Achieving electrical transport in GaN:Si/(Ga,Mn)N/GaN:Si structures

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The rise of semiconductor spintronics both creates new opportunities for novel electronic devices but at the same time it poses new requirements on spin manipulation in semiconducting materials [1]. While the search for a technology-viable magnetic semiconductor at room temperature is still the subject of active research a great deal of knowledge on the underlying physical processes can be gained from investigation of other system at their relevant temperatures. Our material of choice is (Ga,Mn)N – an emerging ferromagnetic insulator whose long range ferromagnetic ordering has been confirmed at the low end of cryogenic temperatures [2]. On the other hand, the mid-gap position of the $Mn^{2+/3+}$ level assures an insulating character, what in turn makes this material well suited for spin filtering and (magnetic) resonant tunneling devices [3]. In this study we report on separate 2- and 4- probe electrical measurements of in GaN:Si/(Ga,Mn)N/GaN:Si spin filter structures with two different magnetic layer thickness: 5 and 7.5 nm. The material has been grown by MOVPE technique on c-plane sapphire substrates and structured for vertical transport configuration by means of e-beam aided mask deposition and reactive ion etching. Electrical contacts of Ti/Al/Au were evaporated and annealed at about 750 ^{o}C for 30 sec in nitrogen atmosphere. The transport measurements revealed a strong non-ohmic behavior at helium temperatures accompanied with a sizable magnetoresistance at millikelvin temperatures in 2-probe configuration. On the contrary, in the 4-probe configuration an ohmic behavior is registered. The results are analyzed in view of a possible contribution of the contact metal/semiconductor barrier to the overall resistance of the GaN-based structure.

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