ESRF	**Experiment title:** Structural study of graphene/Co/Ir ultrathin magnetic layers	**Experiment number**: HC-896
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Shifts: 18	**Local contact(s)**: Roberto Felici	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Jakub Drnec* - ESRF
Sergio Vlaic* - CNRS Grenoble
Helena Isern* - ESRF,
Francesco Carla*- ESRF
Roman Fiala* - Charles University Prague
Johann Coraux - CNRS Grenoble
Nicolas Rougemaille - CNRS Grenoble

Report:

The aim of this experiment was to investigate the structure of graphene/Co/Ir(111) magnetic layer prepared by Co intercalation under the graphene sheet supported on Ir(111) substrate. The structure of the Co/Ir(111) interface was found to be different than previously expected, which in turn question the overall role of the graphene on the magnetic behavior of this layer.As we need to probe the structure of buried interface, we used surface x-ray diffraction (SXRD) technique. Such information is not possible to obtain by common electron diffraction techniques and spectroscopies. This SXRD experiment allowed us to get information about the overall intercalation process, structure of the top graphene layer, structure of the underlying Co film and structure of the Co/Ir(111) interface.

In our previous experiment (IHSI-778), we were able to determine the structural behavior of just a Co layer deposited on Ir(111). The data are complementary to this experiment as it is critical to compare Co/Ir(111) and graphene/Co/Ir(111) systems to properly understand the role of morphology and interlayer atomic structure to the magnetic behavior of the layer. Results from this preliminary experiment for a layer of 12 Å Co thickness is in Fig. 1 and 2.

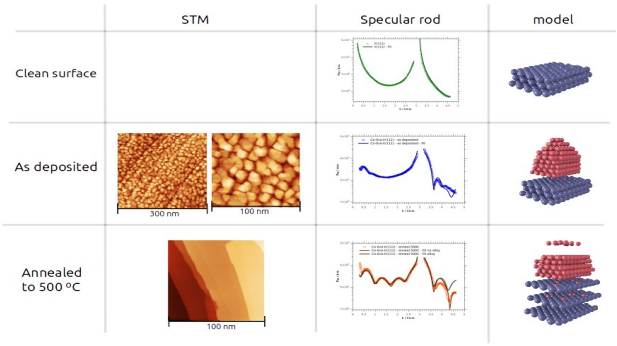

Fig. 1 XRR ans STM results for Co/Ir(111) surface annealed to various temperatures

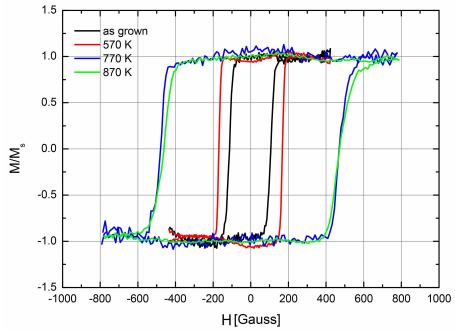

Fig 2 *MOKE measurement for Co/Ir(111) surface annealed to various temperatures*

The main result is that the magnetic properties, in this case coercivity, depend strongly on both morphology (from STM) and Co/Ir(111) interface structure (from XRR). The coercivity increase was previously solely attributed to the presence of graphene.

In this experiment (HC-896) we prepared the graphene contained magnetic heterostructures of various thicknesses (3Å, 12Å and 22Å). Here we show only the main results from 12Å layer, but similar behavior was observed for other thickness. We repeated the same procedure as in experiment IHSI-778 for graphene/Co/Ir(111). During the annealing, the Co intercalates under graphene and forms a new heterostructure (Fig. 3).

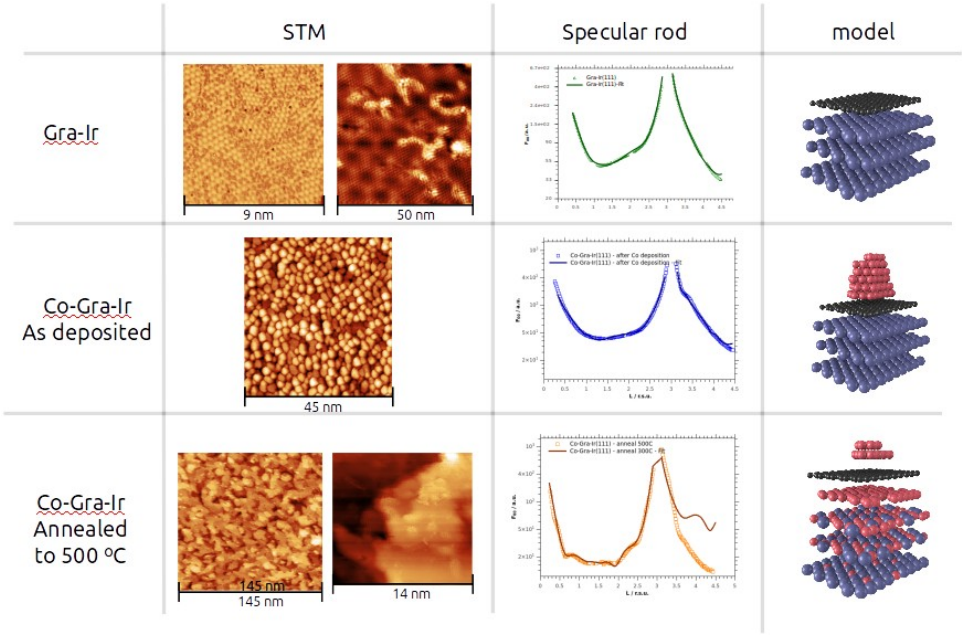

Fig. 3 XRR ans STM results for graphene/Co/Ir(111) surface annealed to various temperatures

We already fitted the specular reflectivity diffraction rods with models. The fitted structures are in good agreement with STM. The results also show great difference between Co intercalated under graphene structures and structures which are obtained by annealing to the same intercalating temperatures but which do not contain graphene layer. The intercalation process greatly enhance the intermixing of the Co/Ir(111) interface and formation of a surface alloy. This is also supported by the shift in Co lattice parameter during the annealing, and therefore change in the Co layer thickness as it alloys with the substrate (Fig. 4). Ongoing analysis of the whole SXRD dataset will give further insight into the process. This alloy, together with the topmost graphene layer, both affect the magnetic properties of this heterostructure. This is seen by the MOKE measurement in Fig. 5.

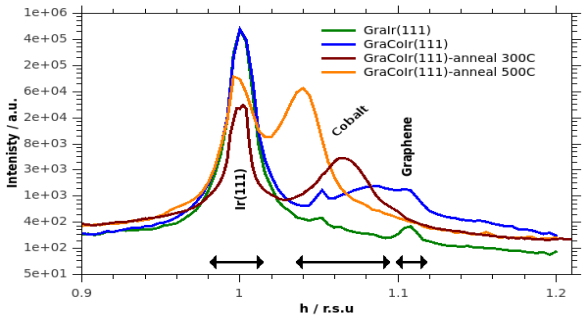

Fig. 4 Change in lattice parameter of Co layer during annealing. The change represents decreasing thickness of the Co layer as Co dissolve in the substrate.

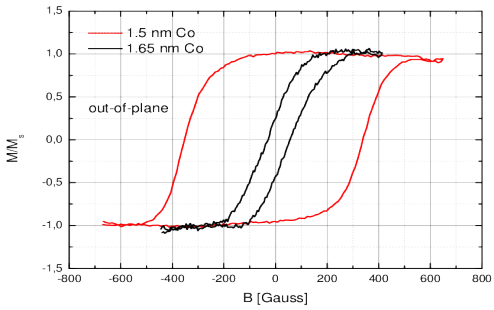

Fig 5. MOKE measurement of graphene/Co/Ir(111) heterostructure. The coercivity changes with thickness of the layer.

In conclusion, we were able to fulfil the proposed experimental plan and obtain unique information regarding the structure of this particular magnetic heterostructure. However some answers still remained unanswered mainly regarding the composition and exact structure of the formed alloy.