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BORON PRECIPITATES IN ION IMPLANTED SILICON

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Long rod-like defects are observed in ion implanted silicon when boron is present either as a prior dopant addition or as the implanted species. For many years, these rods have been described variously as precipitates, lines of point defects, dislocation dipoles, or elongated dislocation loops. The diffraction contrast from the defects has been difficult to interpret unambiguously because of their very narrow spacing. Our recent work indicates that they have the characteristics of narrow extrinsic dipoles or elongated dislocation loops and that there are two different types along each of the six ⟨110⟩ directions.

In this paper, an alternative method, annealing kinetics, has been used to identify the nature of these defects formed during post-implantation annealing in boron ion (100 keV) implanted silicon irradiated at room temperature to a dose of $2\times10^{14}/\mathrm{cm}^2$.

The two different types have been very clearly distinguished by this annealing experiments in which the same area of a foil is repeatedly observed by transmission electron microscopy with intermediate holding at a temperature which causes shrinkage of the rod defects. A typical example is shown in Fig. 1, where type $\bar{A}$ rod defects, e.g., 1. 2, 4 and 5, shrink at a much faster rate than type A, e.g., 3. From the temperature dependence of the shrinkage rate, an activation energy of 3.5±0.1 eV has been determined for type $\bar{A}$. This value of the activation energy suggests that the rate controlling process is boron diffusion. The second type, A, shrinks much more slowly at this temperature. The rate of shrinkage probably depends on the rate of silicon self-diffusion.

Another factor which has been found to influence the shrinkage rate is the distance between the end of the rod and another defect such as a dislocation loop. It appears that these loops may act as vacancy sources or as sinks for boron. Other interesting observations have also been made. During shrinkage, rods have been observed to rotate off the elongated ⟨110⟩ direction and lie along ⟨112⟩. They show a different diffraction contrast after this change, if they had converted from one burgers vector to another.

In conclusion, there exists at least two different kinds of rod-like defects in boron ion implanted silicon. From the activation energy for shrinkage, it is also concluded that one type ($\bar{A}$) is composed largely of boron atoms.

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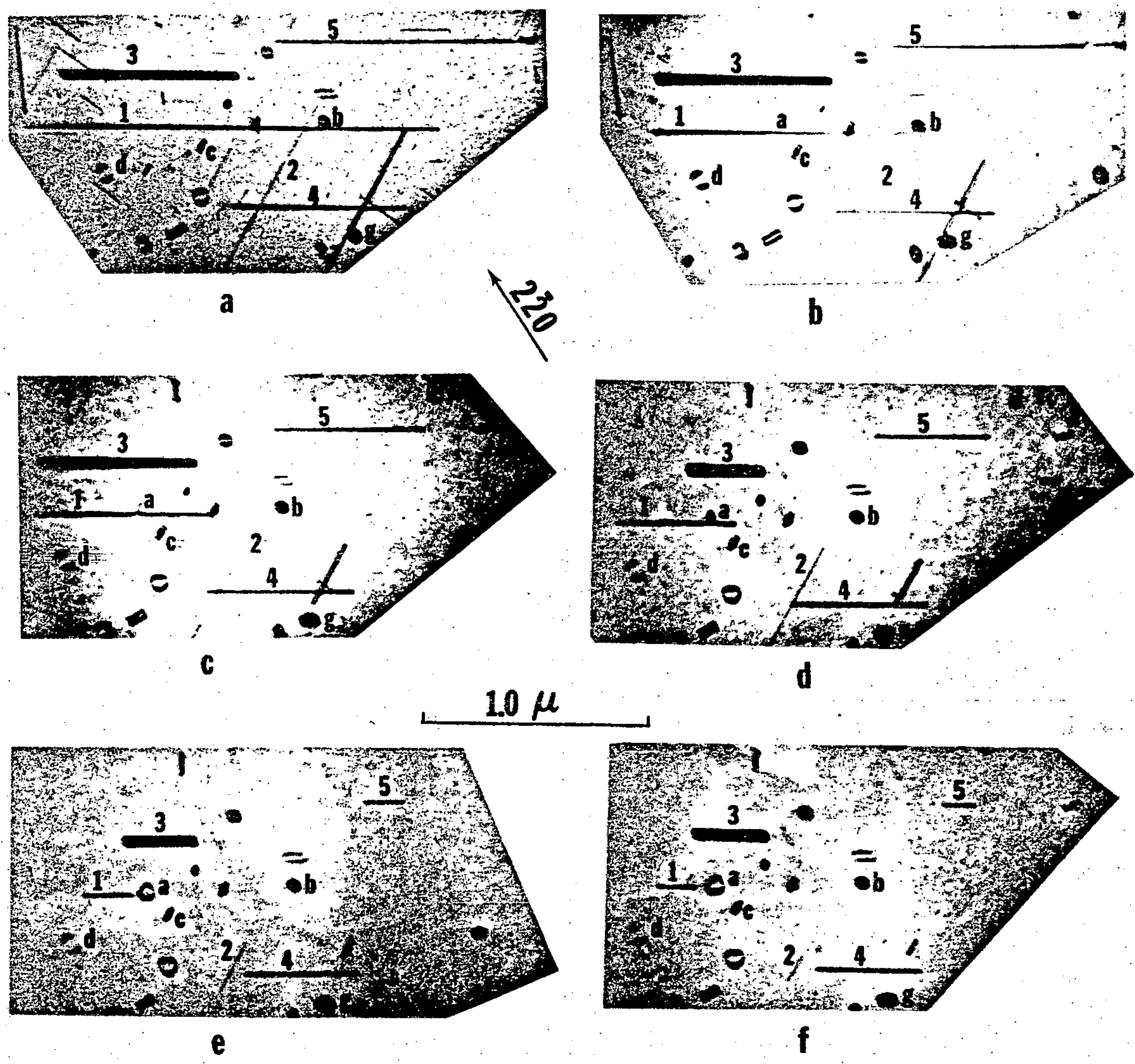

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Fig. 1. The annealing sequence of defects in boron ion implanted silicon The foil was annealed outside microscope. Figure a-d annealed at 800°C for 25 min between each picture. Fig. e is annealed at 800°C for 50 min. Fig. f is annealed at 750°C for 70 min. All micrographs were taken under similar conditions.

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