Gold nanoantennas for optical excitation of spin waves

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Presently the coherent excitation of spin ensembles using plasmonic structures is of prime research importance since it potentially can expand the functionalities of magnonics. In this work, gold nanodiscs deposited by electron beam lithography on magnetic films are investigated, and the optical properties of the resulting samples were studied by simulations and measuring the transmittance and magneto-optical effects.

To date, the latest achievements of science and technology have led to the possibility of creating a new functional magnetic structures of various designs, which have modified optical properties, with characteristic dimensions in the order of several tens of nanometers. Such nanostructures allows to control the characteristics of optical radiation at a scale smaller than the wavelength of light. The effectiveness of this control is achieved mainly by nanostructuring materials¹, which enables to create a medium with predetermined optical properties and enhance the optical and magneto-optical effects by only optimizing the geometric structure. Plasmonic nanostructures are gold nanoparticles (nanodisks) with characteristic dimensions such as diameter of 50-150 nm, height ~ 50 nm and a period of 80-500 nm deposited on a magnetic dielectrics. Bismuth rare-earth iron garnet is used as a magnetic dielectric. Gold nanodisks dimensions must be chosen in such a way that the femto-second laser pulse excites the localized surface plasmon polaritons (LSPP). Upon excitation the LSPP significantly increases the intensity of the magnetic field near the nanodisks, which in turn increases the value of the inverse Faraday effect, which is directly proportional to the intensity of electromagnetic radiation. This is an increase of the effective magnetic field near nanodisks. Consequently, nanodisks can operate as local sources of magnetostatic spin waves, which excited, usually, the magnetic field of the microwave radiation generated by the antenna in the vicinity of the sample². However, in a number of important applications it is required to excite spin waves locally and there is a need to create a certain spin density distribution in space and time. A key factor in this work is the excitation of LSPP at a certain wave, you need to correctly calculate the nanoscale structures using electromagnetic simulation. To investigate the electromagnetic field distributions induced by surface plasmons, we performed the numerical calculation based on the rigorous coupled-wave analysis method (RCWA).

The results of the work are parameters of two-dimensional gold lattice of nanodisks and calculated field of the inverse Faraday effect which is compared with the case without gold and the case of smooth gold on the surface of the iron garnet. Parameters of structure are optimized for effective excitation of LSPP at a wavelength \( \lambda = 820 \text{ nm} \) - a wavelength of a Ti: sapphire laser.

The work was supported by the Russian Science Foundation (RSF) (17-72-20260).

References

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