Abstract

The subject of this work are lithographically defined cylindrical nanopillars containing a stack of two Iron disks separated by a nonmagnetic spacer. The dimensions of the ferromagnetic disks are chosen such that at low magnetic fields, the so-called magnetic vortex is stabilized. In zero field, the magnetization of these objects is basically parallel to the disk plane and circulates the disk center. In doing so, the build-up of large in-plane stray fields is avoided. At the center of this distribution however, exchange forces turn the magnetization out of the disk plane, resulting in the formation of what is referred to as the vortex core. Magnetic vortices have attracted much attention in recent years. This interest is in large parts due to the highly interesting dynamic properties of these structures.

In this work the static and dynamic properties of magnetic vortices and their behavior under the influence of spin-transfer torque are investigated. This is achieved by measuring the static and time dependent magnetoresistance under the influence of external magnetic fields.

The samples allow the formation of a large variety of states. First, the focus is set on configurations, where one disk is in a vortex state while the other one is homogeneously magnetized. It is shown that spin-transfer torque excites the vortex gyrotropic mode in this configuration. The dependence of the mode frequency on the magnetic field is analyzed. The measurements show that as the vortex center of gyration shifts through the disk under the action of the magnetic field, the effective potential in which it is moving undergoes a change in shape. This shape change is reflected in a V-shaped field dependence of the gyration frequency.

Analytical calculations are performed to investigate the effect of the asymmetry of the spin-transfer torque efficiency function on the vortex dynamics. It is shown that by means of asymmetry, spin-transfer torque can transfer energy to a gyrating vortex even if the spin-polarization of the current is perfectly homogeneous.

Subsequently so-called double vortex configurations are considered. These configurations involve states where each of the disks is in a vortex state. Methods for preparing such states are developed and the spin-transfer torque induced dynamics of these configurations is investigated. Rich dynamics is observed, and differences in mode frequencies can be identified as being caused by different combinations of vortex core polarities. The experiments show that double vortex systems are nonlinear oscillators which show the property of phase locking to an external periodic signal.