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Molecular beam epitaxial growth of GaMnN using a single precursor

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Ferromagnetic semiconductor has recently attracted great attention as a promising material for spin-injection devices. GaMnN has been shown to be ferromagnetic at room temperature, but it requires high concentration of carriers for spin-injection. Thus far, the homogeneous GaMnN films as well as other magnetic semiconductors have revealed high resistivity so that the magnetotransport properties were seldom observed.
We grew GaMnN magnetic thin films using a single GaN precursor of $Et_2Ga(N_3)NH_2C(CH_3)_3$. The optimized substrate temeprature was ~650 °C. It, however, revealed an improvement of the crystallinity upon annealing at higher temperatures. Therefore, the main GaMnN layers were grown on GaN buffer layers grown at ~650 °C, but annealed thereafter. Transmission electron microscopy (TEM) revealed a polycrystalline-like *c*-axis oriented growth. Codoping of Mg randomized the growth direction as revealed by x-ray diffraction peaks for non-*c*-axis planes and TEM. For high Mn flux above ~5% incorporation, second phases have precipitated. The dominant phase was Mn_3GaN, which revealed a high conductivity in the GaMnN matrix. It is a ferrimagnetic phase having the transition temperature of ~200K. The precipitae sometimes contain Mn_4N phase, and this can be confirmed by an anomalous temperature dependence of the magnetization curve and the peak shift in x-ray diffraction. He precipitates, however, enhanced the magnetization of the grown films. This result suggests that the metallic precipitates form an ohmic contact with surrounding GaMnN matrix. This is a clear difference from the behavior of the precipitates in GaMnAs system, where the precipitates degraded the magnetic property of the films.