# ABSTRACT

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**Title of the thesis:**Spin Dynamics in Ferromagnetic Nanostructures

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The continuous improvement of electronic devices demand more power efficient and miniaturized circuit elements. However, the silicon-based electronics are approaching its limits regarding performance, miniaturization and power consumption. On the other hand, spin based devices offer some exciting advantages, for instance, substantially reduced resistive (Joule) heating energy loss unlike electronics and spin waves (SWs) with GHz frequencies, which enable fabrication of compact integrated circuits. In magnonic crystals (MCs), the periodic modulation of the magnetic properties in space allows manipulation of the magnons (quanta of SWs) in controlled manner with the aid of external magnetic field. These features make MCs suitable candidates for the applications in nanoscale on-chip data processing and communications devices.

This thesis is based on the investigation of magnetic configuration and spin dynamics in $Ni_{80}Fe_{20}$ (Permalloy; Py) patterned nanostructures by varying different physical and geometrical parameters, for instance, size and shape of the nanostructures as well as various external parameters such as strength and orientation of the bias magnetic field and microwave power of the input signal. We have utilized a broadband ferromagnetic resonance spectrometer to probe the magnetization dynamics in frequency domain. Whereas the ultrafast precessional magnetization dynamics is detected by a time-resolved magneto-optical Kerr effect (TR-MOKE) microscope. The experimental observations are interpreted with the assistance of micromagnetic simulations (OOMMF and LLG Micromagnetics simulator) to underpin the explanations. A rich anisotropic SW dynamics is explored in cross-shaped nanodot (nanocross) arrays by using ferromagnetic resonance technique. The static magnetic configuration at different bias field values are studied. Various interesting phenomena such as mode crossover, mode softening, mode merging and mode splitting are detected in magnetization dynamics. These prime features are substantially modulated with the variation of sizes of the


nanocrosses. Further, the in-plane bias field orientation is varied and the critical angles are tabulated where different prime features are detected for varying dimensions of the nanocrosses. The direction of propagation of the SW can manipulated by varying the in-plane orientation of the bias field. Consequently, a bias field strength and in-plane orientation dependent tunable static magnetic configuration and magnetization dynamics are observed in Pynanocross arrays of varying sizes. In addition, the microwave power of the input signal is varied using vector network analyzer. A microwave power dependent ferromagnetic resonance shift is detected in FMR frequency where sign of the shift depends on the strength of the bias field and static magnetic configuration. In addition, strong magnon-magnon coupling induced two anticrossing features are detected in dipolar coupled nanocross array. This dynamics in ferromagnetic nanocross array can be transformed from linear to nonlinear by enhancing the microwave power of the input signal. We have further investigated the spin dynamics in $Ni_{80}Fe_{20}$ cross-shaped nanoring (CNR) array with the help of a TR-MOKE microscope and micromagnetic simulations. A magnon-magnon coupling induced anticrossing feature is detected between the two lowest frequency spin wave modes. The magnon-magnon coupled modes can propagate longer distance as opposed to the other spin wave modes present in the ferromagnetic CNR array.

All the aforementioned experimental observations are important in the field of magnonics in terms of their applicability in microwave-assisted fast data storage, logic, and various communication devices.

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