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# Magnetization Switching Dynamics of Cofeb/B-W Nanomagnets Driven By Spin Hall Effect

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## Extended Abstract

Magnetic thin film elements when combined with heavy-metals give rise to spin-orbit torque (SOT) that can then be used to switch magnetization; this idea has attracted extensive interests as it promises potential applications in spintronics and random-access memory devices [1]. The principal mechanism responsible for SOT-mediated switching is spin Hall effect (SHE) [2]. In this effect a charge current injected into a non-magnetic heavy metal generates a lateral spin current which can then be used to switch magnetization in adjacent layers. The SOT magnetic tunnel junction (MTJ) utilizing perpendicular magnetic anisotropy (PMA) has its own advantages and disadvantages; however, this design requires the assistance of external magnetic field to achieve deterministic magnetization reversal [3]. On the other hand, field-free SOT magnetization switching can be obtained in in-plane magnetized magnetic components. It has been reported that SOT induced at CoFeB/W interface is sufficiently large to switch the in-plane magnetization of CoFeB layer [4]. Motivated to develop a deeper understanding that utilizes field-free SOT magnetization switching, a micromagnetic model similar to the one investigated by Isogami *et. al.* [5] has been studied here.

The model system is an MgO-based MTJ element, CoFeB (4 nm)/MgO (1 nm)/CoFeB (2 nm), that has a shape of an ellipse with major axis of 370 nm and minor axis of 120 nm. The MTJ element is placed on top of a high-resistivity β-W metal layer which is used as the source of SOT. In simulations, a charge current on the order of few hundred μA passes through the W current line which results in spin current diffusing into adjacent CoFeB layers. The magnetization in both CoFeB layers lie in the film plane with easy axes along the y-direction. The top CoFeB (4 nm) is a fixed magnetic layer, strongly pinned along the +y-direction, while the bottom CoFeB (2 nm) acts as a free magnetic layer.

The SHE, interfacial Dzyaloshinskii-Moriya interaction (DMI), and thermal fluctuations are all taken into account in the modelling and analysis of the nanoelements. The study of magnetic-field-free SOT-driven magnetization reversal process on short time scales revealed that the free magnetic layer can be electrically toggled between the parallel and antiparallel alignment with respect to the fixed magnetic layer without the assistance of external magnetic field [6]. Furthermore, it has been found that the out-of-plane canting of the magnetic moments at the element edges plays an important role in the nucleation and expansion of the reversed magnetization. Since the study includes the thermal effects, it has been realized that the thermally activated magnetization process combined with SOT effect is found to significantly reduce the effective energy barrier to the magnetization reversal. The findings imply that micromagnetic modelling without taking the thermal effects into account may be misleading while studying the underlying mechanisms of SOT-mediated magnetization switching.

## References

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