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Precessional magnetization reversal in magnetic tunnel junctions with a perpendicular polarizer[1]

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The interaction between the spins of itinerant electrons and the magnetization of ferromagnetic materials is of great interest both for fundamental physics and applications. While a ferromagnetic layer can polarize the spin of electrons passing through it, a spin-polarized current also changes the magnetization of the ferromagnet via a spin-transfer torque (STT). Here we present an orthogonal spin transfer device [1] with an in-plane magnetized free layer (FL) and a perpendicularly magnetized spin polarizing layer, separated by a thin copper spacer. The initial STT acting on the in-plane FL is perpendicular to the plane due to the spin polarization from the polarizer. For large torques, the FL magnetization will be tilted out of its easy plane, which creates a demagnetization field on the order of tens to hundreds of millitesla. The FL magnetization will then precess about the demagnetization field. The FL in our device forms a magnetic tunnel junction with an in-plane magnetized reference layer (RL), which is used to read out the state of the free layer. The resistance of the device then depends on the relative orientation between the magnetizations of the FL and the RL. We experimentally demonstrated fast switching of the FL magnetization, switching for pulses less than 500 ps in duration [2]. We also conducted subthreshold single-shot time-resolved resistance measurements that probe the FL magnetization reversal mechanisms on time scales in which thermal fluctuations can play an important role. We identify the antiparallel (AP) and parallel (P) states and the transition between these two states during a pulse from single-shot oscilloscope traces. We find that there is a strong asymmetry between the AP to P and P to AP transitions under the same pulse conditions [3]. The different switching processes can be explained by the strength of the perpendicular spin torque, which depends on the pulse current through the device and is initially larger in the P state than in the AP state. Spin torques from the RL also influence both the switching process and the switching probability. Our results illustrate new ways to control the magnetization of a nanomagnet on short time scales and optimize device operation.

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