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Local magnetic measurements in multi-layered nanowires observed by electron holography

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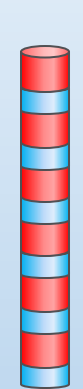
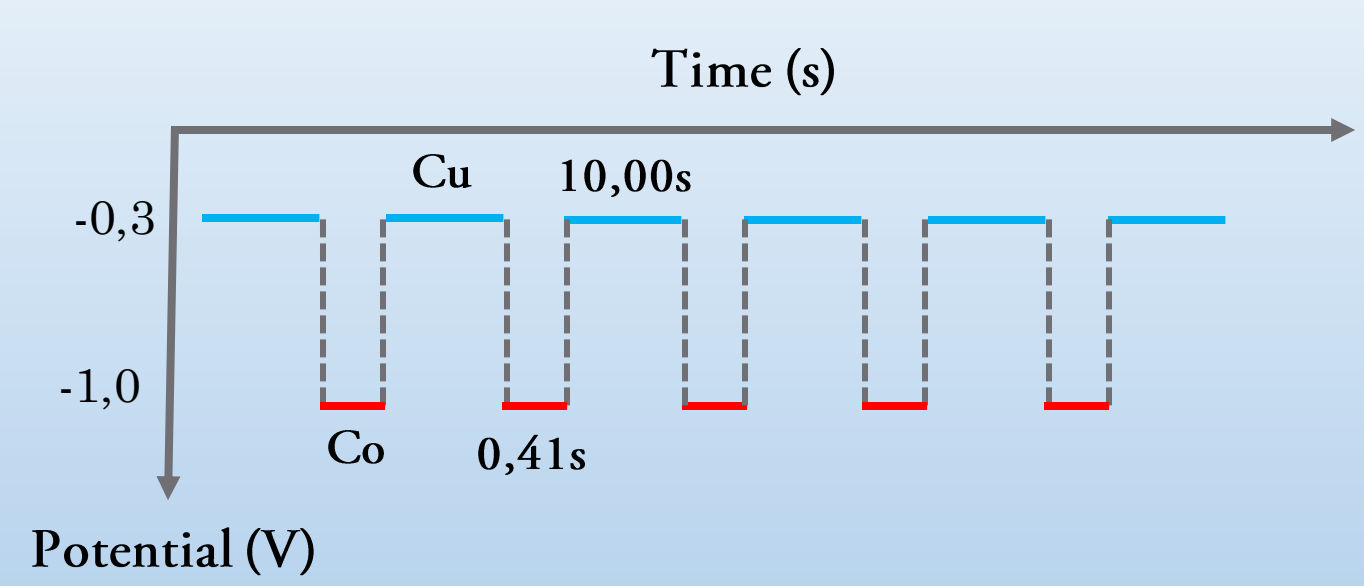
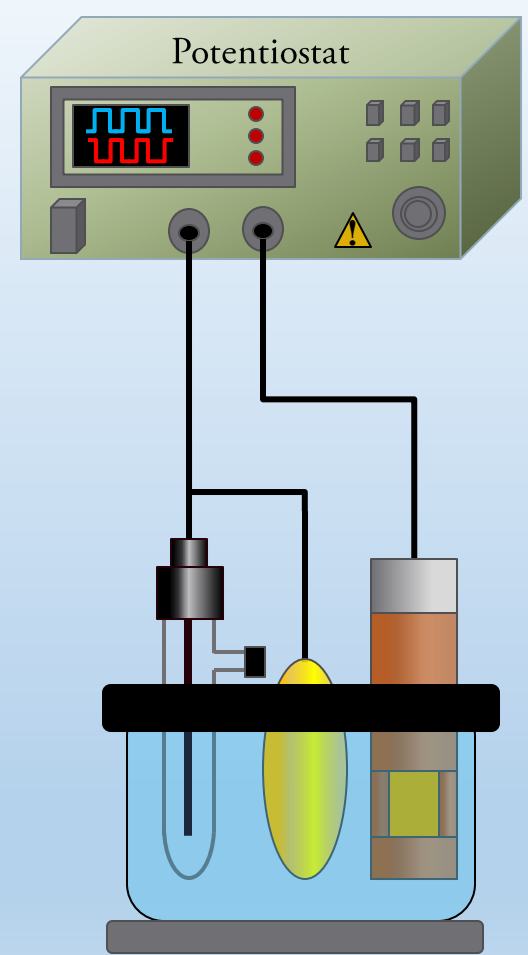
²Université Paul Sabatier, 31062, Toulouse, France

³LSI, École Polytechnique, 91128, Palaiseau, France

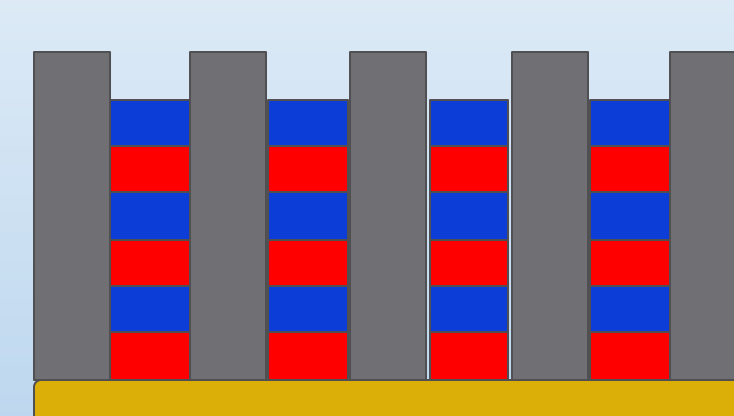
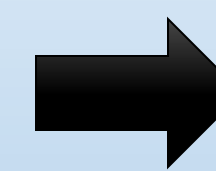
* reyes@cemes.fr

In this study we elaborate multi-layered Co/Cu nanowires by pulsed electrodeposition technique into polycarbonate membranes, with a diameter between 55nm and 80nm. Cobalt and copper maps were obtained by EFTEM to get the position and the average thickness of the layers. Using electron holography we observed the magnetic states in individual cobalt layers for two different configurations.

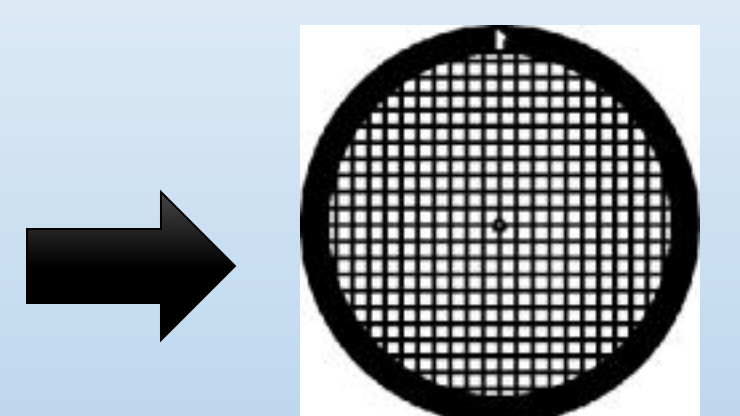
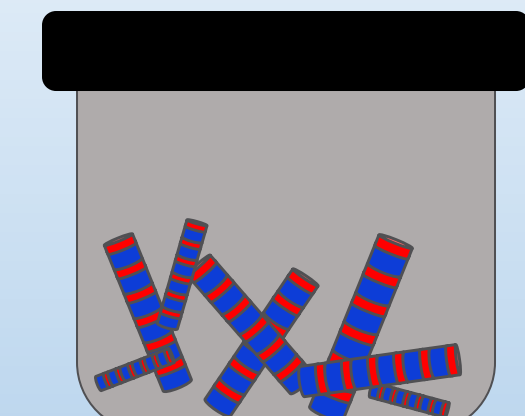
Sample deposition



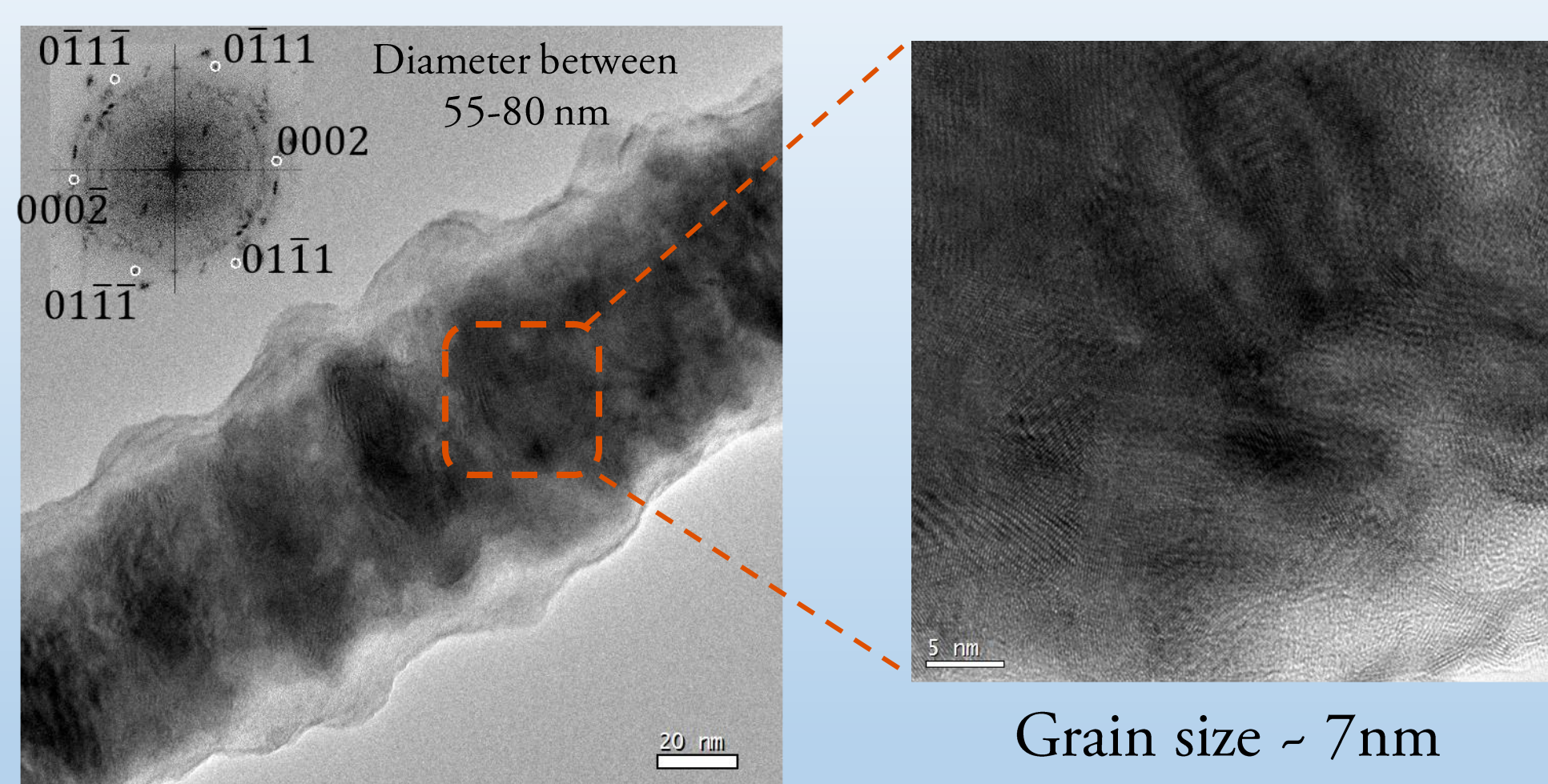
Polycarbonate membrane
30 nm pore size



Membrane dissolution
Dichloromethane



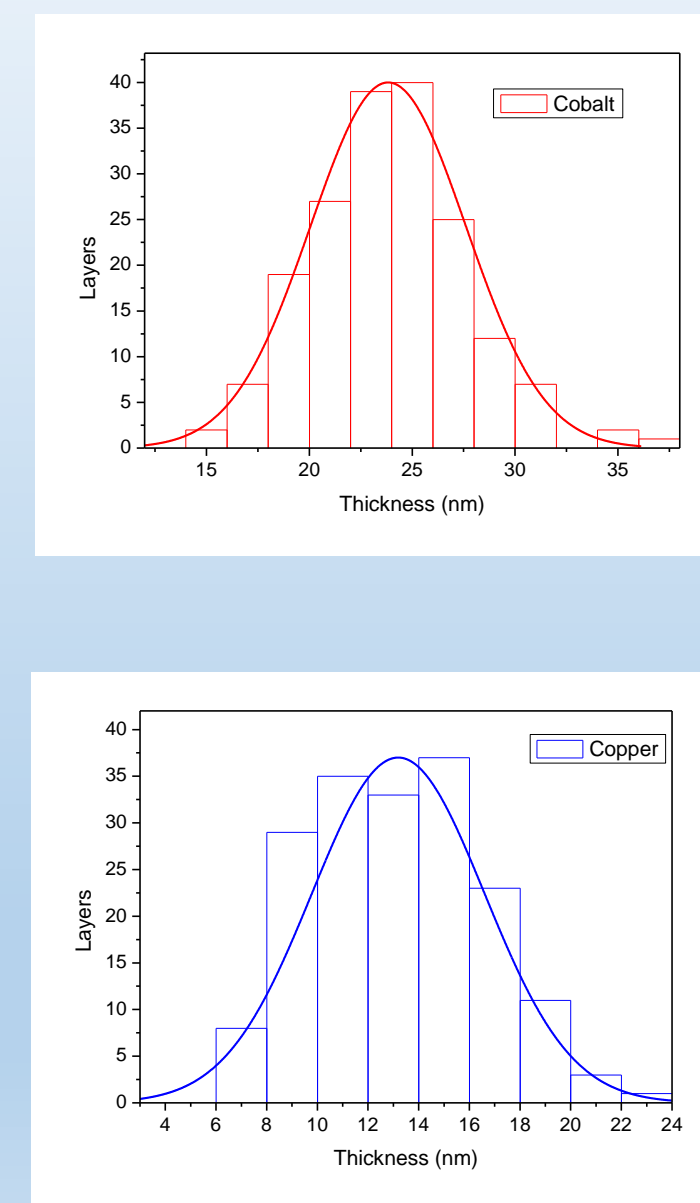
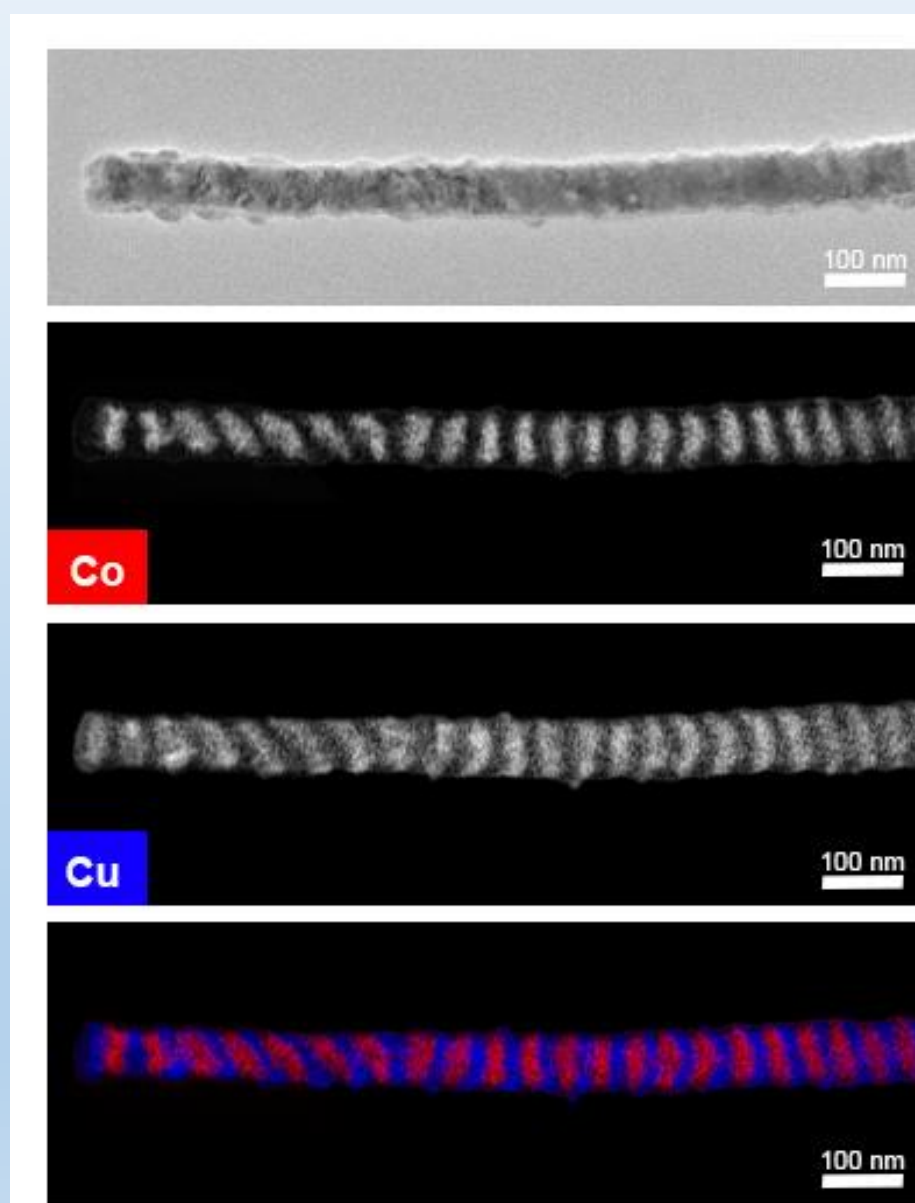
Structural properties



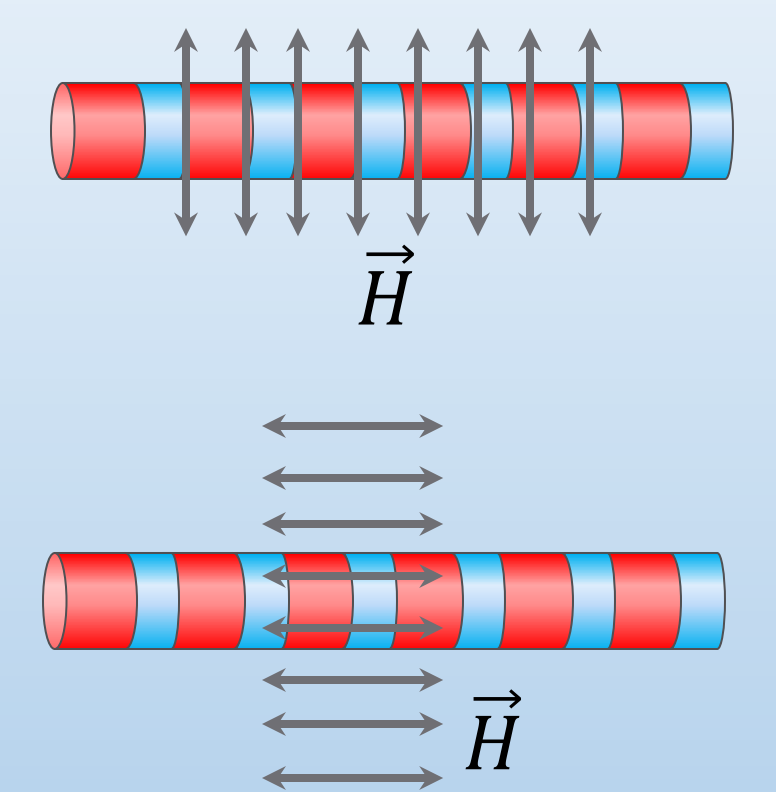
Polycrystalline with texture
Co HCP and FCC
Cu FCC

In the texture we could identify the c axis of the Co HCP $\pm 20^\circ$ respect the axis wire

Chemical properties



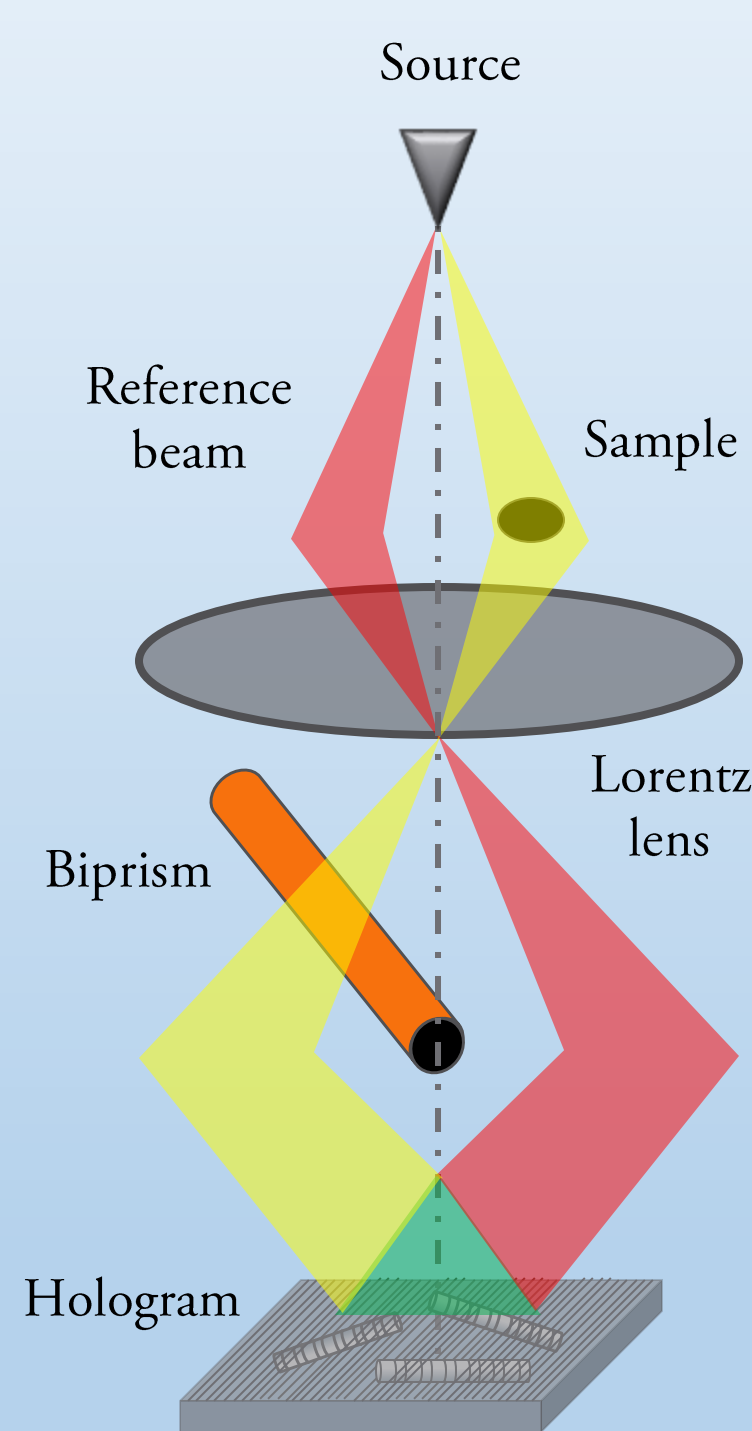
Configurations



$\|\vec{H}\| = 1.3\text{T}$

Magnetic properties were observed in remanence state after apply a magnetic field

Off-axis electron holography



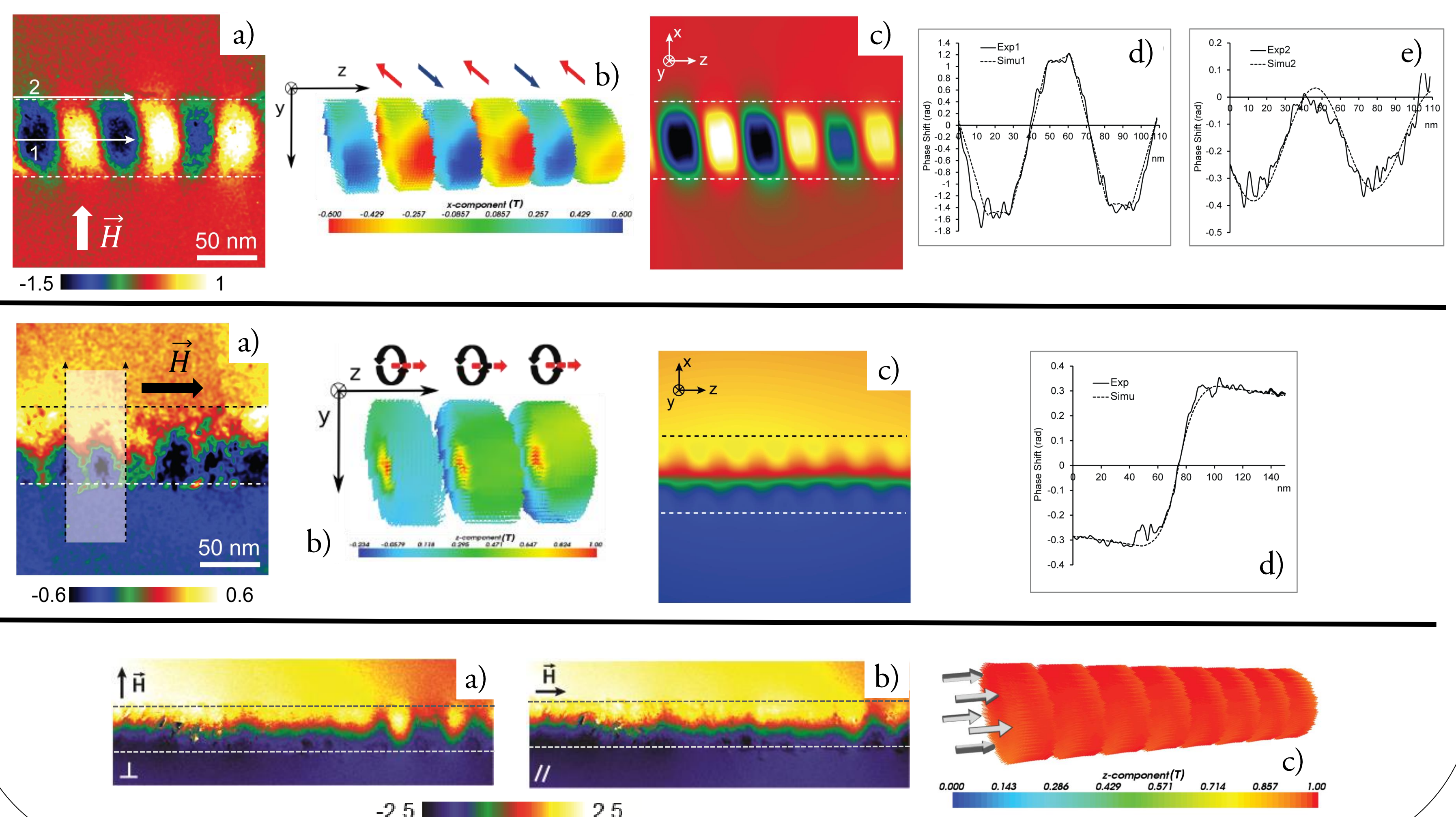
The phase of an electron wave that passed through a specimen will be changed by the electromagnetic by[1]:

$$\phi(x) = C_E \int V(x, z) - \frac{e}{\hbar} \iint B_{\perp}(x, z) dx dz$$

Mean inner potential (MIP): $\phi^E(x) = C_E \int V(x, z)$

Magnetic contribution: $\phi^M(x) = -\frac{e}{\hbar} \iint B_{\perp}(x, z) dx dz$

Magnetic properties



Conclusions

- We elaborate multi-layered Cu/Co nanowires by pulsed electrodeposition with a good quality
- Quantitative and local study combining structural, chemical, magnetic (electron holography) properties and 3D simulations
- We performed a systematic study of isolated nanowires with a spatial resolution no more of 2 nm by electron holography revealing 3 main configurations: a) antiparallel coupling, b) coupled vortices and c) monodomain state

References

[1] Etienne SNOECK and Christophe GATEL, (2013). Transmission Electron Microscopy in Micro-nanoelectronics, WILEY, Chapter 5, pp. 108-126.

Acknowledgments

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