MICROSTRUCTURE AND OPTICAL PROPERTIES OF NANOCRYSTAL PRECIPITATES OF NIS IN SIO_2 AND AL_2O_3

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Ion implantation and thermal processing were used to create NiS nanocrystals in SiO_2 and Al_2O_3 hosts. Compounds containing Ni plus S are particularly interesting because they span a wide range of compositions and crystal structures with different electronic properties. Pure stoichiometric NiS is hexagonal (NiAs structure) at temperatures above 380°C. Bulk hexagonal NiS, when stabilized at room temperature by rapid cooling, undergoes a metal-semiconductor transition at –10°C. If cooled slowly below 380°C, it spontaneously transforms to the metallic millerite form. Nonstoichiometry may also occur to produce compounds such as polydymite (Ni_3S_4) and godlevskite (Ni_9S_8). In the present work, we study the formation of nanocrystal precipitates containing Ni and S formed by ion implantation into SiO_2 and Al_2O_3 hosts. The optical data are compared to those obtained for a reference sample implanted with Ni only. When formed in SiO_2, the resulting particles have a composition close to NiS, as measured by energy dispersive X-ray spectroscopy. The microstructure, size, and crystallinity of the nanocrystals was controlled by varying the thermal processing parameters. The optical transmission data showed a sharp absorption peak at 450 nm that did not occur for the sample implanted with nickel only. Initial data suggest that this may be the surface plasmon for metallic NiS. The peak becomes more pronounced at higher annealing temperatures. In Al_2O_3, both the optical and the X-ray diffraction data imply the presence of more than a one NiS phase and the strong absorption at 450 nm was considerably weaker than for an SiO_2 host. An additional absorption peak occurred at 242 nm in Al_2O_3 specimens annealed above 800°C. The presence of a potential metal semiconductor transition was investigated by performing the absorption measurements at cryogenic temperatures. The results suggest that there is no sharp transition between the metallic and semiconductor phases.

Oak Ridge National Laboratory is managed by Lockheed Martin Energy Research Corp. for the U.S. Department of Energy under contract number DE-AC05-96OR22464.

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