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AMORPHOUS TO POLYCRYSTAL TRANSITION IN ION IRRADIATED CHEMICAL VAPOR DEPOSITED AMORPHOUS SILICON

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Abstract: Kr^+ ion irradiation of Chemical Vapor Deposited amorphous silicon produces the amorphous to polycrystal transition at temperatures around 350°C. The grain size distribution is quite different from that obtained after thermal processing. The activation energy for growth is about 0.28 ± 0.05 eV.

The formation and growth of silicon crystals surrounded by amorphous material has been studied in the temperature range 360 - 450 °C and in the presence of an energetic ion beam.

Samples were prepared by Low Pressure Chemical Vapor Deposition (LPCVD) at 540 °C using a Si/SiO_2 substrate. Transmission electron microscopy of the as deposited material does not reveal the presence of any crystal seed. However after either thermal processing for 30 sec. at 700 °C or 600 KeV irradiation at ~ 350 ° C the deposited layer transforms into a polycrystalline material. The density of growing grains can be controlled by a suitable 130 KeV Ge^+ preirradiation at room temperature.

By using pre-irradiated samples we have compared Si crystal grains grown by thermal and ion beam induced processing. As reported in Fig. 1 the grain size distribution in thermal grains is broad while the distribution obtained after ion beam assisted growth is quite narrow. The average grain size increases linearly with the ion dose and depends upon the irradiation temperature as shown in Fig. 2. The growth rate shows an activated behaviour as reported in Fig. 3 with an activation energy of 0.28 ± 0.05eV, typical of ion beam assisted epitaxial growth of silicon. The results may be interpreted in terms of a preexisting distribution of very small clusters of silicon atoms exceeding the critical size for growth (n ~ 50) but undetected by TEM.

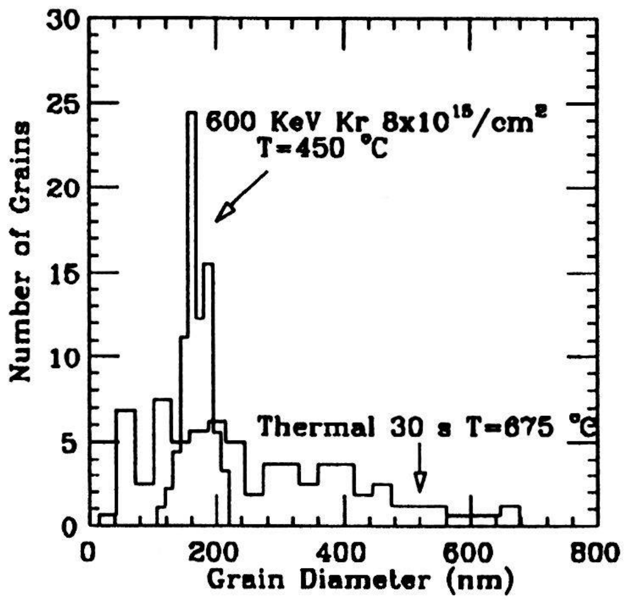

Fig. 1. Comparison of grain diameter distribution for thermally and ion beam irradiated CVD silicon.

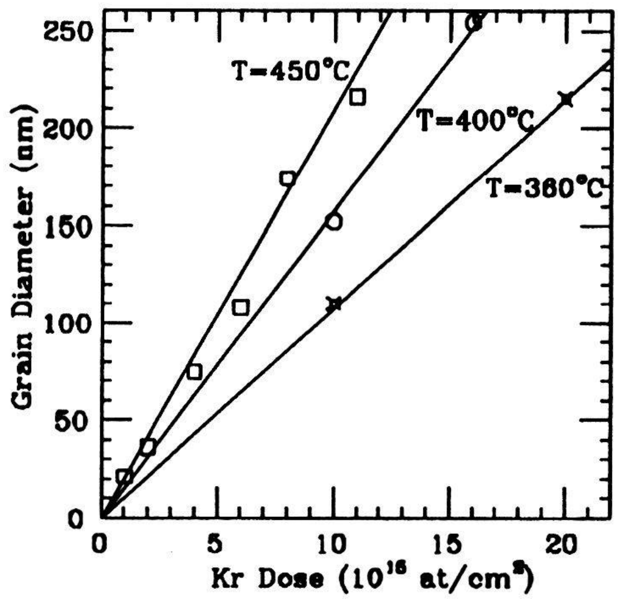

Fig. 2. Crystal grain diameter vs. ion fluence for CVD silicon irradiated with 600 keV Kr at 360, 400 and 450 ^{o}C.

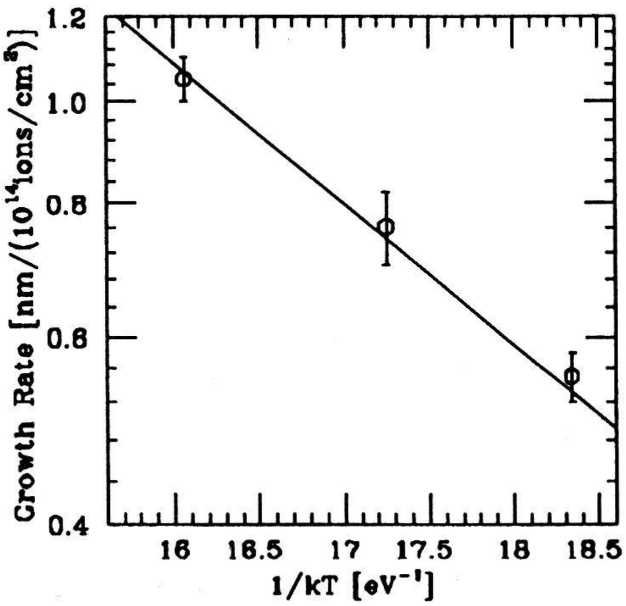

Fig. 3. Growth rate as a function of 1/kT. The growth rate is defined as $dr/d\phi$, where r is the average grain radius and ϕ is the Kr dose.