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Geometry induced doping in thin Si nano-grating layers

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Recently, new quantum features have been studied in the area of nanostructured layers. Nano-grating on the surface of the thin layer imposes additional boundary conditions on the electron wave function and induces G-doping or geometry doping. G-doping is equivalent to donor doping from the point of view of the increase in electron concentration n. However, there are no ionized impurities. This preserves charge carrier scattering to the intrinsic semiconductor level and increases carrier mobility with respect to the conventionally doped layer. We fabricated Si nano-grating layers and measured their electrical characteristics to monitor geometry induced doping (G-doping). Grating was fabricated using laser interference lithography (375 nm laser) followed by reactive ion etching of Si. Next, large square island (0.3 x 0.3 mm) was shaped in the device layer and 4 Si\Ti\Ag ohmic contacts were formed to measure electrical characteristics. The I-V characteristics were recorded using both 4 wire and 2 wire methods. Resistance-temperature (T) dependences (T=4-300 K) were recorded as well. For all 12 samples, nano-grating layers show 2-3 order of magnitude reduction in resistivity. Resistivity anisotropy was in the range 0.2-1 at 300 K. Obtained geometry induced doping level corresponds to "Effective Impurity" concentration of 3 x 1018 cm-3. The (T) dependence is in agreement with G-doping theory. It was observed (data from 12 samples) that nano-grating reduces resistivity of Si layer from 10 Ohm cm (plain layer) to 5 x 10-2-8 x 10-3 Ohm cm. This reduction is in agreement with theoretical prediction of G-doping. Value 10-2 Ohm cm corresponds to "Impurity" concentration of 3 x 1018 cm-3 (phosphorous in Si). G-doping does not require ionized impurities. This allows high carrier mobility and temperature independent carrier concentration. Nano-grating fabrication does not require sophisticated technology and can be used for solar cells and other photovoltaic devices, ultra high frequency electronics and power electronics.

Biography

M Mebonia has completed his Master's from Ilia State University and started his PhD at the same university collaborated with RWTH Aachen University. Since 2014, he has been working in Research Centre Juelich and Fraunhofer Institute of Laser Technology as a PhD Researcher. From 2013, he has been working in Scientific and Technological Centre "Nano Structured Materials for Renewable Energy" the School of Engineering in Ilia State University. He has published some papers in reputed journals.

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