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## Ge:Mn Dilute Magnetic Semiconductor

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This work aims to develop Ge:Mn dilute magnetic semiconductor and study the fundamental origin of ferromagnetism in this system. Using ion implantation at 77 K, a single crystal Ge wafer was doped with magnetic Mn ions. The implantation was done at ion energy of 4.76 MeV with a fluence of  $2 \times 10^{16}$  ion/cm<sup>2</sup>. X-ray diffraction (XRD) of the as-implanted sample showed that the implanted layer was amorphous. Therefore, different samples were annealed at 200°C, 330°C and 600°C in a tube furnace to achieve a solid phase epitaxial regrowth of the implanted layer. XRD of the sample annealed at 330°C for 33 hours showed a polycrystalline layer. The depth profile of Mn in the as-implanted sample and the post-annealed sample at 330°C was determined using secondary ion mass spectroscopy (SIMS) and it was found that some Mn diffused to the surface during the annealing. XRD of the sample annealed at 600°C for 35 minute showed peaks corresponding to an unknown phase in addition to peaks from amorphous and polycrystalline Ge. The sample annealed at 200°C for 168 hour showed no evidence of solid phase epitaxy. A SQUID was used to measure the magnetic properties of all samples. At low temperature, the as-implanted sample showed a paramagnetic behaviour. A magnetic hysteresis at 5K and up to 200K was observed for the samples annealed at 330°C and 200°C. The 600°C annealed sample showed no ferromagnetic response and a significant reduction in the paramagnetic response at low temperature compared to the as-implanted sample.

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