

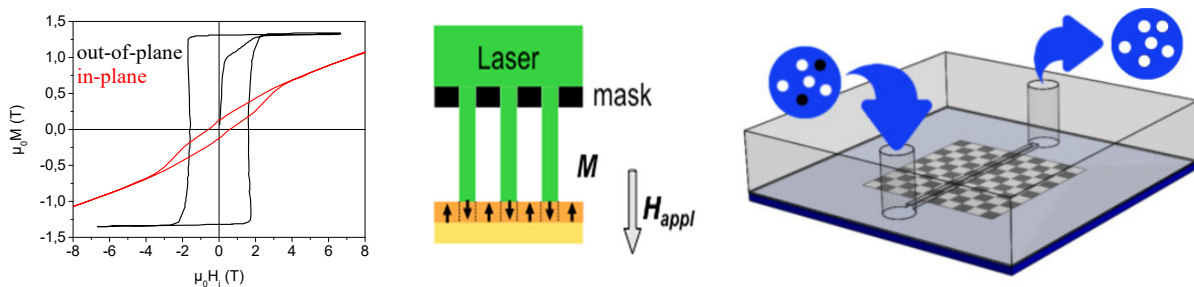
## TP60 - Fabrication of a micro-fluidic device with integrated micro-magnets to manipulate magnetic nanoparticles

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Magnetophoresis refers to the motion of an object under the influence of an inhomogeneous magnetic field and is exploited for the manipulation (trapping, separation, mixing, transportation...) of biological species [1]. As a source of magnetic flux, hard magnetic materials have the advantage to be autonomous, meaning they are active without a power supply (unlike coils) and without an externally applied magnetic field (unlike soft magnets). The magnetophoretic force acting on an object, given by  $F_m = M \cdot V \cdot \nabla B$ , ( $V$  being the volume  $M$  the magnetization of the object and  $B$  the magnetic induction), can be maximized by increasing the field gradient ( $\nabla B$ ), through a reduction in the size of the flux source. Therefore, micro-magnets are an exceptionally powerful driving force for magnetophoresis at microscale.

- The first part (4h) of the practical is dedicated to the fabrication of hard micromagnets through the following process : thick hard magnetic NdFeB film growth by high rate triode sputtering [2], micro-patterning using the Thermo-Magnetic-Patterning (TMP) technique [3], and magnetic characterization.

- The second part (4h) of the practical is dedicated to the fabrication of polymer-based micro-fluidic chips embedding micromagnets into a microfluidic channel, and their use for trapping and manipulation of magnetic micro/nanoparticles in a fluid [4].



**Left:** Magnetic hysteresis loops of a 5  $\mu\text{m}$  thick NdFeB film; **centre:** local patterning of a hard magnetic film using the TMP technique; **right:** PDMS  $\mu$ -fluidic device with integrated  $\mu$ -magnets for particle manipulation.

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[2] N.M. Dempsey, A. Walther, F. May et al., *Appl. Phys. Lett.* 2007, **90** 092509

[3] F. Dumas-Bouchiat, L.F. Zanini, M. Kustov, et al., *Appl. Phys. Lett.*, 2010, **96**, 102511

[4] L.F. Zanini, N.M. Dempsey, D. Givord, et al., *Appl. Phys. Lett.*, 2011, **99**, 232504