Investigation of 4H SiC Homoepitaxial Layers and Substrates Implanted with MeV Se and Al Ions

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In the SiC based technology the ion implantation is frequently used for introducing of active dopant, insulating layers and in "smart cut" technique. It is often accompanied by the deposition of the epitaxial layers which can affect the results of implantation. In particular the epitaxial layers can be of significantly better surface roughness than the polished substrates, hence they can be more useful for exact strain profile determination. Some recent results concerning the implantation of 4H and 6H silicon carbide were described in [1-3].

In the present case the implantation was performed in 4H-silicon carbide homoepitaxial layers on (00·1) substrates with 8° off-cut, and reference 4H-SiC substrates studied before the implantation by means of X-ray diffraction topography, high resolution diffractometry and specular X-ray reflectometry. The dislocation densities in the target samples evaluated from the diffraction topographs did not exceed of 5×10^{3} cm^{-2}. The typical surface roughness evaluated from the reflectometric measurements was 2.3±0.1 nm, and in the case of the epitaxial layers was distinctly lower than 1.4±0.1 nm. 2 MeV Se ions and 1 MeV Al ions were implanted to the four fluences (the same for both types of ions) subsequently increasing by a factor 4-5.

It was possible to obtain a good fitting of the theoretical and experimental profile approximating the strain distribution by sticking two parts of the Gaussian curve. These profiles were otherwise very close to the distribution of the point defects calculated with the SRIM 2008 code. The representative experimental rocking curves with fitted theoretical ones are shown in Figs. 1 - 3. It should be noted that the assumed profile provides a good correspondence of theoretical and experimental curves for two cases of asymmetry both when the glancing angle is increased and decreased respectively. The values of relative strain amplitude evaluated from the best fit theoretical curves are summarized in the following table:

	Ion type	1.0 Mev Al^{+}	2.0 Mev Se^{+}
	Fluence [cm^{-2}]	Strain amplitude	Strain amplitude
1	5×10^{12}	3.1×10^{-5}	6.1×10^{-4}
2	2×10^{13}	0.52×10^{-4}	2.5×10^{-3}
3	1×10^{14}	2.74×10^{-3}	1.1×10^{-2}
4	5×10^{14}	1.1×10^{-2}	Amorphised

The investigation indicated significantly higher increase of the damage level in the case of 2 MeV Se ions as compared to the bombardment with 1 MeV Al ions. In addition we have observed a linear increase of the strain with the fluence. As it was confirmed by the RBS/c measurements, the highest doses of selenium ions caused the amorphisation of the layer. It was also possible to obtain a good fitting of the theoretical and experimental profiles. No significant effect of using the epitaxial layer as a target instead of the substrate was observed.

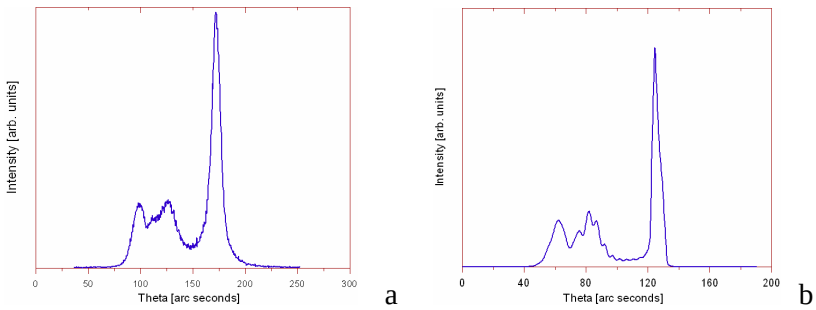

Figure 1: The experimental rocking curve (a) in 4H SiC samples implanted with 2 MeV Se^{+} ions to the fluency $2\times10^{13}cm^{-2}$ compared with theoretical rocking curve (b) calculated using the approximation of the strain profiles by the vacancy distribution.

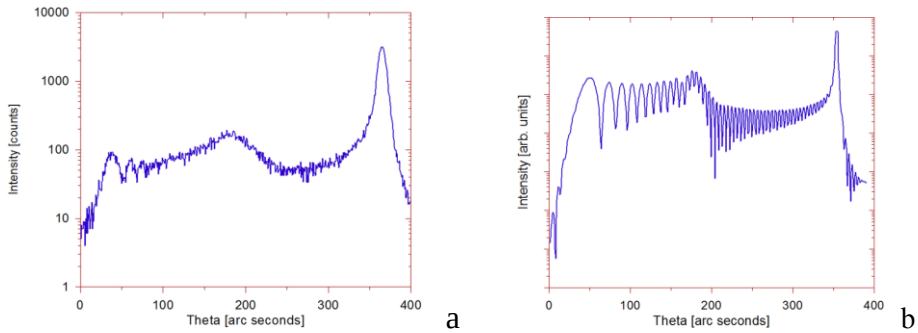

Figure 2: The experimental rocking curve in 4H SiC samples implanted with 2 MeV S^{+} ions to the fluency: $1\times10^{14}cm^{-2}$ – (a) compared with theoretical rocking curve–calculated using the approximation of the strain profiles by the vacancy distribution (b) and the curve obtained by incoherent summation of the curves calculated for randomly distributed defects.

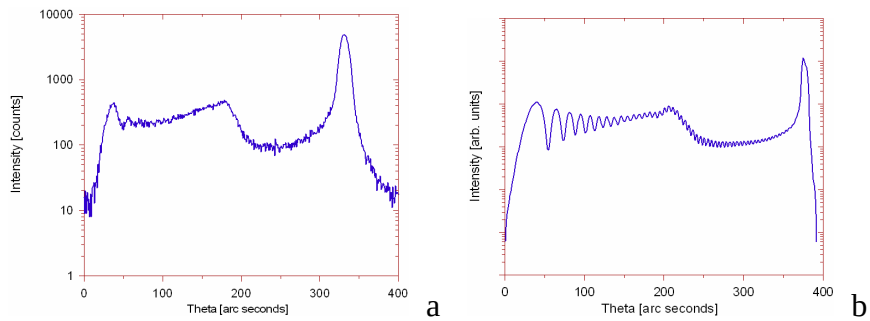

Figure 3: Figure The experimental rocking curve in 4H SiC samples implanted with 1 MeV AL^{+} ions to the fluency: $2\times10^{13}cm^{-2}$ – asymmetry with increased glancing angle (a) compared with theoretical rocking curve calculated using the approximation of the strain profiles by the vacancy distribution (b) and the curve obtained by incoherent summation of the curves calculated for randomly distributed defects.

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