Thermoelectric properties optimization of nc-Si:H thin films deposited by PECVD

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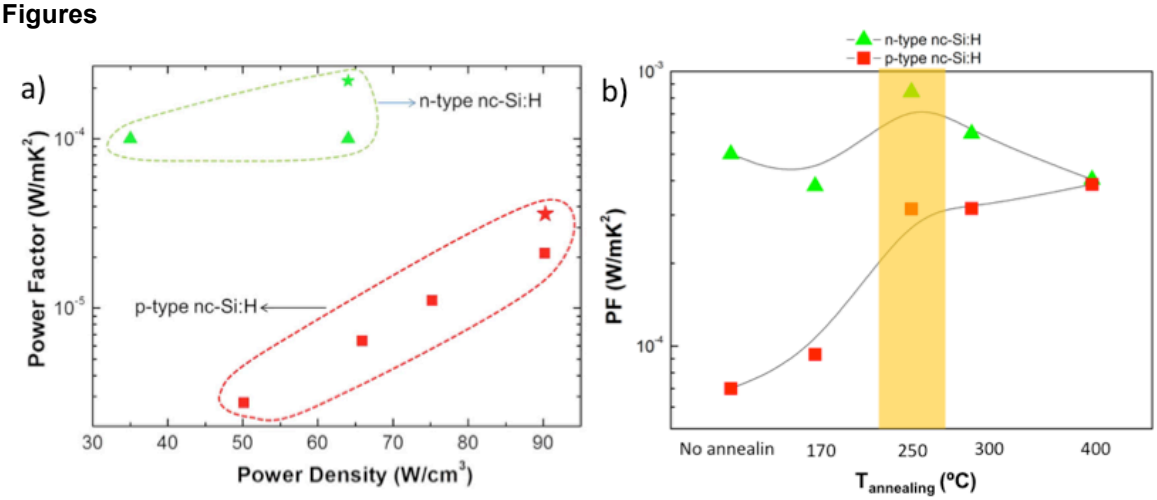
Abstract

The search for materials with suitable thermoelectric (TE) properties that are environmentally friendly and abundant led us to investigate p- and n-type hydrogenated nanocrystalline silicon (nc-Si:H) thin films, produced by plasma-enhanced chemical vapor deposition, which is a low-cost and well-established process in the thin film solar cell industry. In this work, the deposition conditions (rf power density, substrate temperature and pressure) and post deposition annealing step were optimized in order to improve the TE properties. The deposition process optimization led to Seebeck coefficient and Power Factor values of 512 μV/K and 3.6×10^{-5} W/m.K^2, for p-type, and -188 μV/K and 2.2×10^{-4} W/m.K^2, for n-type thin films[1]. Keeping the optimized deposition process but adding a post-deposition annealing step in vacuum, it was possible to further improve the TE properties of the films, with higher impact on the p-type nc-Si:H, reaching a power factor of 4×10^{-4} W/m.K^2 (for an annealing temperature of 400ºC) while the n-type films slightly improved to 10^{-3} W/m.K^2 (for an annealing temperature of 250ºC). Optimized Seebeck coefficient values of 460 μV/K and -320 μV/K were achieved for p- and n-type films, respectively, with crystalline size in the range of 10nm, leading to remarkable low thermal conductivity values (<10 W m^{-1}K^{-1}) at room temperature.

References

[1] Loureiro, Joana, et al., *Applied Physics A* 120.4 (2015): 1497-1502.

Figures



PF dependence on the power density (a) and annealing temperature (b). Data are depicted with triangles for n-type films and squares for p-type. The stars on figure a) correspond to the optimized process, having a slight increase in Dh. On figure b) it becomes clear that the PF of a p-n pair can be optimized at 250ºC.