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Generating Large Magnetic Field in a High Resolution Electron Beam Lithography

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Since discovery of giant magnetoresistance (GMR) [1, 2], spintronics have achieved great progress not only in laboratory research but also in commercial applications two typical examples of which are GMR reader [3] and magnetic random access memory (MRAM) based on tunneling magnetoresistance (TMR) effect [4]. Due to small sizes in three dimensions of the elementary device, it requires accurate lithographic technique, typically electron beam lithography (EBL) to pattern raw films into desired shape as well as to make electrodes with much larger sizes which occupy large area of a wafer and only function as electrical pads during subsequent measurement process.

In this talk we will report about first results and measurements achieved with an electron beam lithographic system (EBL, eLINE Plus CAS) containing a unique in situ setup to not only fabricate but also characterize and measure GMR/TMR based devices. The eLINE Plus CAS is additionally equipped with the capability of generating a large lateral magnetic field, which is indispensible in measurement of spintronic devices or materials, besides of its original SEM and EBL functionalities. This unique EBL instrument, thus, could be not only used as a microscope or a lithography system but also as a analytical instrument for in-situ magnetoelectric transport measurements. Figure 1 shows the structure of the magnet in chamber whose pole tips are placed underneath pole piece of SEM column. The maximum lateral field realized at current stage is about 400 Oe as exciting current is elevated as 2.5 A. This large field has already been applied in in-situ measurement GMR or TMR devices. As shown in Figure 2, utilizing the magnet as well as the other two tungsten probers already installed in the chamber, we have measured magnetotransport properties of a TMR device whose TMR ratio is nearly the same as that measured outside chamber. We will further report about the characterization of the homogeneity of the magnetic field and next steps taken in this project.

It is worthy of accentuating that magnetic field should be switched off as the SEM is used and remanence of the magnet is too small to disturb ordinary operation of the SEM and EBL whose microscopic resolution and lithographic resolution could still remain in the order of 3 nm and 10 nm, respectively.

Combination of magnetic field with ordinary EBL or SEM not only endows them with capability of in-situ magnetoelectric measurement capability but also shed light on hybridization of SEM with magnetic force microscope or magneto-optical Kerr microscope, advancing the development of characterization techniques for magnetic materials or spintronic devices.

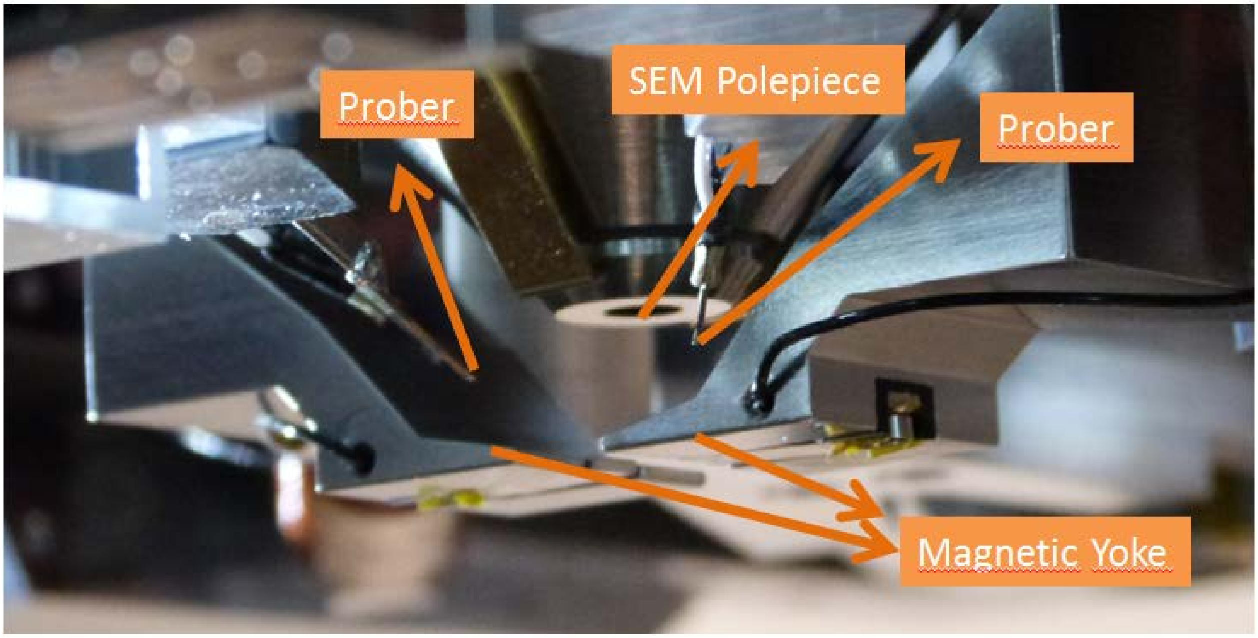

Figure 1. Magnet prober and SEM polepiece arrangement within EBL system chamber

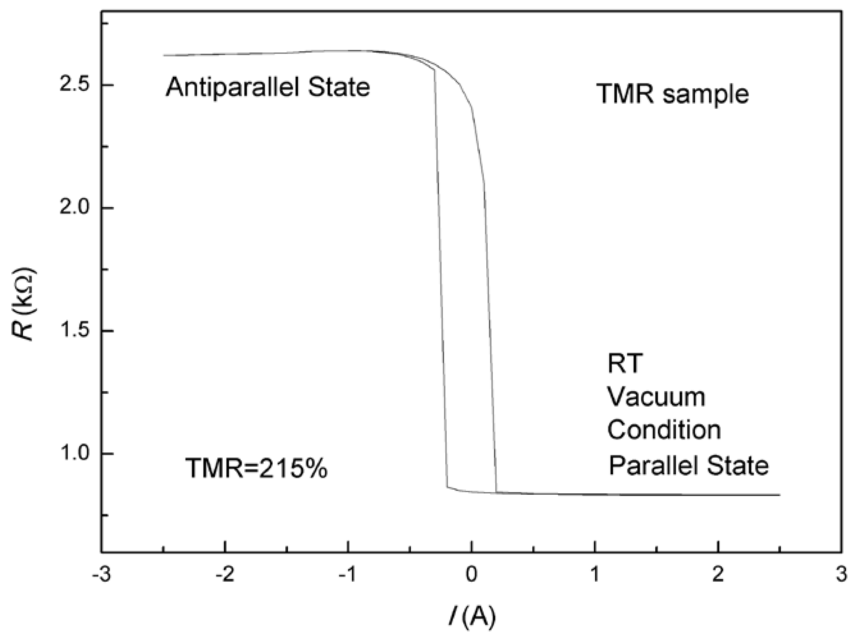

Figure 2 Field dependence of a TMR device measured in EBL chamber.

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