Liquid crystals for electrical control of magnon-polaritons

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In the regime of strong light-matter coupling, polariton modes are formed that are hybrid light-matter excitations sharing properties of both, an electrodynamic cavity mode and a matter mode. In the recent decade, magnon-polaritons were intensively researched using ferromagnetic materials in the microwave range, with potential applications for quantum technology and sensors. Exploring antiferromagnetic resonance (AFMR) raises magnon-polariton frequencies into the terahertz (THz) range [1], and Fabry-Pérot cavities were proved to be suitable for achieving the regime of strong light-matter coupling [2]. However, antiferromagnetic magnons are only tunable with temperature or with very high magnetic fields, but not with electric fields, which limits the possibilities of controlling magnon-polaritons states. Anisotropic nematic liquid crystals (LC) were proved to allow for electrical control of their THz refractive index. For example, such LCs were shown to tune the resonant frequency of a THz metamaterial based on split-square resonators by about 20% [3].

Here, we are investigating AFMR in nickel oxide (NiO) owing to its low spin damping and temperature-dependent frequency close to 1.0 THz above room temperature. We report electrical control of magnon-polariton states formed as a result of strong coupling between modes of (FP) cavity and magnons in NiO. Our FP cavity is formed by NiO parallel-plane slab, placed next to a liquid crystal cell at a wellcontrolled gap in the range of 0.5-5.0 mm. The frequency of AFMR is controlled by the temperature of the NiO crystal. We used a THz time-domain spectrometer to collect reflection spectra, as a function of NiO temperature and electric field applied to the LC cell. The latter parameter changes frequencies of FP modes, thus, as a function of the electric field, we observed narrow avoided crossings of cavity modes with AFMR. This allows for electrical control of magnon-polaritons states, without direct physical contact of LC with the magnetic material.

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