ESRF	**Experiment title:** A crystallographic study of the epitaxial growth mode of antiferromagnetic NiO thin films	**Experiment number**: A25-2-1045
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Report:

We have studied through crystallographic measurements the growth of epitaxial NiO thin films grown on Al_2O_3 (0001), MgO (001), $SrTiO_3$ (001) and TiN buffer Si(001) substrates as well as the exchange bias systems: 1) NiO/$Fe_{20}Ni_{80}$ grown on Al_2O_3 (0001) and MgO (001) substrates and 2) NiO/FeCo grown on TiN buffer Si(001) substrates. The last, have been explored for its integration on silicon based devices.

Grazing Incidence Surface X-Ray Diffraction (GIXRD) experiments have been carried out at the BM25-SpLine beamline at 15 keV at the ESRF (Grenoble, France). Several crystallographic measurements (CTRs, RODs, low and high angle XRR) have been performed in order to determine the crystalline structure of the films, the thickness of the different layers in the heterostructure and the presence of mixing and strains generate during the epitaxial or domain epitaxial growth.

Figure 1 shows representative reciprocal space maps for antiferromagnetic NiO thin films grown on MgO (001), $SrTiO_3$ (001) and Al_2O_3 (0001) substrates, by reactive ion beam sputtering, in which it can appreciate a commensurate growth in the case of MgO substrate and incommensurate growth for $SrTiO_3$ and Al_2O_3 substrates, based in the coincidence or noncoincidence of the diffraction planes between film and substrates.

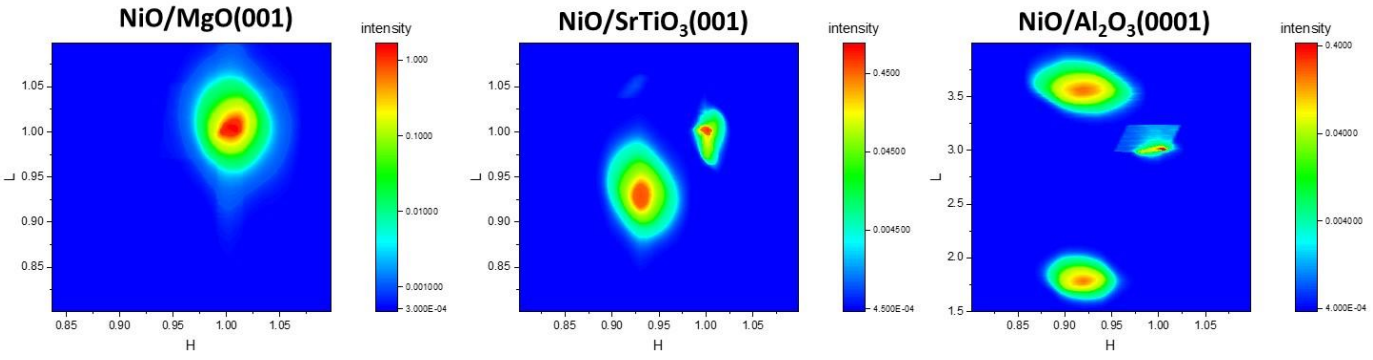

Figure 1. H=K reciprocal space maps for NiO thin films grown on MgO (001), $SrTiO_3$ (001) and Al_2O_3 (0001) substrates

Figure 2 displays the low angle XRR result for different bilayers $Fe_{20}Ni_{80}$(Py) /NiO deposited on Al_2O_3 (0001) substrates for different $Fe_{20}Ni_{80}$ thickness ranging between 5.9 to 24 nm. In all case, the presence of intense Kiessig fringes indicating a sharp Py/NiO interface and smooth surface. The small oscillation observed in 12nm Py/NiO bilayers gives a thickness for the antiferromagnetic NiO layer of 200 nm.

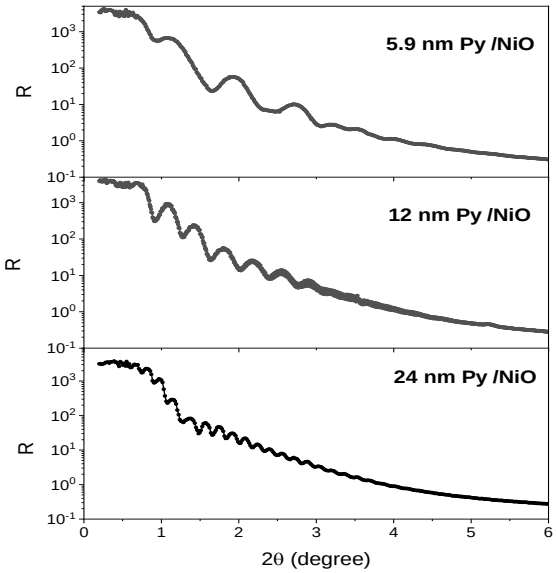

Figure 2. Low angle reflectivity for different Py/NiO bilayers grown on Al_2O_3 (0001) substrates.

The Reciprocal Space Maps (RSM) show in Figure 3 for NiO / TiN / Si(001) and FeCo / NiO / TiN / Si (001) heteroestructures evidence the incommensurate growth of NiO / TiN on Si (001) but also the epitaxial growth of NiO on TiN, in good agreement with the well-known domain epitaxy growth of TiN films on Si (001) substrates through the so-called 5-on-4 cube-on-cube bulk superstructure where 5 unit cells of TiN (0.424nm) sit on 4 unit cells of Si (0.543 nm) and the low mismatch ~ 1.4% between TiN and NiO lattice.

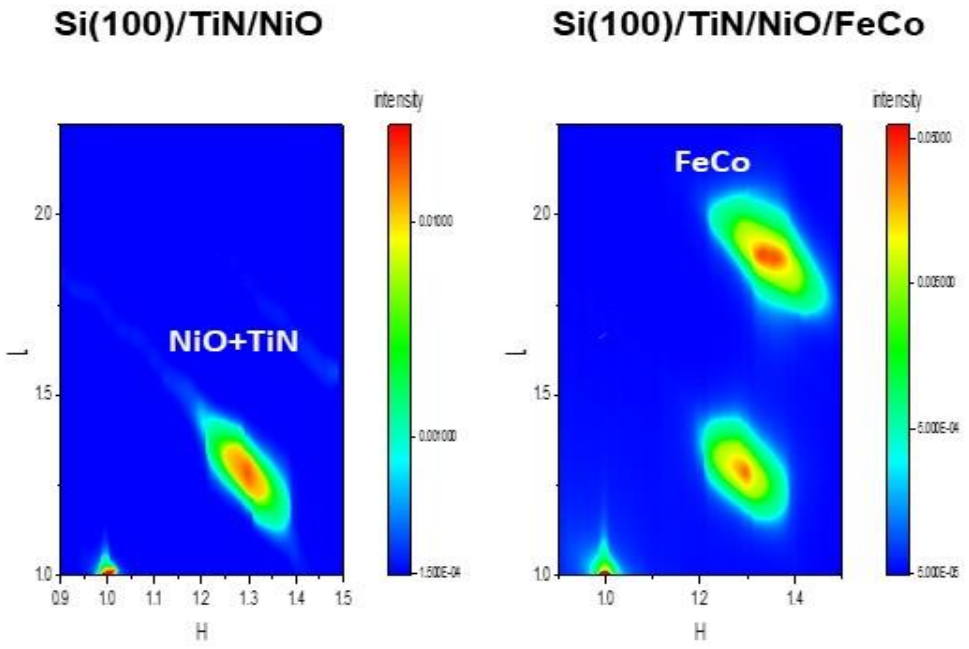

Figure 3. H=K versus L reciprocal space maps (RSM) for NiO and the bilayer FeCo / NiO both grown on TiN buffer Si(100) substrates. The noncoincidence of layers and substrate peaks evidences an incommensurate growth.