Title: "Magnetization Dynamics and Microwave Device Fabrication using Magnetic Nanostructures"

Nanostructured magnetic material offers great advancement in nano-scale devices. My research consists of the investigation of spin dynamics and microwave device fabrication using magnetic nanostructures. I have fabricated epitaxial ferromagnetic thin film of Full Heusler Alloy (Co_2FeSi), and bilayers with 2D Transition Metal Dichalcogenide Molybdenum disulfide (TMD MoS_2, etc.). Full Heusler alloy Co_2FeSi is a spectacular material system that has a very low Gilbert damping, high curie temperature, and half-metallic nature. Thin films of Co_2FeSi were fabricated on a (001) oriented MgO substrate using a Pulsed Laser Deposition as well as by using a magnetron sputtering system. (i) A detailed investigation of magnetization dynamics and magnetocrystalline anisotropies has been conducted using the Ferromagnetic Resonance (FMR) technique to describe a favorable thickness regime of the epitaxial Co_2FeSi film that can be made useful in spintronic applications. (ii) The correlation between magnetization dynamics, static magnetization and film quality has been investigated from atomic force microscopy, X-ray diffraction and vibrating sample magnetometry experiments. (iii) We have also observed and measured the self-induced spin pumping via the Inverse Spin Hall Effect (ISHE) in bare Co_2FeSi film by electrical detection, which arises due to disordered magnetic regions at the substrate-film interface. It was found out that conducting Co_2FeSi layers generate spin electricity without the need for a nonmagnetic metallic layer. (iv) Then, we have fabricated a heterostructure consisting of chemical vapor deposition grown 2D MoS_2 and PLD grown 3D Co_2FeSi films fabricated on a Si/SiO_2 substrate. The spin pumping across the 2D/3D interface has been analyzed by the FMR technique to show the transparency of the interface which allows high spin current injection from CFS to MoS_2 layer.

In the microwave device development part, we have engineered a Hard/Soft magnetic (Barium Hexaferrite, BaM/Yttrium Iron Garnet, YIG) nanocomposite. BaM is a hexaferrite that has a high microwave operating frequency due to its large uniaxial anisotropy and magnetization but has a very broad linewidth. On the other hand, Yttrium Iron Garnet, (YIG) is an important soft magnetic material with a narrow linewidth but due to lower magnetization its operating frequency falls in lower GHz range. Our intention to use BaM/YIG nanocomposites was to utilize the high uniaxial anisotropy and high magnetization of BaM along with low linewidth of YIG to create a new material system that can be useful in microwave devices operating in 10 to 40 GHz frequency range for the application in mm-wave devices. Under this, I have fabricated $BaM_{(1-x)}/YIG_{(x)}$ nanocomposite-based Microwave Phase shifters, Notch-Filters, and Isolators on the RT/duroid® 5870 copper-coated high-frequency dielectric laminate. The BaM/YIG nanocomposite presents a feature to utilized the high anisotropy of BaM to boost the operating frequency along with the narrow linewidth of YIG to achieve narrow device bandwidth.