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(G*) POS-G69 – Three-axis torque magnetometry for study of interfacial exchange coupling in ferromagnetic/antiferromagnetic bilayers.

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Studies of exchange coupling at interfaces in permalloy/cobalt oxide bilayer microdisks are made possible by measurements of a full AC magnetic torque vector [1]. Magnetic cross-product torque involves a linear combination of perpendicular moment and magnetic susceptibility, yielding the rotational magnetic anisotropy or stiffness of the spin texture in response to torque. Single-axis torque measurements are most common and are useful for hysteresis measurements of thin film structures where, in particular, high shape anisotropy yields a near-proportionality of in-plane magnetic moment and magnetic torque along the perpendicular in-plane axis. Three-axis torque measurement provides a platform for obtaining standard hysteresis curves while simultaneously measuring in-plane anisotropies, with no requirement to reorient the sample or the field generators.

Our three-axis methodology uses a modified, single-paddle, silicon-on-insulator, resonant torque sensor. The torsion mechanical susceptibilities to x- and z-torques are maximized by clamping the sensor at a single point. Mechanically-resonant AC torques are driven by an RF field containing frequency components for each fundamental torsional mode. The displacements are read out interferometrically. The sensors are prepared by silicon micromachining and the sample fabrication is completed by lithographic patterning of the active magnetic layers [2].

Investigations of a permalloy/cobalt oxide bilayer sample show an absence of single-vortex behaviour at cryogenic temperatures, in contrast to the well-characterized single-vortex behaviour at both ambient and cryogenic temperatures in permalloy-only samples [3]. In-plane torque measurements yield shifted hysteresis loops consistent with standard exchange bias. Unexpectedly, however, the dominant contribution to the out-of-plane torque observed in the cooled bilayer samples, when measured in strong bias fields, has a rotational symmetry inconsistent with unidirectional anisotropy. This suggests that the AC torsion stiffness, arising from interfacial exchange coupling in these samples, does not hinge on uniform alignment within the antiferromagnetic layer.

[1] K.R. Fast et al., AIP Advances 11, 015119 (2021)

[2] Z. Diao et al., J. Vac. Sci. Technol. B. 31, 051805 (2013)

[3] J.A.J. Burgess et al., Science 339, 1051-1054 (2013)

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