proceedings

Abstract

Exploring the Third Dimension in Magnonic Crystals †

Gianluca Gubbiotti

Istituto Officina dei Materiali del Consiglio Nazionale delle Ricerche, Via A. Pascoli, I-06123 Perugia, Italy; gubbiotti@iom.cnr.it

† Presented at the 37th International Symposium on Dynamical Properties of Solids (DyProSo 2019), Ferrara, Italy, 8–12 September 2019.

Published: 5 September 2019

Magnonic crystals (MCs) are materials with periodically modulated magnetic properties where the spin waves (SWs) band structure consists of intervals of allowed SW frequencies and forbidden gaps in which there are no allowed magnonic states.

In the recent past, most of the studies have been focused on planar nanostructures where the magnetic constituents have the same thickness, while, to the best of our knowledge, there are no reports of SW band structure in 3D MCs. This is mainly due to the difficulties associated with the fabrication of thickness modulated nano-elements by conventional nanofabrication techniques which require multilevel exposure process and alignment between successive fabrications steps.

Very recently, we proposed a new class of MCs constituted by closely packed thickness-modulated Permalloy, Fe/Permalloy and Fe/Cu/Permalloy nanowires. We show that this kind of structures support the propagation of collective SWs in the periodicity direction, thus demonstrating that layering structure and in-plane modulation are very effective for controlling the characteristics of the magnonic band [1].

Another possible approach to achieve a vertical control of the spin wave band structure is to have either an array of layered magnetic elements or an array of ferromagnetic dots deposited on top of a continuous ferromagnetic film. I will review the properties of the spin wave band structure, studied by wavevector-resolved Brillouin light scattering, in dense arrays of Py/Cu/Py nanowires [2,3] and 2D array of elliptical Py/Pt nanodots arranged into dense chains over the surface of a 20 nm thick Py continuous unpatterned film [4]. Particular emphasis is given to the reconfigurable dynamic response of these systems.

Finally, I will present some recent results on three-dimensional model of periodic meander-shaped ferromagnetic films and vertically coupled structures.

References

1. Gubbiotti, G.; Kostylev, M.; Tacchi, S.; Madami, M.; Carlotti, G.; Ding, J.; Adeyeye, A.O.; Zighem, F.; Stashkevich, A.A.; Ivanov, E.; et al. Collective spin waves on a nanowire array with step-modulated thickness. *J. Phys. D Appl. Phys.* **2014**, *47*, 105003.
2. Gubbiotti, G.; Zhou, X.; Haghshenasfard, Z.; Cottam, M.G.; Adeyeye, A.O. Reprogrammable magnonic band structure of layered permalloy/Cu/permalloy nanowires. *Phys. Rev. B* **2018**, *97*, 134428.
3. Gubbiotti, G.; Zhou, X.; Haghshenasfard, Z.; Cottam, M.G.; Adeyeye, A.O.; Kostylev, M. Interplay between intra- and inter-nanowires dynamic dipolar interactions in the spin wave band structure of Py/Cu/Py nanowires. *Sci. Rep.* **2019**, *9*, 4617.
4. Graczyk, P.; Krawczyk, M.; Dhuey, S.; Yang, W.-G.; Schmidt, H.; Gubbiotti, G. 2D re-programmable magnonic crystal with vertical control of the spin wave dynamics: Py film decorated with array of elliptical nanodots. *Phys. Rev. B* **2018**, *98*, 174420.