Electrically assisted photo-magnetic sub-switching regime in garnet films

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In the last decade, a plethora of fundamental mechanisms for magnetization dynamics induced by ultrashort laser pulses has been actively discussed. Recently, it was discovered that only by a single laser pulse, nonthermal and reversible photo-magnetic switching in Co-doped yttrium iron garnet films (YIG:Co) can be obtained [1]. Microscopically, in this mechanism, an incident linearly polarized pump pulse excites strongly anisotropic garnet ions, generating an effective field of photo-induced magnetic anisotropy [2]. This photo-induced magnetic anisotropy is an essential component of the effective field anisotropy, which can drive the magnetization dynamics described by LLG formalism, enabling an all-optical impact on the magnetic state at ultrashort timescales. The photo-magnetic strong contribution is short-lived (about 30 ps) and is closely tied to an external light pulse, which can trigger the precession or even switch the magnetization if the conditions are sufficient [3]. However, this contribution must be differentiated from other external and internal contributions to the anisotropy which further affect the overall anisotropy and therefore the magnetization dynamics as well.
Here, we examine the potential of using an electric field to modify the magnetic anisotropy in YIG:Co films. Employing a garnet patterned with a gold-plated comb-like structure of electrical contacts, we apply the electric field to influence the anisotropy, subsequently affecting the frequency of the photo-magnetic precession. We investigate the dependency of the amplitude and orientation of the electric field with respect to the crystallographic axes in garnets. Conducted measurements reveal a precession frequency decrease of up to 10% with the external magnetic field parallel to the electric field with the amplitude < 2 MV/m. Additionally, we observe both frequency decrease and increase dependent on the amplitude of the external magnetic field in the case of a perpendicular electric field. This opens new opportunities for controlling photo-magnetic dynamics and switching through anisotropy design and manipulation via an electric field. Appropriate design of anisotropy leads to the possibility of optimized magnetization state control by a single ultrashort laser pulse and is the key to using the photomagnetic effect in applicable devices.
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References

[1] A. Stupakiewicz, K. Szerenos, D. Afanasiev, A. Kirilyuk, A.V. Kimel, Nature 542, 71 (2017).
[2] A. Frej, I. Razdolski, A. Maziewski, A. Stupakiewicz, Phys. Rev. B 107, 134405 (2023).
[3] T. Zalewski, L. Nowak, and A. Stupakiewicz, Phys. Rev. Appl. 21, 044026 (2024).