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Room-temperature ferromagnetism of Cu ion-implanted GaN

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Diluted magnetic semiconductors(DMS), semiconductors that exhibit ferromagnetism by the substitutional doping of transition metal ions in semiconductor host, have attracted a great deal of attention due to their application in spintronics device. Among the various semiconductors, GaN and ZnO doped by Transition metal(TM) (V, Cr, Mn, Fe, Co, and Ni) have been widely studied because their Curie temperature was reported to be a near- or above-room-temperature both theoretically and experimentally. However, it remains to be unclear whether the observed ferromagnetism is from the magnetic substitutional ion in the lattice, or from the secondary magnetic phases and metal precipitates. The origin of ferromagnetism is still under debate because commonly TM dopants themselves are intrinsically magnetic, and thus their clusters or precipitates may also contribute to the observed ferromagnetism. To circumvent the ferromagnetic behavior originated from these clusters or precipitates for DMS, Cu, a non-magnetic element itself, was chosen as magnetic dopant element in GaN.

GaN films were implanted with 1 MeV Cu ion at dose of $1x10^{17}$ions/cm^2. As-grown and as-implanted sample does not exhibit a ferromagnetic behavior, while post-annealed samples at 700 ℃ and 800 ℃ show ferromagnetism at room-temperature. The saturation magnetization (Ms) of these samples is estimated to be 0.057 and 0.27 μ_B/Cu atom from M-H curves, respectively. And this ferromagnetism does not result from the defects induced by ion irradiation. However, post-annealed sample at 900℃ does not show ferromagnetism due to precipitation of Cu metal phase. The ferromagnetic behavior shows above the dose of $3x10^{16}$ions/cm^2.