Summary

Synthetic antiferromagnet (SAF) is a unique class of magnetic structure engineered to exhibit antiferromagnetic (AFM) coupling between adjacent magnetic layers through non-magnetic spacer. In the case of a metallic spacer, the interaction between the two FM layers happens through the spin-polarized conduction electrons present in the NM spacer layer. The interlayer exchange coupling (IEC) here is of an oscillatory decaying nature, which can be described through the Ruderman–Kittel–Kasuya–Yosida (RKKY) interaction. These systems show properties such as high thermal stability, low susceptibility to external magnetic fields, easy characterization through conventional techniques used for FMs, etc., which make them suitable for applications in magnetic sensors, magnetic tunnel junctions (MTJ), and other spintronic devices. Apart from this, there are other aspects for which SAFs are in focus nowadays for spintronic research. One such aspect is it can host chiral magnetic textures like skyrmions. While driving in a track of a single ferromagnetic layer, these skyrmions move towards the edge of the track due to topological Magnus force, known as the skyrmion Hall effect (SkHE). This problem can be addressed by driving the skyrmions in a track of SAF where the opposite topological Magnus force experienced by the skyrmions of both the FM layers will be cancelled and the skyrmions will move in a straight-line path along the direction of the current flow thereby minimising the skyrmion Hall effect. Another aspect of SAF is that it can be a good material system to host magnon-magnon coupling among the AFM-coupled FM layers through antiferromagnetic interlayer exchange interaction. Magnons in spintronics hold the unique advantage of low energy consumption, non-volatility, high-speed operation, etc. Taking advantage of the coupling phenomena in these SAF systems, we have broadly explored the two aspects of it in our work. One aspect is, that we have studied the magnetization reversal, domain structures, and skyrmions in perpendicular magnetic anisotropic (PMA) SAF system. The other one is, that we have studied the spin dynamics in such SAF systems with in-plane magnetization

easy axis. Further, we have explored the possibility of having magnon-magnon coupling in this in-plane magnetized SAF system.

The results are summarized into five sections depending on the spacer layer used as well as the purpose of studying the particular system with variation of IEC through the spacer layer. We have prepared SAF samples with PMA by considering Ru as a spacer layer between the two Co layers. Samples with lower Co thickness i.e. 0.8 nm shows a larger antiferromagnetic coupling plateau than the samples with Co thickness 1.0 nm. Further, by changing the spacer layer to Ir with the Co being 0.8 nm, we have observed three different types of magnetization reversal. With Ir 1.0 nm, the coupling becomes FM whereas, with Ir 1.5 nm, the coupling becomes AFM. By changing the Ir thickness to 2.0 nm, it shows a canted magnetization reversal. The domain images are smaller in AFM-coupled samples as compared to the FM-coupled samples. Further, the presence of chiral spin textures in the samples with Ir thickness 2.0 nm has been confirmed by the topological Hall effect (THE) measurement and Nucleation of skyrmions has been observed by performing MFM measurements on these samples. Further, we have considered the sample structure as Si/SiO2/Ta(3)/Pt(2.5)/[Pt(1)/Co(t_{Co})]$_3$/Ir(1.3)/[Co(t_{Co})/Pt(1)]$_2$/Pt(2.5). The Simultaneous contribution of dipolar coupling and RKKY interaction in Pt/Co multilayer with Ir spacer gives rise to the nucleation of isolated and high-density skyrmions in these systems. The skyrmion size and density increase with the increase in Co thickness in the multilayers. We have also stabilized in-plane SAF with CoFeB as FM and Ir as the spacer layer and explored the possibility of magnon-magnon coupling in this system. However, we could not observe any avoided crossing area between the acoustic and optical mode of magnons extracted from the FMR data which indicates the absence of magnon-magnon coupling in our system.