The influence of effective constitutive parameters of a planar periodical structure with a YIG film on the photon-magnon coupling strength

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There is a large interest in the field of quantum technologies, namely, the conversion and transmission of quantum information. For implementation of quantum computing, the information exchange that preserves quantum coherence is needed [1]. For some specific applications, hybrid systems consisting of two or more different physical systems, strongly coupled with each other, are needed. For example, a microwave resonator coupled with a ferromagnetic sample. For efficient transfer of quantum information a very large photon-magnon coupling strength is required.
In this work, the resonant structure in the form of the fine-stratified planar periodical structure (PPS) [2], the period of which has a small value compared to the working wavelength (Fig. 1), is considered. The operating frequency of the PPS structure was about 6 GHz, and the first peak with low Q-factor in transmission spectrum is observed (Fig. 3).

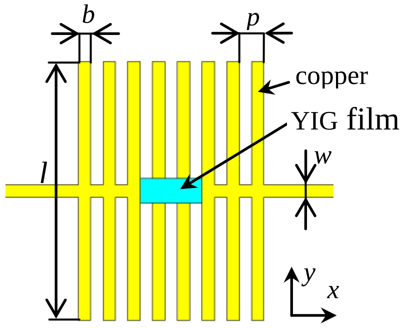

Fig. 1. Schematic view of resonator in the form of a fine-stratified planar periodical structure with a YIG film.

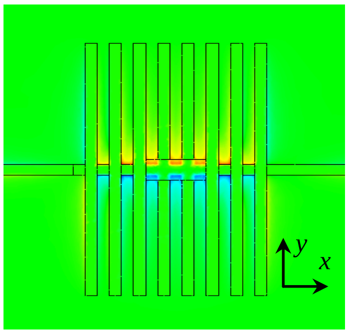

Fig. 2. The spatial distribution of the magnetic field (normal *z*-component) near the resonator surface.

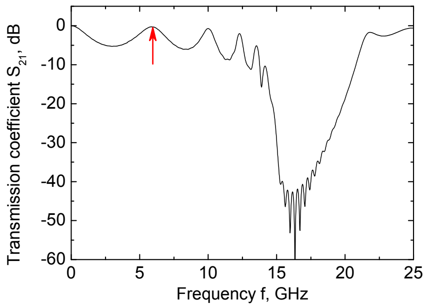

Fig. 3. The transmission coefficient spectrum of electromagnetic waves passed through the resonator (resonant peak is marked by arrow).

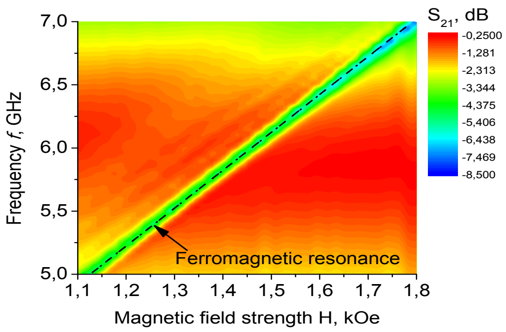

Fig. 4. The transmission coefficient spectrum of electromagnetic waves passed through the resonator on the frequency and magnetic field strength.

The PPS resonator (Fig. 1) consisting of alternating strips crossing the feeding microstrip line is placed on a substrate with metallization below. Approximately half of wavelength is placed on the structure (Fig. 2). At the same time, the half-wave microstrip resonator [3] length is about 3 times larger than the PPS resonator. The numerical electrodynamic modeling in the frequency domain of the transmission coefficient for the PPS resonator with yttrium iron garnet (YIG) film on its surface at external magnetic field was carried out (Fig. 4). The spin-number-normalized photon-magnon coupling strength for such a system is about g_N= 0.517 Hz. For comparison, a half-wave microstrip resonator with YIG film at the same resonance frequency has g_N= 0.361 Hz. It is expected that photon-magnon coupling strength is mainly affected by compression of the resonant area. With such a compression, the magnet filling factor by the magnetic field increases. This leads to the greater value of photon-magnon coupling strength for the PPS resonator.

Conclusions

- The resonant structure in the form of the fine-stratified planar periodical structure (PPS) is considered.
- The PPS resonator length is about 3 times smaller than the microstrip resonator at the same resonance frequency. It can be explained by the large value of the effective constitutive parameters of the fine-stratified PPS.
- Decreasing of the resonant wavelength in the PPS resonator leads to increasing of the spin-number-normalized photon-magnon coupling strength compared to the conventional half-wave microstrip resonator up to 43%.

Acknowledgments

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References

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