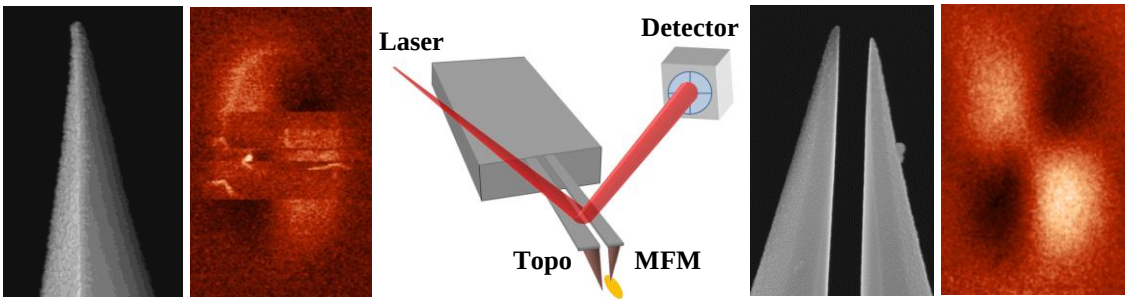
Magnetic memories and magnetic-field imaging

Magnetic alternative to semiconducting microelectronics–based computing promises highly efficient and ultra-low-power operation close to the theoretical limit of thermodynamic efficiency. Proposed and developed are novel concepts of magnetic memories (i.e. race-track and skyrmion memories) based on magnetically soft objects (domain walls and vortices).

Together with new memories, systems for their control have to be improved. Nowadays, magnetic force microscopy (MFM) is mostly used for magnetic field imaging at nanoscale. MFM consists of two passes realized by one, magnetic tip. Within the first (topography) pass the tip directly touches the magnetic sample. Such contact can completely destroy the magnetic state of the nanoobjects with magnetic domain walls and vortices.



Single magnetic tip shows disturbed image of vortex while dual-tip gives correct one.

To avoid the sample touching by the magnetic tip, the team at the Institute of Electrical Engineering introduced a novel method for the magnetic field imaging, so called dual-tip magnetic force microscopy. In the method, the topological and magnetic scans are segregated using two different tips, one magnetic and one non-magnetic. Tips are located on a cantilever cut by focused ion beam technology. The non-magnetized tip is used for the topography only, and the magnetized one (shorter) is used for the magnetic field mapping only (avoids surface touching). Our experiments show that the dual-tip technique minimizes the perturbations of the magnetic tip present in standard two-pass scanning.

Introduced dual-tip magnetic microscopy can be used to explore magnetically soft objects like magnetic vortices and magnetic domain walls in a variety of magnetic samples and is perspective in a wide range of applications, e.g. in data storage systems (race-track memories, skyrmions, etc.) and also in biomedicine to explore magnetic nanoparticles in living cells.

Marián Precner, Ján Fedor, Ján Šoltýs and Vladimír Cambel, Dual-tip magnetic force microscopy with suppressed influence on magnetically soft samples, *Nanotechnology* **26** (2015) 055304. doi:10.1088/0957-4484/26/5/055304.