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MS-12-O-3526 Direct-write Deposition of Magnetic Nanowires in a Scanning Electron Microscope - A new fabrication route for nanomagnet logic applications

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Scanning electron microscopy is not only indespensable for high-resolution imaging of nanowires, nanotubes or nanoparticles. Recently it has also become popular as a direct-write nanofabrication technique of achitectured nanomaterials. In a precursor gas environment the focused beam of electrons can be used for inducing a chemical vapor deposition on the nanoscale. In particular, this focused electron beam-induced deposition (FEBID) has been employed for the development of catalytic templates for nanowires, for nanoelectronic devices and for functional nanostructures such as ultrasharp AFM-tips.

This work presents the application of iron penatcarbonyl as metalorganic precursors for magnetic nanostructures. The FEBID nanofabrication of functional magnetic materials is attracting increasing attention for applications in smart magnetic sensing, data storage and nano magnetologic (NML) devices [1,2]. We have previously employed FEBID for the direct-write deposition of functional magnetic tips for MFM. In this work we will demonstrate how FEBID of iron nanostructures can be used for magnetic information processing (Fig. 1). FEBID fabricated iron nanowires exhibited a high iron content (Fe>80at.%). By magnetic force microscopy (MFM) a ferromagnetic behavior could be identified. Due to sub-µm size nanowires displayed a single domain structure. Depending on the initial external magnetisation 2 different states encoding the Boolean "0" and "1" were obtained, Such elongated single domain magnetic nanostructures are the key-elements in nanomagnetlogic (NML) technology. Conventional an advanced fully functional NML gates have been realized by FEBID (Fig. 2). Further advantage of the novel design such as a reduction of the error probability and the potential to merge several NWs in future NML constituents will be discussed.

Furthermore, using FEBID we have deposited different object geometries including lines, triangles, rectangles, pentagons and circles (Fig. 3). The magnetic domain structure was determined by the geometry of structures on the nanoscale level. Nanostructures with different rotational symmetries showed a controlled transition from the single domain to a flux closure multi-domain state in dependence on the aspect ratio.

Concluding, FEBID has been proven a successful approach for guiding the "non-structural disorder" in magnetic nanostructures. Future prospects and developments of FEBID in NML will be discussed.

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