Room temperature skyrmion in alternative layer molecular beam epitaxial grown B20 Fe-rich $Fe_{1.2}Ge$ films

Tao Liu, Roland Bennett, Shuyu Chen, Adam S. Ahmed, Roland K. Kawakami
Department of Physics, The Ohio State University, Columbus, Ohio 43210, USA

Magnetic Skyrmions are localized, topological spin textures that arise from competition between exchange interaction and Dzyaloshinskii-Moriya interaction (DMI) in magnetic materials with broken inversion symmetry. Their topological stability, small size, and the ability to be very energy efficiently written, read and manipulated, put them at the forefront of candidates for next generation storage technology. However, it is still challenging to find a material which can achieve skyrmion at room temperature with size no more than 10 nm, which has already become a major bottleneck of their developments. In order to realize this goal, it requires strong exchange interaction strength *J,* which sets the temperature scale, and a large DMI strength *D* that determines skyrmion stability and size, *Ja/D* (*a* is the atomic lattice spacing). Current skyrmion research is focused on two classes of materials: metallic multilayers and B20 crystals. Neither of them can meet this challenge. Metallic multilayers can meet the criteria of room temperature operations, but with small DMI arising from surface inversion symmetry broken. B20 crystals have a large bulk DMI and nanoscale skyrmions with sizes down to 3 nm, but cannot achieve room temperature operations.

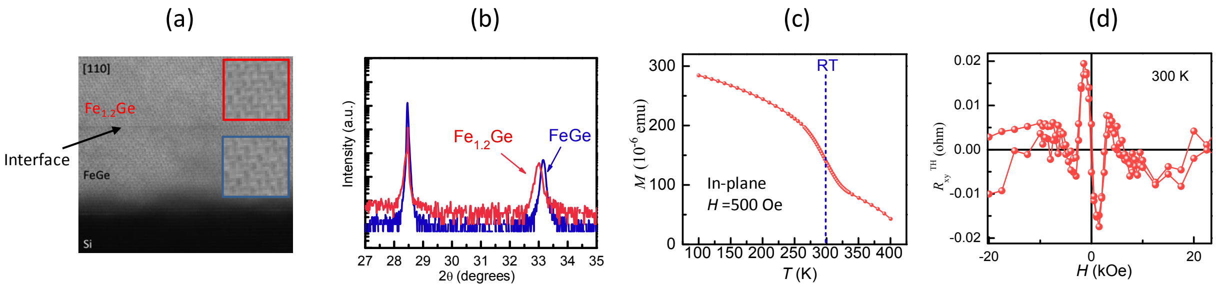

Fig. 1. (a)Cross section TEM; (b) XRD; (c) temperature dependence magnetization; (d) Topological Hall resistance of a sample with structure of $Fe_{1.2}Ge$ (54 nm)/FeGe (5 nm)/Si 111 substrate

In this work, we successfully synthesized Fe-rich $Fe_{1.2}Ge$ films by alternative layer molecular beam epitaxy at room temperature and adding extra Fe atoms at the Fe-sparse atomic layers. As shown in figure 1, the cross sectional TEM result indicated that the Fe-rich $Fe_{1.2}Ge$ film is B20 structure. Its XRD peak position shift to a lower angle relative to FeGe film, which might be good evidence indicating the extra Fe atoms went into the B20 structure rather than formed another stucture phase. The Curie Temperature of the Fe-rich $Fe_{1.2}Ge$ film has been pushed above room temperature (RT), and the observing of clear topological Hall resistance with maximum value around $H=\pm 1.5$ kOe could be result of the stabilization of RT skymrmion .