The effects of high temperature thermal annealing on thin amorphous silicon films deposited by electron cyclotron resonance PECVD

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Abstract

Thin amorphous silicon films, having thicknesses on the order of 1000 Å, have been deposited using electron cyclotron resonance plasma enhanced chemical vapor deposition (ECR-PECVD). Subsequent to their deposition these films were subjected to thermal annealing in an argon ambient at temperatures of 400 to 1200 °C for times up to 120 minutes to remove any argon incorporated into the film through the deposition process. The presence of argon in these films, as well as other atomic species such as oxygen and hydrogen, has been analyzed using Rutherford backscattering (RBS) and elastic recoil detection (ERD) experiments.

Annealing was also used to modify film structure and produce microcrystallinity. The structure of these films has been analyzed through optical microscopy, atomic force microscopy (AFM), and x-ray diffraction (XRD) experiments as a function of both the anneal temperatures and times. Figures 1(a) and (b) show AFM images for the films annealed at 1100 and 1200 °C, respectively. The former of these images shows the formation of rectangular pits with lengths on the order of a few microns all oriented along the same directions. After annealing at higher temperatures the pit sizes are seen to increase and a highly porous structure results. Each image also shows the presence of localized defects which begin to appear in films annealed at temperatures as low as 600 °C. This type of defect shows porosity after annealing at 1100 °C, however, after annealing at 1200 °C the defect becomes smooth but recessed. The nature of these defects has been analyzed using transmission electron microscopy (TEM) experiments.

Finally, results from analysis of the optical properties and photoluminescence (PL) of these films will be presented. The optical properties have been analyzed through the use of spectroscopic ellipsometry in the range of 600-1100 nm and correlated with the modification of structure resulting from annealing. Photoluminescence experiments have been done on the films using a He-Cd laser.

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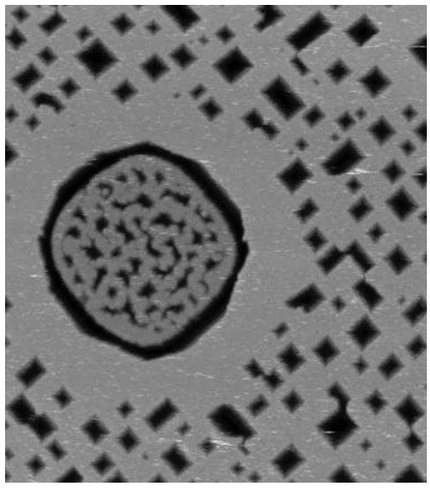
(a)



(b)

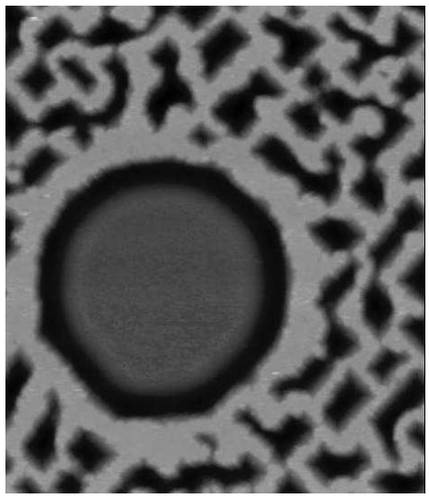


Figure 1: AFM images of amorphous Si films annealed at a) 1100 °C and b) 1200 °C for 60 minutes.