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Effects of neutron beam irradiation and heat treatment for GaMnAs

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Magnetic semiconductor is a technology area in which a new degree of freedom of spin can be employed for devices, but it is an area located at its infant stage of the development. Neutron irradiation has its unique impact on modification of materials structure and properties, and can be applied to the study of the magnetic semiconductors.

Solid solution GaMnAs, precipitated GaMnAs, and Be codoped GaMnAs were grown by low temperature molecular beam epitaxy. The specimens were irradiated with fast neutron (> 0.82 MeV, flux of 3.45×10^{10} neutron/cm^2-sec) in the HTS test hole of the HANARO (High-flux Advanced Neutron Application Reactor) research reactor for 24 hr and 100 hr. The specimens with neutron irradiation were heat treated at 900 °C for 30 sec by rapid thermal processing (RTP) in argon. Structural and magnetic properties of the grown layers were investigated by x-ray diffraction (XRD) and superconducting quantum interference device (SQUID).

The crystalline quality and magnetization properties of GaMnAs and GaMnAs:Be were degraded after neutron-irradiation. The resistivity has increased. When the irradiated GaMnAs are annealed, magnetization has improved while the resistivity has further increased. The GaAs matrix as well as second phase seems to decompose by neutron irradiation. The decomposed Ga, Mn, As, and Be seems to rearrange by annealing, and converts to a phase of high magnetization. The new phase may be MnAs and/or MnGa. Magnetic properties might be originated from the ferromagnetic clusters of MnGa and MnAs embedded in GaAs.