Ultra MFM - an ultimate resolution and sensitivity with a table-top AFM

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The investigation of magnetization textures is a cornerstone in modern nanomagnetism and spintronics, associated with novel fundamental questions, as well as applications in data storage and computing. Nanosized systems of increasing complexity and decreasing size are considered, requiring continuous progress in the sensitivity and spatial resolution of magnetic microscopy. It is in this context that we identified the need for an advanced although table-top instrument for magnetic imaging.

Following a broad technical investigation, the choice went for a prototype being developed by the Nanoscan company, combining the sensitivity and resolution of the high-performance instruments with the versatility required from a platform instrument. This can be achieved with an instrument operating under secondary vacuum, decreasing losses associated with air viscosity, thereby increasing the sensitivity. In turn this allows us to use sharper and low-moment tips, thus improving the spatial resolution.

The unprecedented combination of technical features like a 5 µm-resolution optical view (to locate nanofabricated devices), sample size up to 100x100x15 mm (suitable from wafers to bulk materials) and its unique 200x200x15 mm (X, Y, Z) stage travel range with a 20 nm resolution reached an almost limitless repositioning capability.

After few years of joined development with the company, this prototype, the first of its kind, was able not only to give access to high sensitivity and high resolution in MFM, but also to open new possibilities like surface potential measurements and static magnetic force measurements on functional materials and devices with a remarkable easiness of use. These features opened the doorway to collaborations and gave access to measurements that were never reached before on the AFM platform of the NEEL Institute.

Fig. 1: Nanoscan VLS-80 microscope installed at the NEEL open AFM facility.

In the future, the development of a variable-temperature sample stage (100K – 600K) will be finalized in a collaboration between the Nanoscan company and NEEL combining their complementary expertise on high temperature and cryogenics, respectively.

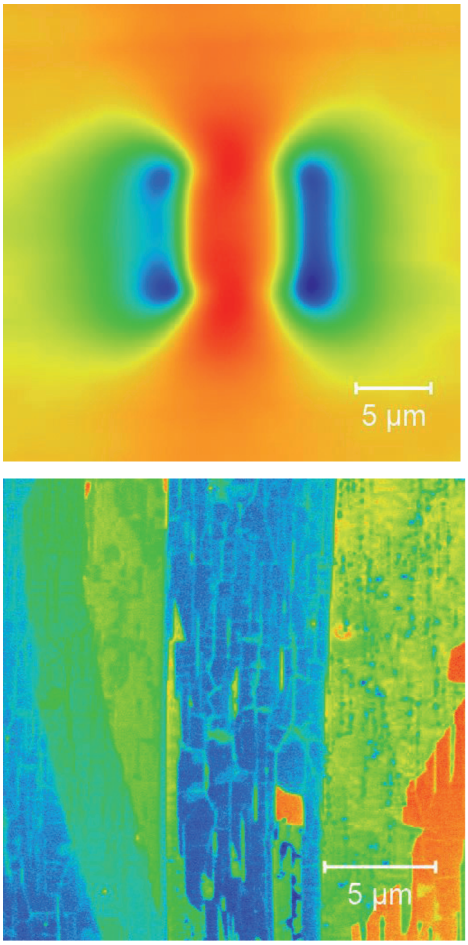

Fig. 2: Top: magnetic force measurement above an iron micro pillar. Bottom: Graphene on SiC CPD

OUTCOMES

Collaboration: Claire Berger, GeorgiaTech, USA.

Publication: Mechanotransductive cascade of Myo-II dependent mesoderm and endoderm invaginations in embryo gastrulation, Nat. Commun. 8, 13883 (2017)see also those of the PhD students.

PhD : Ioan-Augustin Chioar (2012-2015), Michal Stano (2014-2017), Lorenzo Camosi (2015-2018), **Post doc fellow:** Vladimir Prudkovskiy (NEEL/GeorgiaTech)

Leverages: DARPAproject N° HR001117S0038. 2018-2021, coordinated by O. Boule (INAC). Partners CNRS-Thales, FZ Jülich

ANR TOPSKY: TOpological Properties of magnetic SKYrmions and opportunities for novel spintronic devices. 2018-2021, coordinated by S. Pizzini (NEEL).

ANR SHAMAN: Soft in HArd MAgnetic Nanocomposites, 2018-2021, coordinated by N. Dempsey, (NEEL).