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IT-13-P-2432 Optimization of the sample preparation method for semiconductor dopant contrast observation with SEM

Druckmüllerová Z.[1,2], Kolíbal M.[1,2], Vystavěl T.[3], Šikola T.[1,2]

[1]Institute of Physical Engineering, Brno University of Technology, Brno, Czech Republic, [2]CEITEC, Brno University of Technology, Brno, Czech Republic, [3]FEI Company, Brno, Czech Republic

Email of the presenting author: zdenadr@seznam.cz

Since semiconductor devices are being scaled down to dimensions of several nanometers, there is a growing need for techniques capable of quantitative analysis of dopant concentrations at nanometer scale in all three dimensions. Therefore we optimized the sample preparation methodology for imaging dopant contrast by scanning electron microscopy (SEM) at incident electron energies about 1keV [1], which enables to visualize and analyze dopant concentration changes. SEM analysis at such conditions became widely used providing promising results, but many unresolved issues hinder its routine application for device analysis, especially in case of buried layers where the site-specific sample preparation is challenging. We report on optimization of a site-specific sample preparation by the focused Ga ion beam (FIB) providing an improved dopant contrast in SEM. As a testing sample we used differently doped multilayer structure deposited on Si (see Fig. 1). Similarly to the lamella preparation for transmission electron microscopy by FIB, a polishing sequence with decreasing ion energy is necessary to minimize the thickness of the electronically dead layer [2]. We have achieved the contrast values comparable to the cleaved sample, being able to detect dopant concentrations down to 1x1016 cm-3.(see Fig. 2). A theoretical model shows that the electronically dead layer corresponds to an amorphized Si layer [3] formed during ion beam polishing. Our results also demonstrate that the contamination caused by electron beam scanning is significantly suppressed for focused-ion-beam treated samples compared to the cleaved ones.

References:

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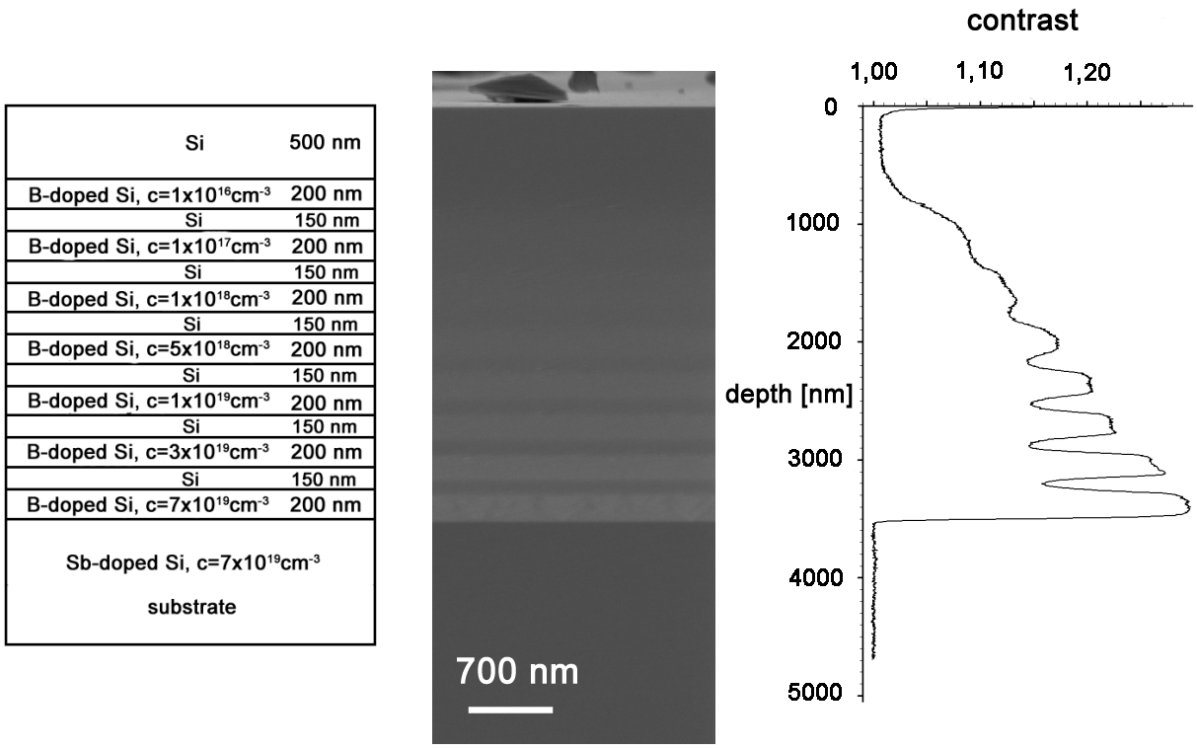

Fig. 1: Description of the sample used: SEM image of the cleaved multilayer structure deposited on n-doped silicon substrate is in the middle, a schematic description of alternating layers of intrinsic silicon (150 nm) with p-doped layers in depicted on the left. The contrast profile normalized to n-doped substrate is shown on the right.

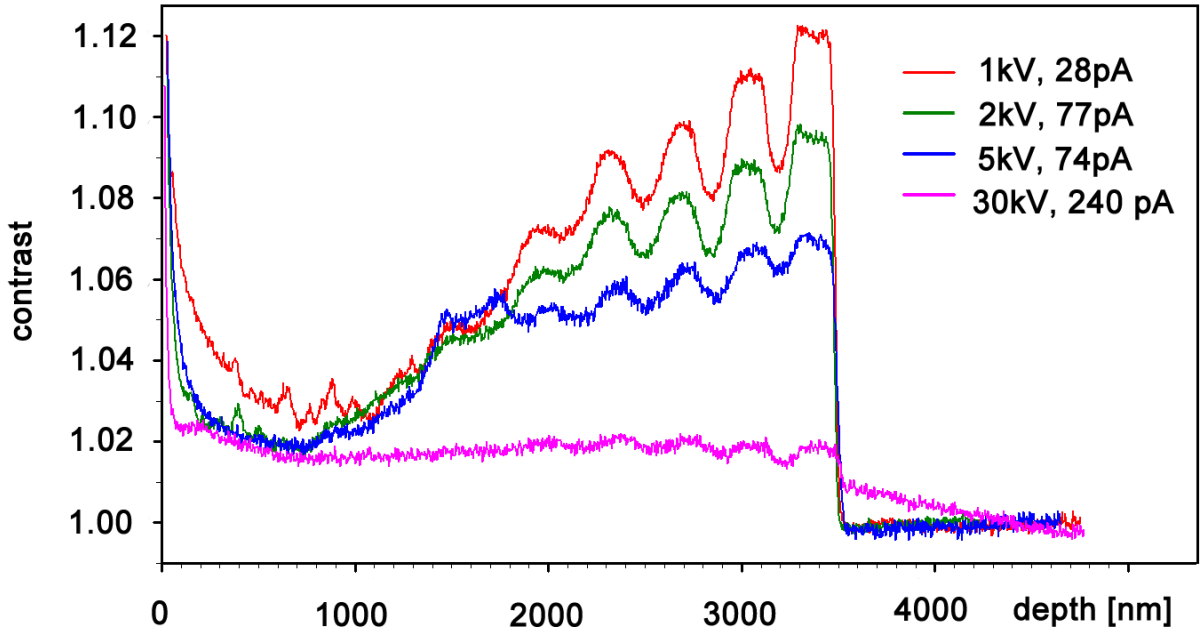

Fig. 2: SEM contrast improvement of sample cut by Ga FIB using decreasing final polishing energy.