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DIRECT OBSERVATION OF RADIATION INDUCED PRECIPITATION IN HIGH VOLTAGE ELECTRON MICROSCOPE

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Long needle-shaped radiation induced precipitates oriented along (110) directions were first reported by Nes and Washburn from observation using hot stage high voltage electron microscopy. Similar long rod-like defects have also been observed in boron ion implanted silicon.

Our recent results show that most long rod-like defects formed during post-implantation annealing of boron ion implanted silicon are boron precipitates. The cause for the formation of these long rod-like defects is assumed to be replacement of substitutional boron by silicon self-interstitials.

To substantiate this mechanism two samples were irradiated in the high voltage electron microscope. Sample A was a boron doped (111) oriented silicon of resistivity 0.75 Ω-cm (2.5×10^{16} B/cm^3) and sample B was phosphorous doped, of resistivity 2 Ω-cm (2.7×10^{15} P/cm^3).

Figure 1 shows the sequential development of long rod-like defects in sample A held at 620°C during irradiation with 650 keV electrons. No such defects were observed in sample B under similar conditions. This is consistent with the idea that the rods are boron precipitates. The boron concentration in sample A is not high enough to cause rapid local supersaturation of boron by direct displacement of boron atoms. However, the very high production rate of self-interstitials, typically 5×10^{18} Frankel pairs/cm^3 sec, during high voltage electron irradiation in the microscope beam ensures that only a few minutes are needed to cause local supersaturation of boron atoms and give the observed rapid growth rate of the rod (~5×10^{-7} cm/sec), if the replacement mechanism between self-interstitials and substitutional boron is operative. The present result shows that a large number of linear defects was observed during only a few minutes of irradiation and reached a maximum after about 20 min. This strongly suggests that the formation of these boron precipitates is governed by the replacement mechanism and that the number of these defects is controlled by the amount of boron present.

The effect of impurities and irradiation temperatures on the morphology of defects needs further investigations.

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2. This conference.
Fig. 1. The sequential development of long rod-like precipitates in boron doped silicon irradiated by 650 keV electrons at 620°C. The successive irradiation times are as marked.
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