

# Freezing and unfreezing of antiferromagnetic spins in CoO(111) epitaxial films on a ferromagnetic support.

A. Kwiatkowski,<sup>1</sup> E. Oleś,<sup>1</sup> M. Szpytma,<sup>2</sup> M. Zając,<sup>2</sup> E. Partyka-Jankowska,<sup>2</sup> E. Świerkosz,<sup>1</sup> P. Drózdź,<sup>1</sup> A. Koziol-Rachwał,<sup>1</sup> T. Ślęzak,<sup>1</sup> and M. Ślęzak<sup>1</sup>

<sup>1</sup>*AGH University of Krakow*

<sup>2</sup>*SOLARIS National Synchrotron Radiation Centre, Jagiellonian University*

Blocking( $T_B$ ) and Néel ( $T_N$ ) temperatures of ultrathin epitaxial CoO(111)/Fe(110) bilayers grown on W(110) single crystal surface were studied as a function of antiferromagnetic CoO layer thickness [1]. The checkerboard-like architecture of the studied sample was used with macroscopic steps covering 50 - 150 Å thickness range in case of Fe bottom sublayer and 15 - 120 Å for CoO overlayer. After the sample was field cooled to 80 K, longitudinal Magneto-optic Kerr Effect (LMOKE) technique was used to measure magnetic hysteresis loops in 80 – 320 K temperature range. For each hysteresis loop its coercivity and shift field  $H_{EB}$  was determined in order to quantify the exchange bias(EB) effect and its temperature dependence. Our measurements show that the blocking temperature, which marks the onset of exchange bias effect, strongly depends on the thickness of CoO layer. In our monocrystalline samples, for CoO thicknesses of 30 Å and 45 Å we observe a pronounced coercivity bump at temperatures slightly below the blocking temperature, similarly to results already reported for textured and polycrystalline systems [2] as well as predicted theoretically [4]. X-ray Magnetic Linear Dichroism (XMLD) measurements of CoO revealed that Néel temperature of antiferromagnetic CoO overlayers is 260 K, i.e. close to bulk-like value, independent of the CoO thickness [1]. As the reduction of  $T_B$  with decreasing CoO thickness does not coincide with the lowering of  $T_N$ , classical finite-size effects, as major factor responsible for blocking temperature modulation, can be excluded. Such lack of correlation between AFM ordering and blocking temperatures in AFM/FM system [3] will be discussed in terms of thermal stability of AFM domains in the vicinity of critical temperatures [4]. Partial unfreezing of antiferromagnetic spins in the vicinity of blocking temperature allows reorientation of the particular population of antiferromagnetic spins for the given temperature. Subsequent cooling down of the system refreezes those spins in a new orientation [1]. Tailoring of coercivity bump below  $T_B$  in the AFM/FM [5] systems can potentially be interesting for heat assisted magnetic recording (HAMR) ideas.

## References:

- [1] A. Kwiatkowski, M. Ślęzak et al. *Sci Rep* 16 (2026), 2809
- [2] J. Nogués, I. K. Schuller, *Journal of Magnetism and Magnetic Materials*, 192 (1999), 203–232.
- [3] P. J. van der Zaag, Y. Ijiri, *Physical review letters*, 84 (2000), 6102.
- [4] M. D. Stiles and R. D. McMichael, *Physical review B*, 60 (1999), 12950.
- [5] S. P. Bommanaboyena, D. Backes and L. S.I. Veiga et al. *Nature Communications*, 12 (2021), 6539.