16} ions/cm^2. Measurements were performed at the ESRF ID21 beam line by means of the Fribourg high-resolution von Hamos x-ray spectrometer [2]. Since the critical angle of Si is larger than that of Al, the bulk Si x-ray fluorescence was limited to a surface layer of only a few tens of nanometers which resulted in a relative increase of the Al x-ray fluorescence signal. The background due to bulk Si was further decreased by selecting the beam energy below the K-absorption edge. Thus, the sensitivity and the quality of the Al depth-profile measurement were enhanced. The measured angular dependences of intensities of the Al-Kα fluorescence line excited by 1570 eV photons for the Si wafers implanted by Al ions are presented in Figure. The shape of the depth profile is determined by the implantation energy whereas the concentration of implanted ions depends upon the implantation dose. By means of the described high resolution GEXRF excited by synchrotron radiation the depth profiles can be determined accurately and the effect of thermal processing (annealing, diffusion) on the concentration profiles can be evinced.



Measured intensities of the Al-Kα fluorescence line excited by 1570 eV photons versus the grazing emission angle for the Si wafers implanted by Al ions for different ions energy.

[1] A. Kubala-Kukus et al. ,XXV International Conference on Photonic, Electronic, and Atomic Collisions (ICPEAC),25-31 July 2007, Freiburg, Germany, Book of Abstracts p. We048.

[2] J. Hoszowska et al., Nucl. Instr. Meth. Phys. Res., A 376 (1996) 129-138.