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Porous germanium and silicon layers with metal nanoparticles fabricated by ion implantation

Experiments on formation of nanoporous and germanium and silicon layers with silver and copper nanoparticles by low-energy high-dose ion implantation are observed. For this task Ag^+ -ion implantation into monocrystalline silicon and germanium substrates at energy 30-40 keV with doses from $7.5 \cdot 10^{16}$ to $1.5 \cdot 10^{17}$ ion/cm² was realized. Surface nanoporous semiconductor structures were studied by scanning electron microscopy, imaging and energy-dispersive X-ray analysis. It is demonstrated that nanoporous silicon and germanium with silver nanoparticles could be fabricated by Ag^+ -ion implantation. The average sizes of porous holes and thickness of walls between porous in silicon are about 110-130 and 30-60 nm, respectively. Silver nanoparticles are synthesized and uniformly distributed over the silicon surface. In germanium, regular holes were not observed. A porous amorphous germanium layer of a spongy structure consisting of a network of intersecting nanofibers with an average diameter of ~10-20 nm is formed. At the ends of the nanofibers, the formation of Ag nanoparticles is detected. It is found that the formation of pores during implantation with Ag^+ ions is accompanied by the effective spraying of the silicon and germanium surface. Thus, ion implantation is suggested for industry to be used for a formation of nanoporous semiconductor thin layers containing metal nanoparticles, which could be easily combined with the crystalline substrates for various applications such as, for example, solar cell. This study was supported by the Russian Science Foundation, project no. 17-12-01176.

Biography

Since 1992, Dr. A Stepanov is with Kazan Physical-Technical Institute, Russian Academy of Sciences. In 1997-1999, he was a Research Fellow at the Sussex University, UK (the Royal Society/NATO). From 1999 to 2003, A. Stepanov was a Research Fellow of the RWTH in Germany (the Alexander von Humboldt Foundation). During 2003-2004, he was granted by Lise Meitner Fellowship (Austrian Scientific Society) in Karl-Franzens-University in Graz. From 2004 to 2011, he was a Research Fellow in Laser Zentrum Hannover in Germany (DAAD, DFG and the AvH). In 2013, he was granted by the National Scholarship of the Slovak Republic. Main research subjects of his interest are Nanooptics, Nanoplasmonics, Nanophotonics, Metal nanoparticles, Nonlinear optics, Laser annealing and Ion implantation. He has more than 250 publications in periodic journals, 25 patents, more than 25 invited book chapters and 4 monographs. His Hirsch index is 35.

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