

SUPPLEMENTARY MATERIAL

Contents

- 1) Methodology for thickness measurement in 2D assemblies (page 2)
- 2) Magneto-optical characterization of P5 (pages 3-5)
- 3) Magneto-optical characterization of P2 (pages 6-8)
- 4) High-angle X-ray diffractometry results (page 9)

Methodology for thickness characterization

The thickness characterization is performed with the help of an optical profiling system model Wyko NT1100 from VEECO. The system utilizes white light interferometry for high resolution 3D surface measurements, from sub-nanometer roughness to millimeter-high steps (0.1 nm - 1mm range). It is equipped with an automated stitching stage for substrates up to 4 inches in diameter.

We take measurements along the four line-grooves in the sample (figure 0a). Each measurement region consists of a 200 microns width (x coordinate) and 20 mm long area (ℓ coordinate). The RAW profiling of each region is the resultant average from 10 measurements. Each measurement data is processed as follows using Matlab.

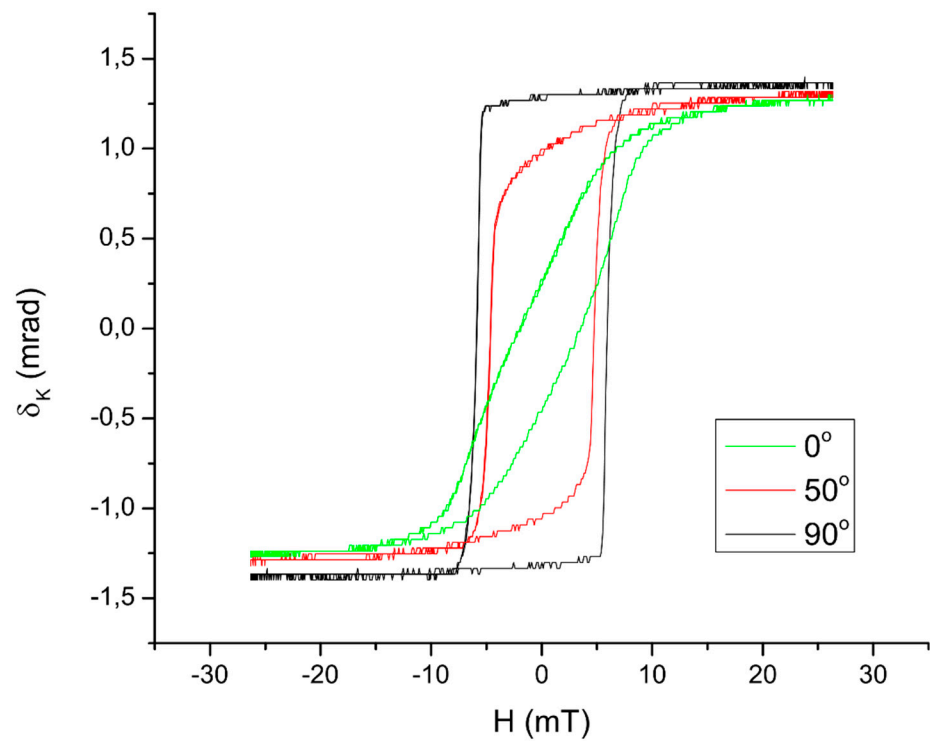
According to the equipment specifications, lowest nominal resolution would be 0.1 nm. However, a more genuine resolution would be around 1 nm, which can be decreased to 0.5 nm with the statistical analysis explained here.

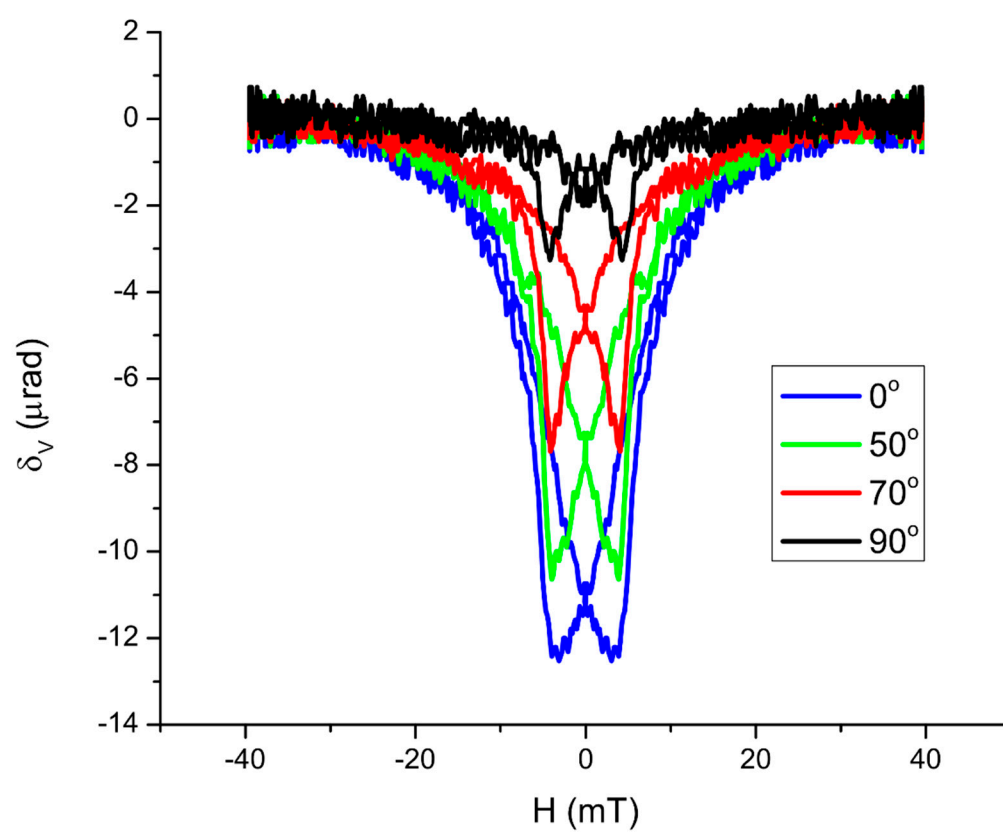
Firstly, the curvature of the substrate is corrected. As it can be seen in figure 0b, the RAW data presents a curvature of more than 1 μm . The data is fitted to a second order polynomial using the least-squares method. The polynomial is then used to remove the curvature and facilitate the step detection. This is performed in the whole measurement area and on each four lines (figure 0b).

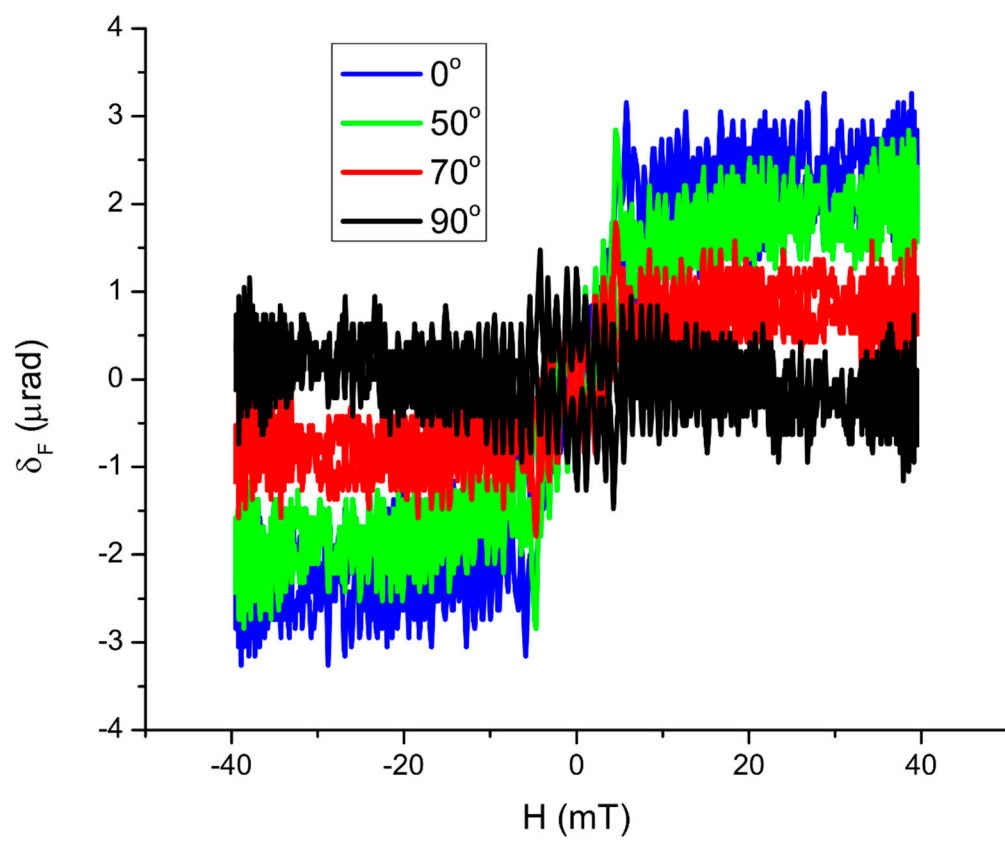
Next, the corrected profile height is then fitted to a step down-step up sigmoid:

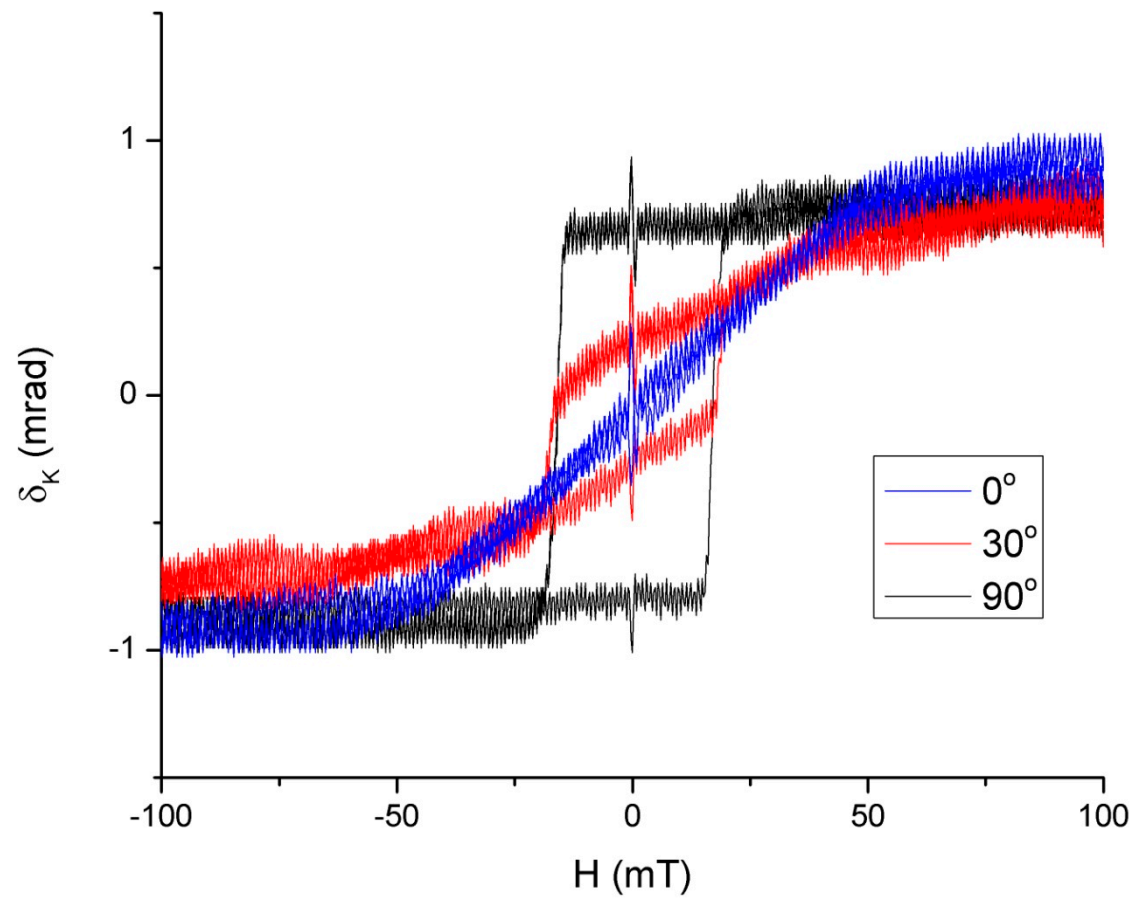
$$y = H \left(\frac{1}{1+e^{-2(x-x_1)}} + \frac{1}{1+e^{2(x-x_2)}} \right),$$

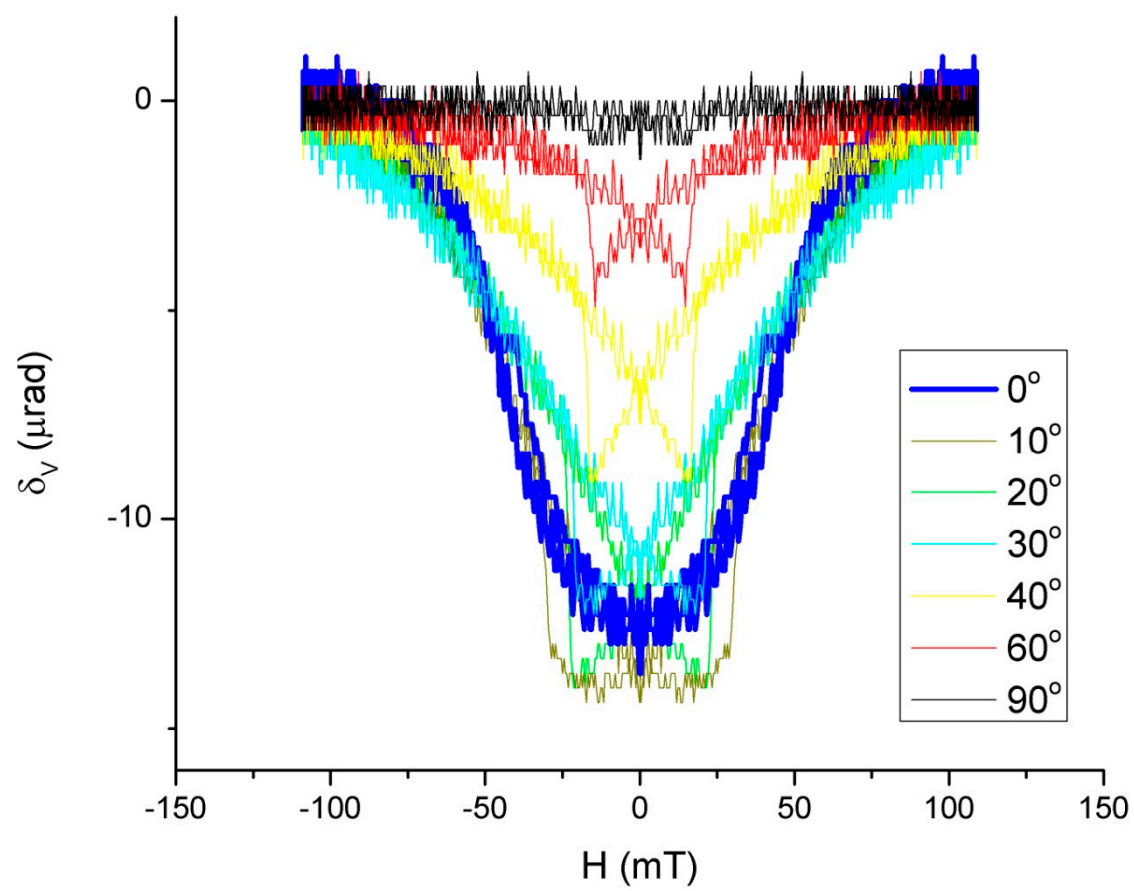
where x is the coordinate across the groove, x_1 and x_2 are the step-down and step-up positions and H represents the groove height. A non-linear least square method with the trust-region-reflective algorithm is used to find the values for the parameters H , x_1 and x_2 . This procedure is performed for all transverse cuts in the four-line grooves to obtain the groove height along them (figure 0c).

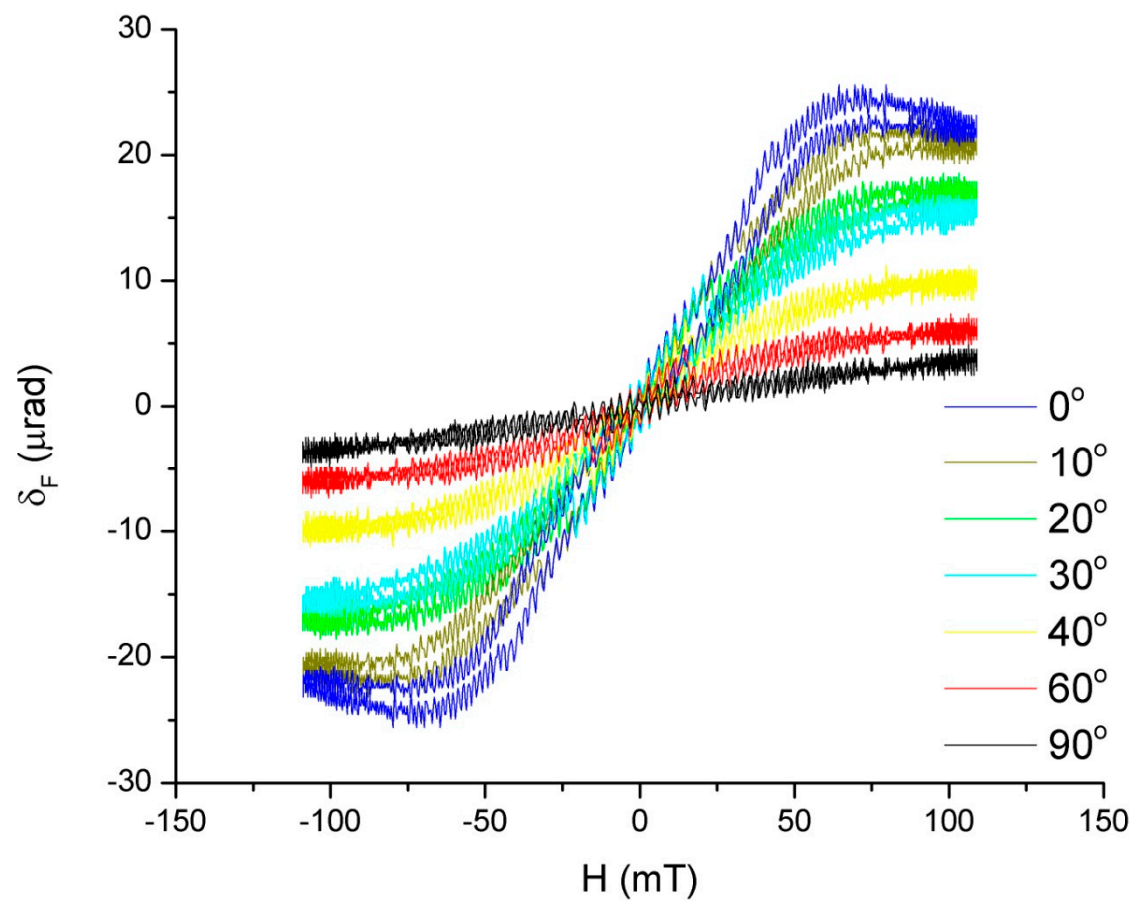




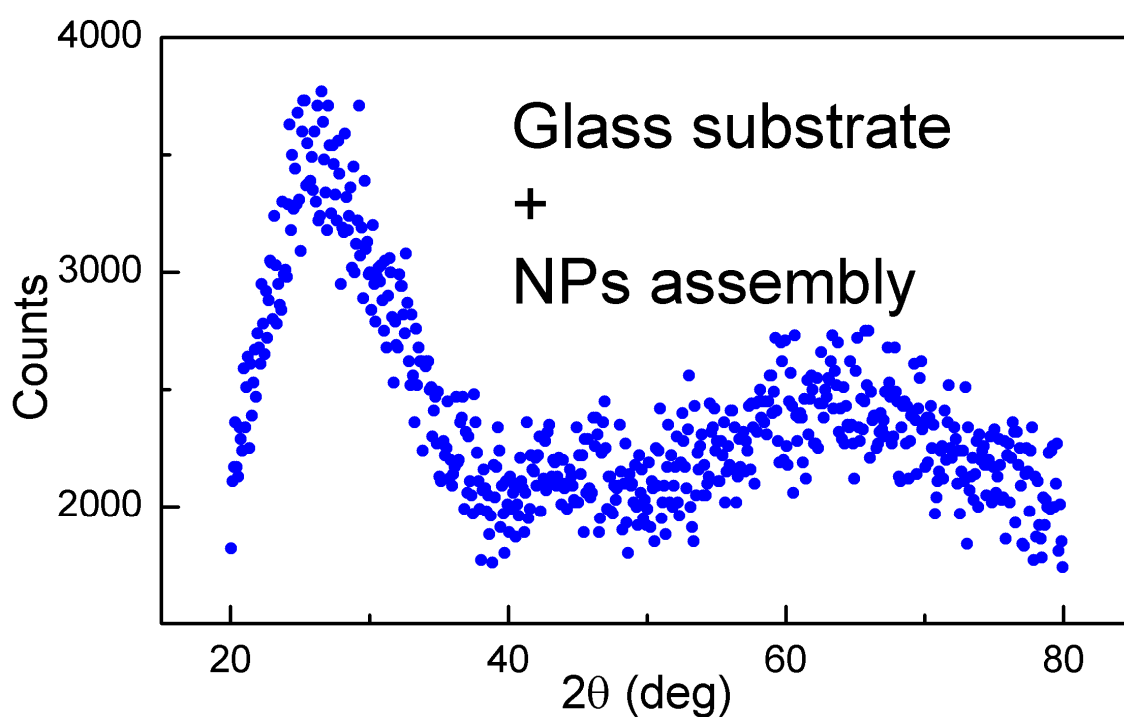
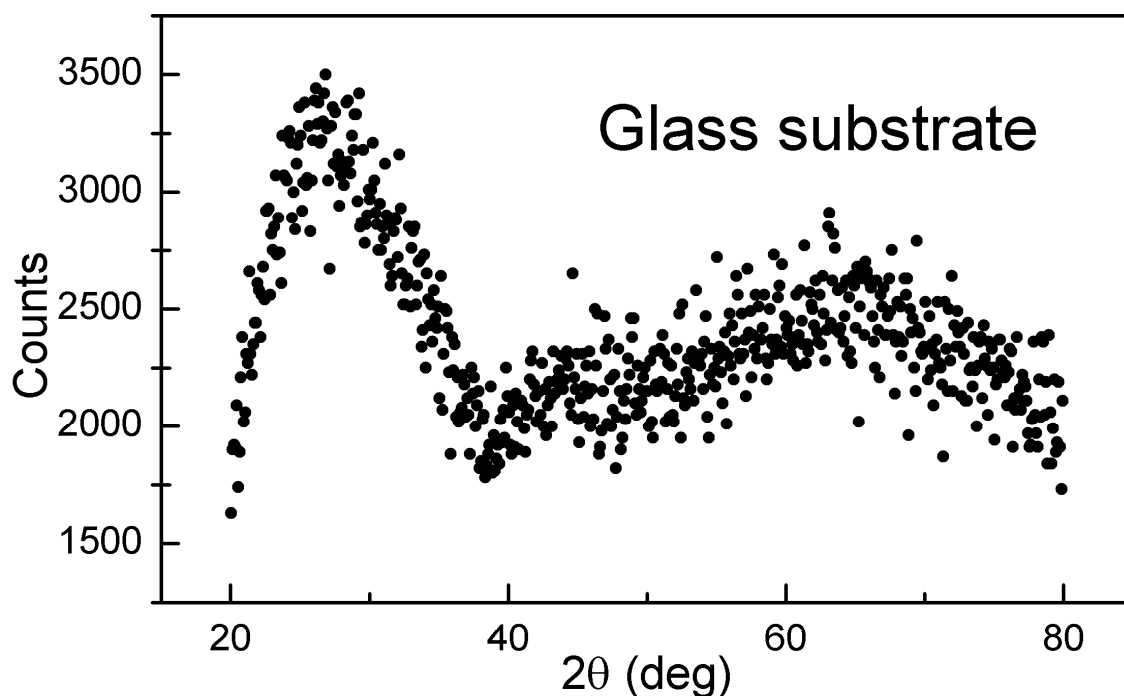








Measurement parameters: 2θ angular range (20° - 80°), angular step 0.1° , time constant 5 s and detector line CuKAlpha1= 1.54056 \AA . In the measurement range, no diffraction peaks were visible apart from the substrate baseline.



X-ray diffraction patterns of the glass substrate (up) and with the Co nanocluster assembly deposited onto the glass substrate (down).