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# Magnetic patterning using Ne, Co, and Dy FIB

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Magnetic nanostructures needed for magnonics and spintronics are usually processed by conventional lithography techniques in combination with lift-off or broad-beam ion etching. However, it has been shown [1] that the quality and shape of the structures' edges play an important role for the magnetization dynamics as structures become smaller and smaller. Furthermore, regarding optical measurement techniques, hard-to-remove resist masks that become hardened by ion etching are problematic. Direct-writing focused ion beams (FIB) do not have these issues. In addition, using non-standard ion species opens various paths for local magnetic patterning, i.e., influencing the magnetic properties locally.

I will present results for maskless magnetic patterning of ferromagnetic nanostructures using He and Ne ions as well as a few liquid metal alloy ion sources (LMAIS) for FIB systems. He/Ne FIBs are well established and commercially available. Irradiation of (paramagnetic) FeAl films by Ne ions creates local ferromagnetic nanostructures caused by disorder that are embedded in a paramagnetic matrix [2]. The precise Ne FIB also enables us to trim the edges of magnetic nanostructures enhancing their magnetic fidelity and creating certain localized magnon states at the edges of the samples. Using specifically developed LMAIS, like e.g., $Co_{36}Nd_{64}$, CoDy, or CuDy [3,4] in combination with a Wien mass filter offers further new paths for magnetic patterning. I will present results on the modification of $Ni_{80}Fe_{20}$ (permalloy) strip samples. Using the CoNd LMAIS a narrow track of Co ions was implanted. The induced magnetic changes were measured with microresonator ferromagnetic resonance (FMR) before and after the implantation. Structures as small as 30 nm can be implanted up to a concentration of 10 % near the surface. Such lateral resolution is hard to reach for other lithographic methods. Using Dy ions one can locally increase the Gilbert damping parameter of the magnetization dynamics by more than a factor of four with a lateral resolution of about 100 nm.

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