Direct deposition of poly-crystalline silicon germanium on a glass substrate at 450°C and their TFT application

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During the past decade, low temperature poly-crystalline silicon (poly-Si) film device technology has attracted more and more interests from the mobile and giant electronic applications. The poly-Si generally costs higher to fabricate than amorphous Si, whose transformation to poly-Si needs ongoing technologies such as excimer laser annealing[1] and metal-catalyzed annealing[2]. Direct deposition of device-grade poly-Si on glass substrate has not been achieved yet in spite of its high industrial potential, leading to reduction of the fabrication cost.

We have been investigating this with a new CVD technique, i.e., the reactive thermal chemical vapor deposition (RTCVD), which is one of the cold wall type thermal CVD featuring a set of reactive gasses [3]. Our leading concept is schematically shown in figure 1. In this work, poly-$Si_{1-x}Ge_x$ films are deposited with disilane (Si_2H_6) and germanium tetrafluoride (GeF_4) as a set of source gases. Despite a small incorporation of Ge in the film, e.g., less than 5 atm%, polycrystalline films are grown at the temperature as low as 450°C. Furthermore, direct nucleation of the small crystallites takes place on a glass substrate (Figure 2), leading to a homogenous crystallinity of the film. We characterized the film properties such as film composition, crystallinity, hydrogen content, and spin density as well as electrical properties[4-6].

With 200nm-thick poly-$Si_{1-x}Ge_x$ films, we fabricated bottom gate TFTs on n-type (100) Si wafer on which 75 nm-thick of thermal oxide. We found that the thermal annealing treatment at 450°C for 1 hour to activate ion-implanted dopant and atomic hydrogen treatment to passivate defects are very important to improve TFT performance. In fact, if the crystallinity of the film is more than 75%, the dangling bonds in the film are terminated by atomic hydrogen (Figure 3), even more than 10^{18} cm^{-3}, and the internal stress between the cyrstalline grains are removed by the annealing. The mobility of p-channel and n-channel TFTs attained 32-54 cm^2/Vs and 57 cm^2/Vs, respectively. The present results give us a good basis for the first step to industrial application of directly deposited poly-Si on a glass substrate.

References
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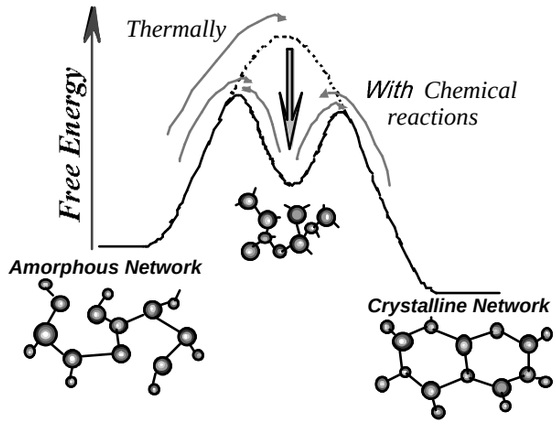

Figure 1*. Schematic picture of the structural relaxation of Si-network into crystalline form via chemical equilibrium with the contribution of reactive species on the growth surface.*

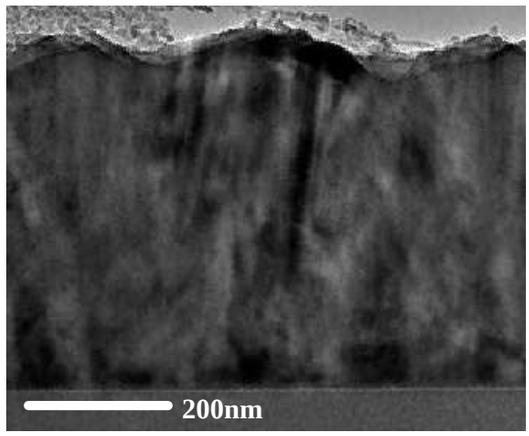

Figure 2*.Cross sectional TEM micrograph of poly-$Si_{1-x}Ge_x$ film on a glass substrate. Direct nucleation on the glass at 450°C substrate is observed.*

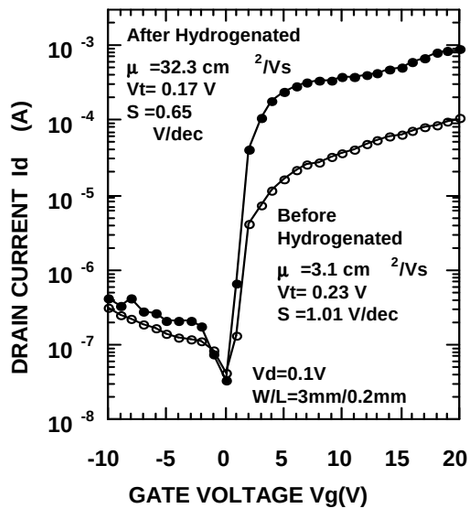

Figure 3*. Id-V_g characteristics of n-channel TFT before and after hydrogenation. The field effect mobility after hydrogenation becomes ~10 times larger than before.*