Optimization of p-type microcrystalline and epitaxial silicon layers deposited by PECVD at low temperature

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Deposition of microcrystalline silicon thin films by PECVD is usually carried out at temperatures in the range of 150 to 250 °C because at such temperatures surface diffusion of precursor species, cross linking reactions, and activation of dopants are supposed to lead to optimal material properties. In this study, following the idea of film growth using silicon nanocrystals synthesized in the plasma as building blocks for deposition [1], we have decrease the substrate temperature down to 50 °C. Interestingly, by co-depositing films on glass and crystalline silicon substrates (silicon-on-insulator or SOI substrates to be precise), we found that the decrease of temperature resulted in the formation p-type silicon layers (microcrystalline on glass and epitaxial-like on c-Si) with remarkable properties. The crystalline quality of the films and the epitaxial relation with the SOI substrate will be further studied via cross-section TEM. The electronic properties of the films have been characterized via Hall effect measurements in the as-deposited state and after annealing in air at 200, 250 and 300 °C, as shown in Figure 1. In the as-deposited state, the highest conductivity is achieved for the film deposited on glass. However, after annealing at 300 °C, the film deposited on SOI at 75 °C displayed an exceptional conductivity of 300 S/cm, which is noteworthy for any p-type film deposited by PECVD and particularly at such a low temperature. These results will be discussed with respect to the process conditions and the applications of such materials deposited with very low thermal budget.

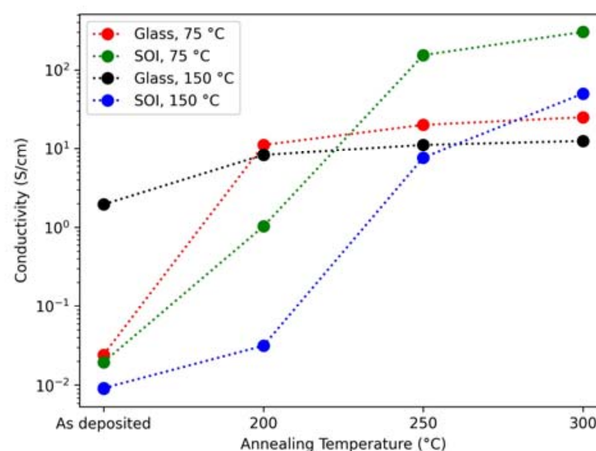

Figure 1. Evolution of the dark conductivity measured at room temperature in the as-deposited state and after annealing for samples co-deposited on glass and SOI substrates at 75 °C and 150 °C.

[1]. Ka-Hyun Kim, Erik V. Johnson, Andrei Kazanskii, Mark V. Khenkin, and Pere Roca i Cabarrocas: "Synthesis of silicon nanocrystals in silane plasma and their contribution to growth of polymorphous silicon thin films". Sci. Reports 7 (2017) 40553.