Transparent conducting oxide $NiCo_2O_4$

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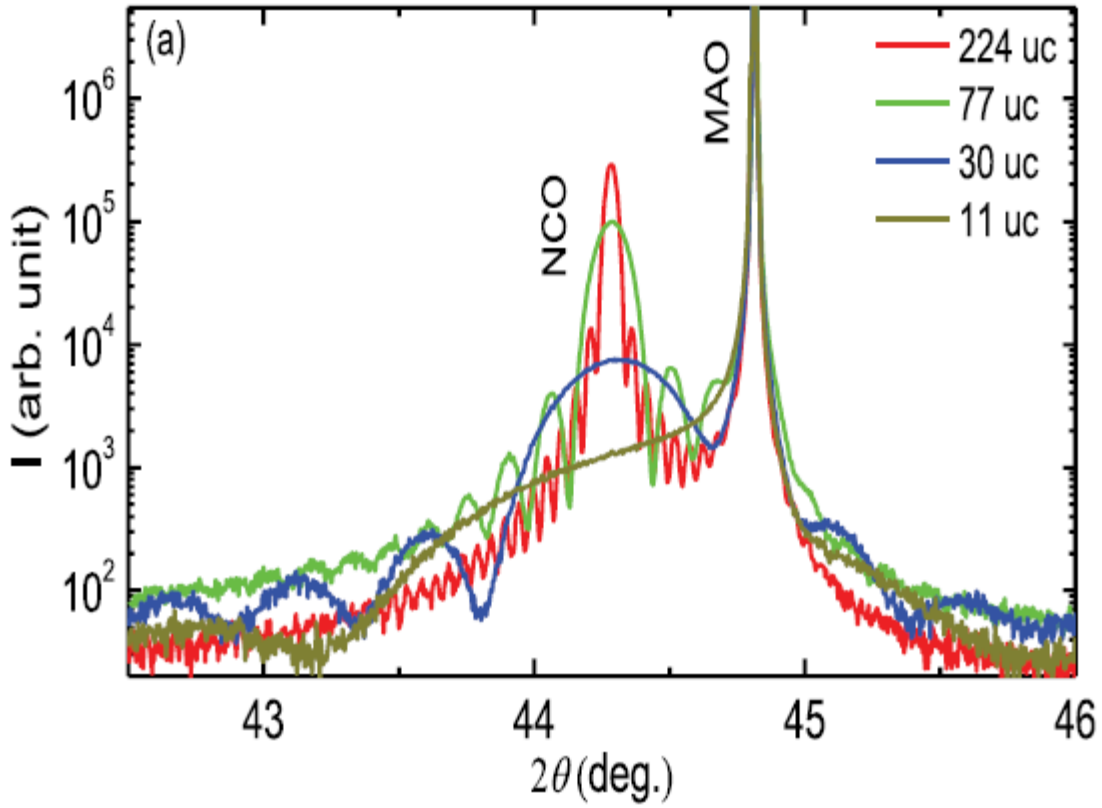
Introduction

- The structural examination of the films reveals that the epitaxial stain is independent of the films' thickness.
- the films are metallic with p-type conduction and ferromagnetic down to 2 unit cells with an enhanced coercive field in the films thinner than 30 unit cells.
- the observed resistivity minimum results from the disorder-induced quantum interference effects.

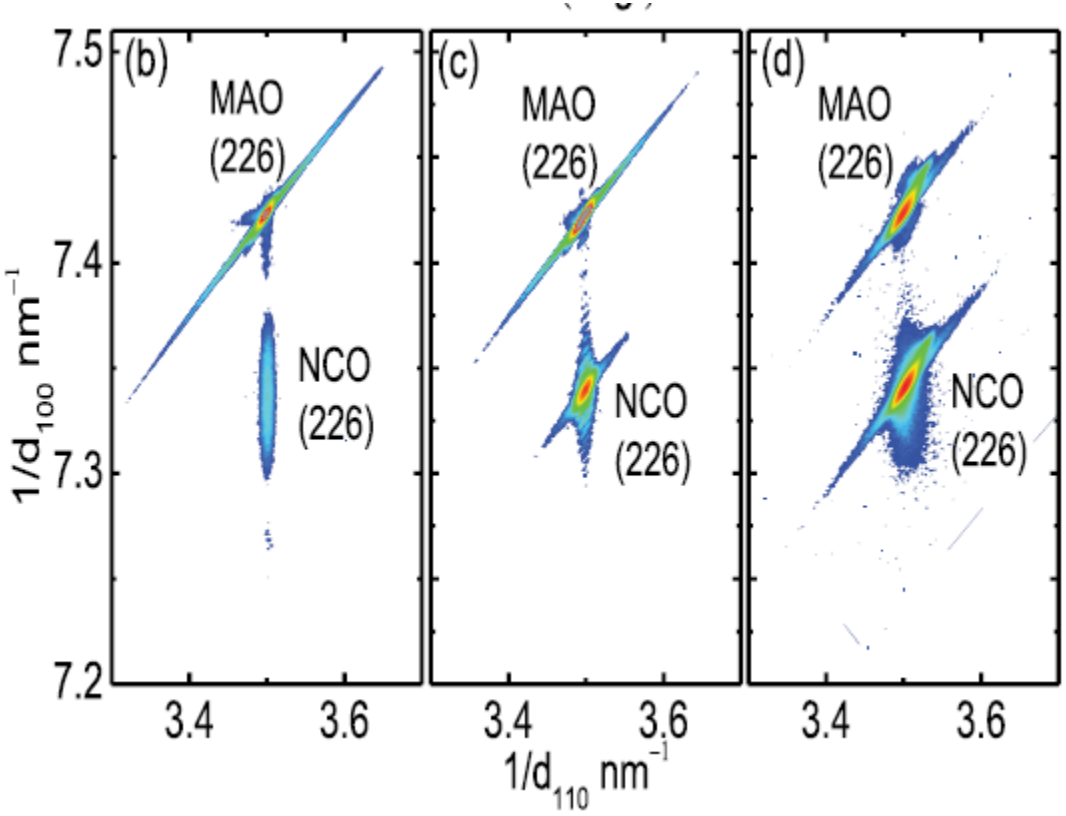
Experiment details

- Substrate :$MgAl_2O_4$
- T= 350 C
- P=50 milli Torr O_2 pressure
- thickness ranging from 1 uc to 228 uc
- Measured by X-ray diffraction(HR-XRD), x-ray reflectivity (XRR), superconducting quantum interference device (SQUID) magnetometer

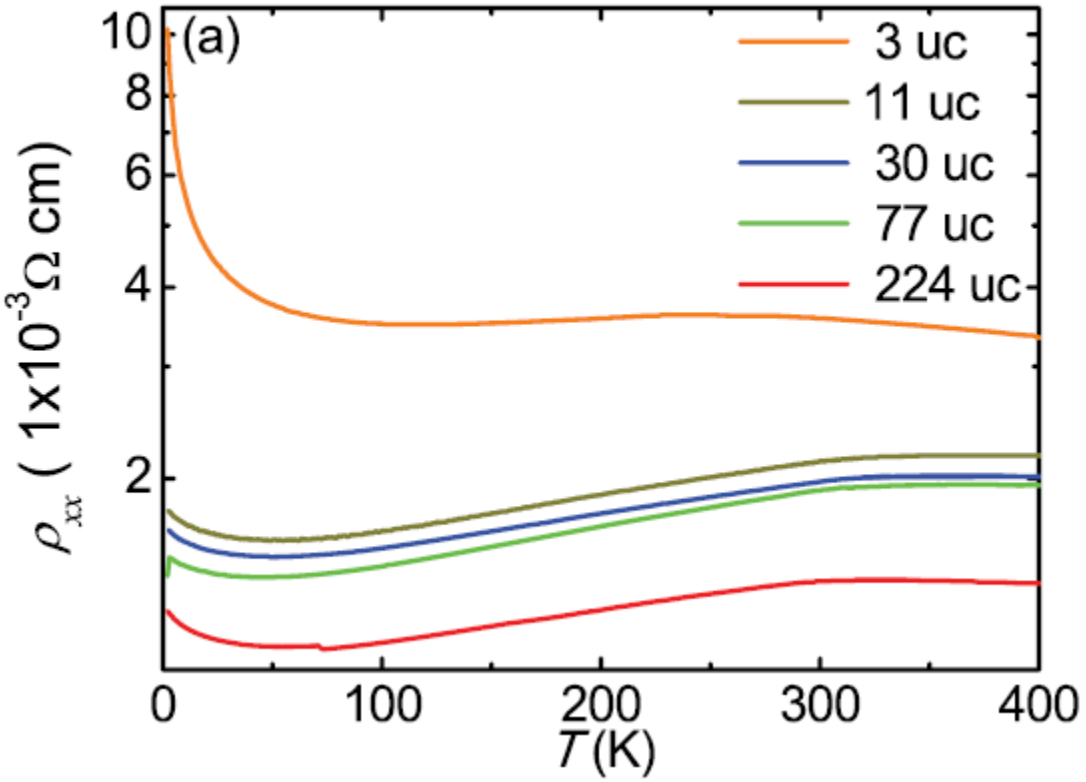
Results



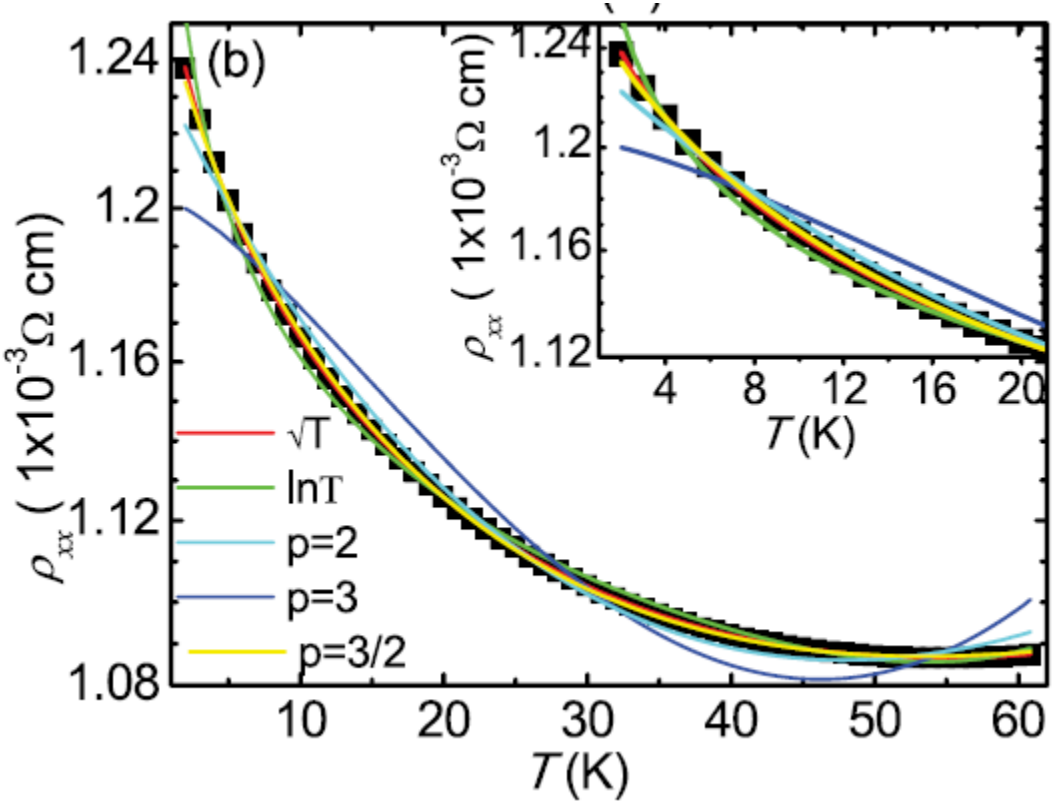
XRD 2Θ-Θ scans through the (004) symmetric reflections of the film and substrate for the 11, 30, 77, and 224 uc thick films



HR-XRD reciprocal space maps around the (226) reflections of the NiCo2O4 films on MgAl2O4 substrate with the thickness 11, 224, and 875 unit cells



In-plane resistivity ρ vs. temperature T for the NiCo2O4 with the thicknesses of 3, 11, 30, 77, and 224 unit cells



Resistivity ρ(T) for the 224 uc film and the fitted curves.

we fit the temperature dependence of q(T) in the 2–60K range with the functional form

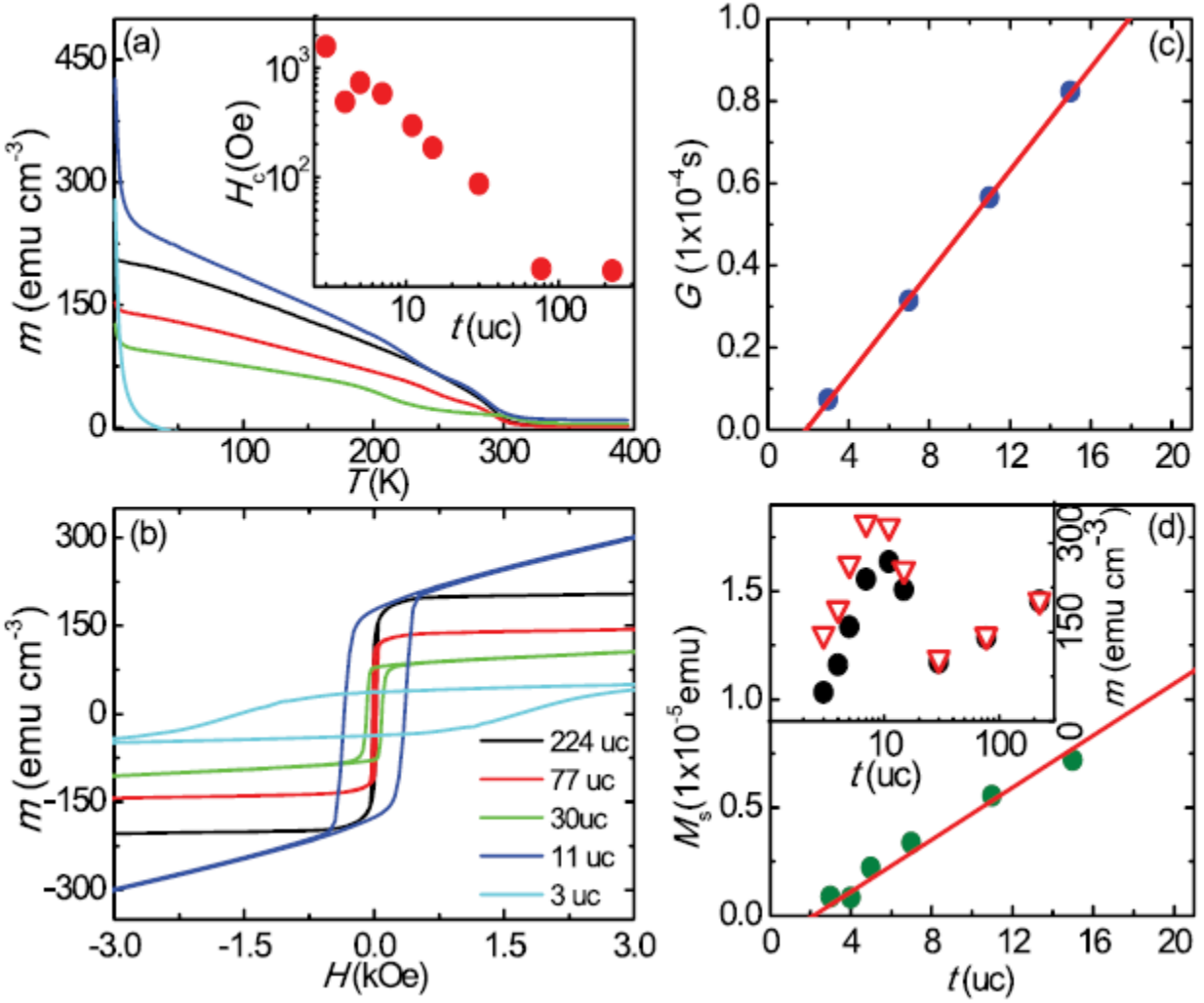
$$\rho(T) = \frac{1}{\sigma_0 + ClnT} + AT^n$$

The disorder-induced localization tendencies in the 3D limit are described by the following equations

$$\rho(T) = \frac{1}{\sigma_0 + B\sqrt{T}} + AT^n$$

$$\rho(T) = \frac{1}{\sigma_0 + BT^{p/2}} + AT^n$$

magnetic measurements



Summary

- The structural analysis revealed that the epitaxial strain in the $NiCo_2O_4/MgAl_2O_4$ (001) films is independent of the films' thickness up to 700 nm.
- the films remain metallic and magnetic down to 2 uc in thickness.
- The resistivity minimum with Tmin 50–60K is explained as the consequence of the disorder-induced quantum interference effects.
- The enhanced magnetic properties and the metallicity make the ultrathin epitaxial $NiCo_2O_4$ films a good candidate material for spintronics

Thanks