Magnetic Vortex Lattice

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Magnetic nanostructures have attracted large interest due to their unique properties. In this regard, as the size of a magnetic structure is reduced, the multi-domain state becomes energetically unfavorable and either a single domain or an inhomogeneous magnetization configuration is formed. In particular, for soft ferromagnetic disks in the micron size range a so called vortex state is favored, where the magnetization is forming an in-plane flux closure structure to minimize the magnetostatic energy. In addition, in the center, a vortex core occurs where the magnetization is pointing perpendicular to the disk plane as a result of minimizing the exchange energy. In our study, a two dimensional vortex lattice was prepared by magnetic permalloy (Py) film deposition onto self-assembled densely packed particle arrays forming magnetic cap structures. Strong coupling is induced by deposition of thick Py films, where neighboring caps will be interconnected at the contact areas, resulting in direct magnetic exchange coupling [1]. Here, we report on the influence of magnetic coupling on the reversal behavior and the in-plane circulation orientation of neighboring caps, which can lead to frustration in a hexagonal cap array. Moreover, exchange biased Py/CoO vortex structures studying magnetization reversal, cooling field dependence, and training will be discussed [2].

In a further study, the vortex cores were investigated by an in-field scanning magnetoresistive microscope (SMRM). This device uses a state-of-the-art magnetic recording head of a hard disk drive and individual vortex cores can be investigated and their lateral displacement when an in-plane field is applied can be evaluated. In addition, this tool allows applying a magnetic field pulse to individual vortices. A successful sequential switching process of individual vortex cores is obtained, where vortices with core polarization “down” (dark) were reversed to the opposite direction “up”, revealing bright contrast after the switching event [3]. This study is accompanied by micromagnetic simulations, revealing that the reversal processes are dominated by strong suppression of spin waves excitations using a local field pulse [4].

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