3 - 44 Production and Annealing Behavior of Lattice Damage in Energetic Kr Implanted 6H-SiC

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Specimens were implanted with 5.0 MeV $^{84}Kr^{19+}$ ions, to successively increase fluences of 5×10^{13}, 2×10^{14}, 1×10^{15} ions/cm^2 at room temperature in the 320 keV High-voltage Platform. The implanted specimens were subsequently thermally annealed in a vacuum around 2×10^{-4} Pa at 500, 700 and 1000 ℃, respectively. Cross-sectional specimens for TEM observation were prepared by using a small angle cleavage technique[1], and were investigated in a transmission electron microscope of a JEOL 2010.

Cross-sectional HRTEM images of a specimen implanted to 5×10^{13} Kr ions/cm^2 are shown in Fig. 1. In the as-implanted specimen (Fig. 1(a)), the implantation-induced edge dislocations are observed. However, in the samples annealed at 700 ℃ (Fig. 1(b)), no defects can be observed. It is indicated that the implantation to a fluence of 5×10^{13} Kr ions/cm^2 can produce defects including edge dislocations in a low number density, which can be thermally annealed via recovery processes at higher temperatures.

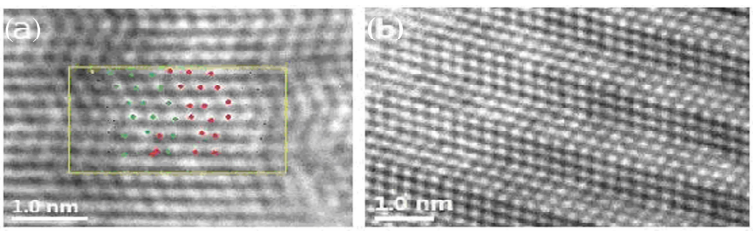

Fig. 1 Cross-sectional HRTEM images for 6H-SiC irradiated to 5×10^{13} Kr ions/cm^2 at room temperature (a) as-implanted, an edge dislocation isobvious, (b) anneal at 700 ℃ where no defects can be observed.

Cross-sectional HRTEM images of a specimen implanted to a higher fluence of 2×10^{14} Kr ions/cm^2 are shown in Fig. 3. In the specimen annealed at 500 ℃ (Fig. 2(a)), the defects like edge dislocations and lattice distortions can be observed. In Fig. 2(a), The cross-sectional view of a sample annealed at 700 ℃ is shown in Fig. 2(b) and (c), where the lattice deformations and edge dislocations can be observed in the framed regions. Fig. 3(d) shows in the cross-sectional image of the sample annealed at 1000 ℃, no defects can be observed. Which consistent with results of the previous work[2,3].

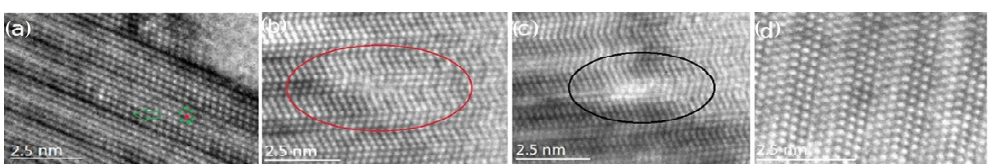

Fig. 2 Cross-sectional HRTEM images for 6H-SiC irradiated to 2×10^{14} Kr ions/cm^2 at room temperature (a) annealed at 500 ℃ where edge dislocations and lattice deformations can be observed, (b) and (c) annealed at 700 ℃ where edge dislocations and lattice deformations can be still observed, (d) annealed at 1000 ℃ where no defects can be observed.

Lower magnitude cross-sectional TEM images in diffraction contract together with selected-area electron diffraction (SAD) patterns of a specimen implanted to 1×10^{15} Kr ions/cm^2 are shown in Fig. 3. A damage layer in a sample annealed at 500℃ was shown in Fig. 3(a), where a selected area electron diffraction pattern of the framed region shows an approximate halo pattern corresponding to an amorphous phase. The amorphous layer is 600 nm in width and located at 1629 nm deep below the specimen surface, When the anneal temperature is up to 700℃, a selected area electron diffraction pattern of the framed region shows a perfect halo pattern corresponding to a fully amorphous layer (Fig. 3(c)); the amorphous layer is approximate 1600 nm in width and located at 700 nm deep below the surface. No crystallite can be observed. It is indicated that the amorphous layer was broadened with the increase of anneal temperature from 500 ℃ up to 700 ℃. An interpretation for this phenomenon is that the migration of Kr atoms may re-

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sult in the formation of Kr/vacancy complex, which could increase the lattice disorder and enhance lattice amorphization[4]. At same time, when the anneal temperature is up to 1000 ℃, we found that the amorphous layer was replaced by recrystallized layer completely.

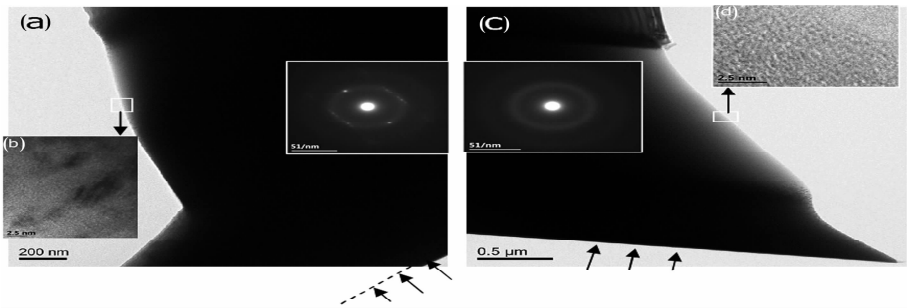

Fig. 3 Lower magnitude cross-sectional TEM images and electron diffraction patterns for 6H-SiC irradiated to 1×10^{15} Kr ions/cm^2 (a) and (b) annealed at 500 ℃, amorphous layer and transition region are presented, respectively. (c) and (d) annealed at 700 ℃, a very broad amorphous layer was observed. (d) is a magnified map for framed region of (c).

Under 5.3 MeV Kr ion implantation to fluences of 5×10^{13} and 2×10^{14} ions/cm^2, the implantation-induced defects can recover completely on thermal annealing at 1000 ℃. To a higher implantation dose of 1×10^{15} ions/cm^2, an amorphous layer surrounded by two transition regions is observed in 6H-SiC. And the amorphous layer becomes broader with increasing anneal temperature from 500 ℃ to 700 ℃, The transition from the increase of the amorphous layer thickness to the recrystallization of the amorphous layer occurs under temperature between 700 and 1000 ℃.

References

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