Self-assembly and strain engineering of bimetallic nanowires: tuning magnetic nanoalloy properties via vertical epitaxy

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Strain is a key parameter affecting the physical properties of nanosized objects. In addition to size and composition, it represents another degree of freedom which allows for functionality tuning of nanoalloys. During the last decade, vertically assembled nanocomposites, *i.e.* hybrid columnar structures with strong interfacial coupling, have emerged as a novel platform for strain engineering approaches. But while oxide-oxide systems have been studied extensively [1,2], the full potential of multicomponent metallic structures vertically epitaxied in oxide matrices has not been explored in detail yet [3].

With this background, we present results on hybrid Co-based metal-oxide systems obtained *via* sequential pulsed laser deposition. Using high-resolution transmission electron microscopy, X-ray diffraction and X-ray absorption spectroscopy, we demonstrate that our synthesis approach allows to grow ultrathin nanoalloy wires, vertically epitaxied in various oxide matrices like $SrTiO_3$ or CeO_2. Depending on the nanoalloy, these wires can be perfectly mixed (*e.g.* CoNi), or display interesting segregation patterns (*e.g.* CoAu). By complementing these results with detailed magnetometry measurements, we demonstrate how $\langle \epsilon_{zz} \rangle$, the average axial strain in the wires resulting from nanoalloy-matrix interactions, impacts the effective magnetic anisotropy of the composites. We eventually show that $\langle \epsilon_{zz} \rangle$ can be tuned by changing the nanoalloy size, composition or the oxide matrix type, thereby paving the way for full strain engineering of these hybrid nanoalloy-based systems.

[1] J. Huang, J. MacManus-Driscoll and H. Wang, Journal of Materials Research **32** (2017) 4054-4066

[2] A. Chen, J.-M. Hu, P. Lu, T. Yang, W. Zhang, L. Li, T. Ahmed, E. Enriquez, M. Weigand, Q. Su, H. Wang, J.-X. Zhu, J. L. MacManus-Driscoll, L.-Q. Chen, D. Yarotski and Q. Jia, Science Advances **2** (2016) e1600245

[3] F. J. Bonilla, A. Novikova, F. Vidal, Y. Zheng, E. Fonda, D. Demaille, V. Schuler, A. Coati, A. Vlad, Y. Garreau, M. Sauvage Simkin, Y. Dumont, S. Hidki, and V. Etgens, ACS Nano **7** (2013) 4022-4029