Investigation of smooth epitaxial growth of Mn_3Sn films on *c*-plane GaN using molecular beam epitaxy

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Recently, Chen *et al.* studied the all-antiferromagnetic tunnel junction consisting of Mn_3Sn / MgO/ Mn_3Sn (011$\underline{1}$), where they observed a tunnel magnetoresistance (TMR) effect at a ratio of 2% at room temperature. [1] Furthermore, Bangar *et al.* reported the epitaxial growth of *c*-plane Mn_3Sn on the Al_2O_3 substrate using a Ru seed layer. They demonstrated a technique of engineering intrinsic spin Hall conductivity in Mn_3Sn by adjusting the Mn composition slightly for functional spintronic devices.[2] These works indicate great potential for kagome antiferromagnetic material, and it is essential to investigate the growth of Mn_3Sn on various substrates. In our previous work, we demonstrated the deposition of Mn_3Sn (0001) on Al_2O_3 (0001) at 524 ± 5°C, which resulted in a 3D island growth. We observed dome-like structures, which may be related to the significant lattice mismatch with sapphire (19%).[3] Subsequently, we began to explore new substrates, and recently, we tried the growth on the MBE-grown N-polar GaN (000$\underline{1}$). The growth was monitored *in-situ* using reflection high energy electron diffraction and measured *ex-situ* using X-ray diffraction, Rutherford backscattering, and atomic force microscopy. The sample grew at 524 ± 5°C for 71 mins, resulting in an epitaxially smooth growth of Mn_3Sn on GaN (000$\underline{1}$). The *in-plane* lattice constants indicate a strain of -2.13 %, while the XRD indicates a 0001 orientation with a strain of -0.53% and an 11$\underline{2}$0 orientation with a strain of + 2.73%. Furthermore, the effect of varying growth temperature and Mn: Sn flux ratio on film orientation and crystallinity will be discussed in detail. We are also planning to begin scanning tunneling microscope experiments.

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[1] X. Chen *et al.*, "Octupole–driven magnetoresistance in an antiferromagnetic tunnel junction." Nature **613**, 490 (2023).
[2] H. Bangar *et al.*, "Large Spin Hall Conductivity in Epitaxial thin films of Kagome Antiferromagnet Mn_3Sn at room temperature", Adv. Quantum Technol. **6**, 2200115 (2023).
[3] S. Upadhyay *et al.*, "Exploring the interfacial structure and Crystallinity for Direct Growth of Mn_3Sn (0001) on Sapphire (0001) by Molecular Beam Epitaxy", *Surfaces and Interfaces (accepted).*

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Supplementary Pages (Optional)

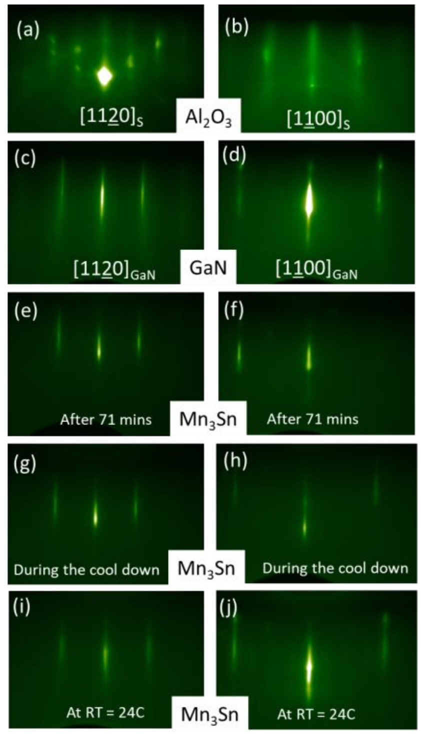

Figure 1: RHEED patterns of GaN (000$\underline{1}$) and growth of Mn_3Sn at 524 ± 5°C. (a-b) annealed Al_2O_3; (c-d) GaN at room temperature (e-f) after 71 mins of Mn_3Sn growth (g-h) Mn_3Sn during the cool down (i-j) Mn_3Sn next day at room temperature.

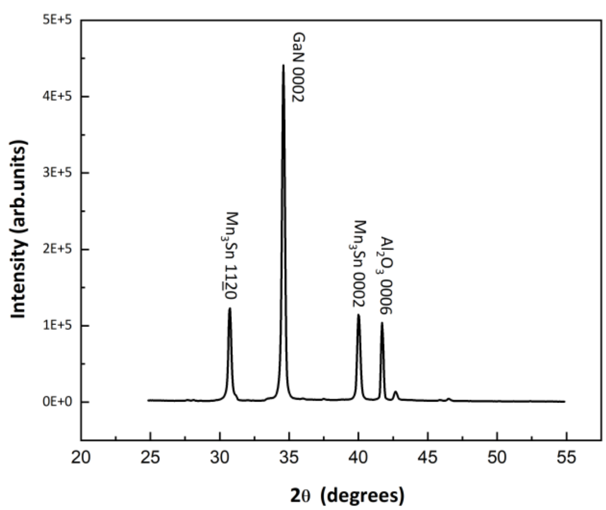

Figure 2: X-ray diffraction of Mn_3Sn/GaN (000$\underline{1}$) / Al_2O_3 (0001) at 524 ± 5°C.