## Electron-beam-induced cobalt deposition

**Elizaveta Nikulina**[1], Roger Llopis[1], Olatz Idigoras[1], Fèlix Casanova[1,2], Luis E. Hueso[1,2], Paolo Vavassori[1,2], Andrey Chuvilin[1,2]

[1]CIC nanoGUNE Consolider, Tolosa Hiribidea 76, San Sebastian-Donostia, Spain
[2]Ikerbasque, Basque Foundation for Science, Alameda Urquijo 36-5, Plaza Bizkaia, Bibao, Spain
e.nikulina@nanogune.eu

Focused electron-beam-induced deposition (EBID) and ion-beam-induced deposition (IBID) have been established as one-step techniques for the fabrication of 3D nanostructures. In the last decade there has been a growth of interest in the development of EBID processes for magnetic materials, namely for Fe [1], Co [2-3] and Ni [4], which may provide a new route for the fabrication of magnetic nanodevices. Since the magnetic properties of these three metals are particularly defined by purity, it is a challenge to fabricate ferromagnetic and conductive structures with the highest possible metal content by the EBID method. Among these metals Co attracts the most attention, this is because an exceptional purity of up to 95 % [3] can be obtained under the correct deposition conditions. In comparison to Co, Fe and Ni give a metal content of 60 % at best in non-ultrahigh vacuum conditions. There exists a broad variety of literature data on deposition rates, purities and physical properties of EBID Co deposits, but the data is not systematic and in some cases contradictions are present. In the current work we present a systematic investigation and optimization of deposition parameters, and characterization of physical properties and structure of the EBID cobalt deposits formed. Dependencies of deposition rate and purity of the material obtained in this work are in agreement with the literature data, i.e. we observe the growth of deposition rate with an increase of current and a decrease of the beam energy. Deposition yield demonstrates an exponential decay with an increase of beam current; this has been previously reported for Fe EBID. Purity and the crystallinity of cobalt deposits are related characteristics and EBID cobalt patterns deposited at high beam currents have high metal content and well-pronounced polycrystalline structure while those fabricated at low currents show low cobalt content and consist of a carbonaceous matrix with embedded cobalt crystals of the size of a few nanometres (see Fig 1). In contrast to an expectation based on EBID Fe data, only a minor influence of water vapour pressure on deposition purity was observed in a pressure range of mPa.
In order to characterize physical properties of the fabricated deposits the magnetic and electrical measurements have been performed. Magnetic properties of deposits were characterized by MOKE microscopy. Optimum ranges of deposition parameters were defined ensuring both ferromagnetic nature of deposits and a high fabrication resolution. Resistivity vs. temperature measurements of cobalt structures grown at optimized beam conditions proved that those cobalt deposits are conductive and demonstrate metalic behaviour.

### References

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### Figures

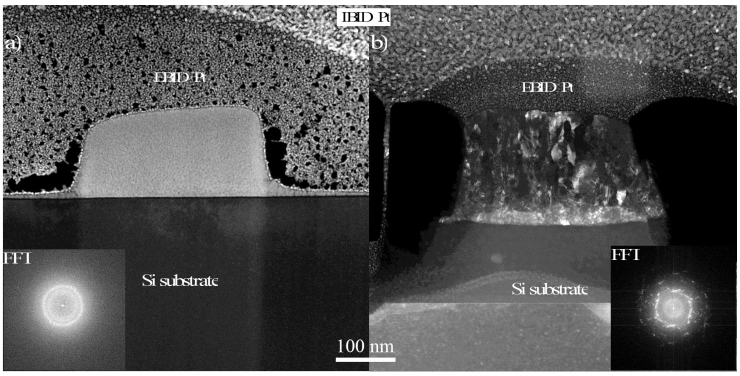


**Figure 1.** (a) STEM-HAADF TEM image of cobalt deposit fabricated at 1kV, 43pA; (b) STEM-HAADF TEM image of cobalt deposit fabricated at 25kV, 2700pA, inserts on (a) and (b) show DP of inner parts of corresponding deposits.