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Strain induced/enhanced ferromagnetism in Mn_3Ge_2thinfilms

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In Mn-Ge equilibrium phase diagram, many Mn-Ge intermetallic phases can be formed with difference structures and magnetic properties. The MnGe has the cubic structure and antiferromagnetic(AFM) with Neel temperature of 197 K. The calculation predicted that the $MnGe_2$ with Al_2Cu-type is hard to separate between the paramagnetic(PM) states and the AFM states because this compound displays PM and AFM configuration swith similar energy. Mn-doped Ge showed the FM with Currie temperature of 285 K for bulk samples and 116 K for thin films. In addition, the Mn_5Ge_3 compound has hexagonal structure and FM with Curie temperature around 296K. The $Mn_{11}Ge_8$ compound has the orthorhombic structure and Tc is low at 274 K and spin flopping transition is near to 140 K. While the bulk Mn_3Ge_2 exhibited tetragonal structure (a=5.745Å;c=13.89Å) with the FM near to 300K and AFM below 150K. However, amorphous Mn_3Ge_2 (a-Mn_3Ge_2) was reported to show spin glass behavior with spin-glass transition temperature (Tg) of 53 K. In addition, the transition of crystalline Mn_3Ge_2 shifts under high pressure. At the atmospheric pressure, Mn_3Ge_2 undergoes the magnetic phase transition from AFM to FM at 158 K. The pressure dependence of the phase transition in Mn_3Ge_2 has been determined up to 1 GPa. The transition was found to occur at 1 GPa and 155 K with dT/dP=-0.3K/0.1 GPa. Here report that Ferromagnetic Mn_3Ge_2 thin films were successfully grown on GaAs(001) and GaSb(001) substrates using molecular beam epitaxy. Our result revealed that the substrate facilitates to modify magnetic and electrical properties due to tensile/compressive strain effect. The spin-flopping transition around 145 K remained for samples grown on GaSb(001) while it completely disappeared for samples grown on GaAs(001). The antiferromagnetism below 145K changed to ferromagnetism and remained upto 327K. The saturation magnetization was found to be 1.32 and 0.23 μ_B/Mn at 5 K for samples grown on GaAs(001) and GaSb(001), respectively.