Structural and Magnetic Phase Diagrams of Co and Mn Doped Ge (100) Epitaxial Films

BRIAN COLLINS, LIANG HE, FRANK TSUI, University of North Carolina, YUNCHENG ZHONG, STEFAN VOGT, YONG CHU, Advanced Photon Source — We present studies of structural and magnetic properties of epitaxial films of Co$_x$Mn$_y$Ge$_{1-x-y}$ magnetic semiconductors, grown by combinatorial MBE on Ge (100) substrates. Structural effects were examined in-situ by reflection high energy electron diffraction and ex-situ by microbeam x-ray diffraction. A ternary epitaxial phase diagram has been determined for doping concentrations (x and y for Co and Mn respectively) up to 30 at %, where regions of coherent epitaxy and associated strain states, and regions of rough disordered growth and the nature of the disorders have been examined and identified. Specifically, within a narrow range of compositions around the atomic ratio between Co and Mn (x/y) of 3, the observed epitaxial strain is low (<0.1%) and coherent epitaxial growth is most stable, where the thin film lattice constants obey Vegard’s law and they match those of the Ge at x/y = 3. Within this region of compositions, high quality epitaxial films of p-type magnetic semiconductors can be stabilized for total doping concentration of transition metal dopants as high as 13 at % and with $T_C$ as high as 300 K. A ternary magnetic phase diagram has been measured using magnetooptic Kerr effect. The interplays between structural effects and magnetism have been investigated.

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