Design and Fabrication of Si-based multi-barrier structures using non-uniform doping distribution

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Abstract:

Energy filtering is a promising strategy to achieve high improvements of the power factor in thermoelectric (TE) materials. This mechanism, which eliminates low-energy carriers through energy barriers, increases the Seebeck coefficient and the mobility of charge carriers as well, thereby increasing simultaneously the electrical conductivity. Heavily boron-doped silicon nanocrystalline thin films annealed up to 1000 °C have been reported with a power factor ~30 times higher than that of the pristine material.[1] Here, we attempt to extend this approach and to validate the energy filtering model by fabricating Si structures with multiple barriers and wells using non-uniform doping distribution along the channel.

Si multi-barrier structures were fabricated with the top-down method, using high-resolution electron beam lithography, rapid thermal annealing and wet etching. Selective doping is carried out in alternate subsections using thermal diffusion of phosphorus atoms and SiO_2 nano-strips as masks. Differential doping with $n^- - n^+$ junctions and variable inter-barrier spacing down to 30 nm allow us to build the energy barriers. At the final stage, heater, temperature sensors and metal contacts made of Au metal tracks, are going to be constructed using metal evaporation to measure TE properties. We report the design of the integrated device, showing the strategies used to develop and improve the multi-barrier structures. This will enable to explore experimentally the potential of energy filtering for TE enhancement in Si and to investigate how critical parameters, such as the barrier height, the doping level and the inter-barrier distance, affect the TE properties.

Reference:

[1] N. Neophytou, X. Zianni, H. Kosina, S. Frabboni, B. Lorenzi and D. Narducci, *Nanotechnology*, 24, (2013), 205402.