

Néel Vector Rotation Driven by Spin-Orbit Torque in Amorphous Ferrimagnetic GdCo Thin Films

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Spin superfluidity is a novel phenomenon for low-dissipation transportation of spin angular momenta with a magnetization rotation in a plane [1,2]. Since magnetic dipolar interactions disturb the long-distance transportation of the magnetization rotation, antiferromagnetic materials serve as a better platform to study the spin superfluidity than ferromagnets. Observing this phenomenon requires the continuous rotation of an antiferromagnetic Néel vector within its magnetic easy plane [1,2]. While the control of the Néel vector by spin-orbit torque has been widely studied [3-5], the Néel vector rotation has not been demonstrated because the energy barrier of magnetocrystalline anisotropy hampers the Néel vector rotation [5]. To overcome this problem, we used an amorphous ferrimagnet GdCo that is free from magnetocrystalline anisotropy and the magnetic dipolar interaction at the magnetization compensation temperature. In ferrimagnet, the magnetic moments of the two sublattices are confined to a plane perpendicular to the applied magnetic field (H_{ext}) when H_{ext} exceeds a spin-flop transition field, forming a pseudo-magnetic easy plane.

We deposited a film stack of Ta(5)/Gd_{0.28}Co_{0.72}(3)/Pt(5) (unit: nm) trilayer on a thermally oxidized Si substrate by using DC magnetron sputtering. The buffer Ta layer and the capping Pt layer serve as the spin current sources to apply a spin-orbit torque (SOT). The films were micro-fabricated into Hall bar devices. GdCo layer holds magnetic easy axis perpendicular to the film plane, as confirmed by magnetic field sweeps of the anomalous Hall resistance. We measured an anomalous Hall resistance with applying a pulse current of 10- μ s-duration under the magnetic field of 8 T in the film plane, which is sufficient to induce spin-flop transition at 240 K. When the pulse current exceeded the threshold, the anomalous Hall resistance exhibited stochastic binary switching. We infer that the Néel vector rotation was driven by SOT during the pulse current application and eventually relaxes along the out-of-plane direction, randomly pointing either upward or downward. To elaborate this behavior, we also performed the homodyne detection of the Néel vector rotation with a microwave current in a Hall geometry. We found that the rotation frequency was in the range of several GHz. Our results provide strong evidence of the continuous rotation of Néel vector.

<References>

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