The Search for Tbits/in^2: Understanding the Fundamentals of Nanomagnetism

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Control of switching in magnetic nanostructures is critical for device applications from MRAM cells to patterned recording media [1]. Typically, we desire that very large numbers of these nanoscale magnets switch in an identical way when subject to same external conditions e.g. applied field and temperature. In the case of bit patterned media created from arrays of nanomagnetic islands [2], such as those shown in fig.1, each element should switch when subject to a particular head field. In practice, identical switching of magnetic elements is not observed and this leads to a finite switching field distribution (SFD), fig.2. The SFD has two components; an intrinsic component due to physical variations of material properties and a component due to magnetostatic fields from neighbouring islands. The magnetostatic component can be determined both by measurement and by simulation [5] and becomes increasingly significant as the period of the patterned magnetic arrays is reduced.

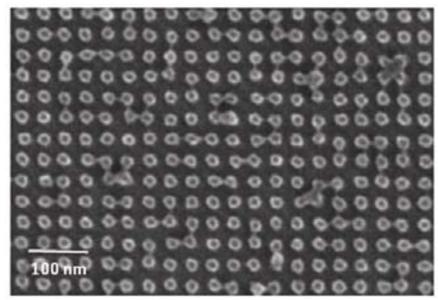

Fig.1: Patterned array of Co/Pd islands with 28 nm period (820 Gbit/in^2) produced by Extreme Ultraviolet Interference Lithography (EUV-IL) at PSI, Switzerland [3-4].

The intrinsic component of the SFD results from a distribution of anisotropy that occurs at length scales set by the exchange (nucleation) length. The intrinsic distribution of anisotropy can be probed by varying the number of nucleation sites and measuring the field needed to reverse the element; provided that domain wall pinning energies are much less than the nucleation energy. In the case of Co/Pd multilayer islands with large perpendicular anisotropy and high exchange coupling where this condition is met, we show that by measuring the reversal properties as a function of island size, fig.3, the intrinsic distribution of anisotropy can be quantified. Knowledge of the anisotropy distribution allows possible physical mechanisms for these material variations to be studied.

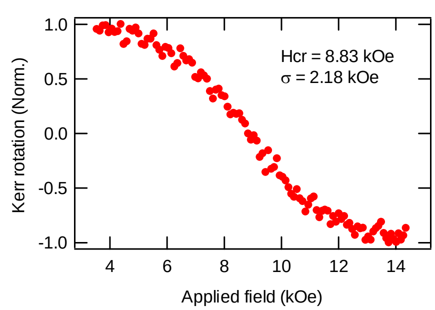

Fig.2: Kerr rotation remanence curve for 32 nm period Co/Pd magnetic island array. In this sample the SFD (σ/H_{cr} = 0.25) which is much greater than could be used in a particular device.

The current status of patterned media as a future data storage technology will also be discussed briefly in the context of some recent results on quasi-static recording of patterned nanostructures.

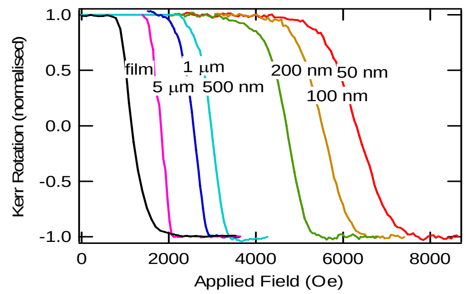

Fig.3: Remanence curves as a function of island size of a series of Co/Pd nanomagnetic island arrays.

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