“Optimization of the conductivity and crystalline fraction of p-type µc-SiOx:H films for SHJ solar cells”

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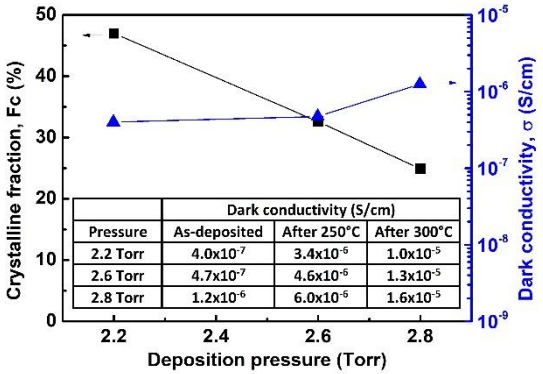
Abstract

While the production of n-type of hydrogenated microcrystalline silicon oxide (µcSiOx:H) layers has been widely reported on, p-type are far more challenging. The tradeoff between optical properties, passivation quality, and electrical transport requires detailed optimization of the process parameters and post-deposition annealing. We show how the crystalline fraction and electrical conductivity of p-type µc-SiOx:H depend on RF power, trimethylboron (TMB) gas flow rate, and total pressure during deposition at 150 °C, and how these properties evolve with annealing at 250 and 300 °C while preserving the passivation quality. P-type µc-SiOx:H films were obtained with a conductivity around 10^{-6} S/cm in their as-deposited state and 10^{-5} S/cm after annealing The layers optimized on glass substrates are then implemented in SHJ solar cells having the structure n-type µc-SiOx:H/ a-SiOx:H/ N-type FZ c-Si/ a-SiOx:H/ p-type µc-SiOx/p-type µc-Si:H where all the layers are deposited by PECVD. The lifetime and the quality passivation are improved but the J(V) characteristics are limited by low FF.

Keywords: Microcrystalline silicon oxide thin films; p-type; SHJ solar cells.

Microcrystalline silicon oxide (µc-SiOx:H) films present better transparency, leading to a potential improvement in short circuit current due to its lower refractive index and low absorption coefficient. Three series of p-type µc-SiOx:H films were deposited on glass substrates for their optoelectrical characterization. First, the RF power was varied from 8 to 12 W. Next, the TMB gas flow rate was varied from 2 to 10 sccm. Finally, the deposition pressure was varied from 2.2 to 2.8 Torr.



	Dark conductivity (S/cm)		
Pressure	As-deposited	After 250°C	After 300°C
2.2 Torr	4.0×10^{-7}	3.4×10^{-6}	1.0×10^{-5}
2.6 Torr	4.7×10^{-7}	4.6×10^{-6}	1.3×10^{-5}
2.8 Torr	1.2×10^{-6}	6.0×10^{-6}	1.6×10^{-5}

Figure 1. Crystalline fraction (Fc) and dark conductivity of as deposited p-type µc-SiOx:H films as a function of deposition pressure.

Fig. 1 shows the Fc decrease (black squares) increasing the pressure while the conductivity (blue triangles) increase. In the table inserted in Fig 1, we can see that the conductivity after both anneals increases up to 1.6×10^{-5} S/cm. The layers optimized on glass substrates are then implemented in SHJ solar cells. The lifetime and the quality passivation are improved by a better conductivity on p-type µc-SiOx films but the J(V) characteristics are limited by higher series resistance and consequently a low FF.