Spin-wave behavior in single and double rectangular $Ni_{80}Fe_{20}$ microstrips: micromagnetic simulations vs TR-STXM direct imaging

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Information transport and processing can benefit from fundamental understanding of the spin-wave (SW) dynamics in confined rectangular microstructures [1]. The design of microstrips affects the SW behavior and can be used as a manipulating mechanism [2]. TR-STXM [3] with the use of the planar microresonators [4] enables direct, time-dependent imaging of the spatial distribution of the precessing magnetization across the nm-thin microstrips during FMR excitation at the GHz frequency range with elemental selectivity [5].

In the presented work FMR and SW modes in a single and double rectangular ($1 \times 5 \times 0.027\,\mu m^3$) $Ni_{80}Fe_{20}$ (Py) microstrips were directly imaged using STXM-FMR and the findings were corroborated by micromagnetic simulations [5]. Overview of the SW profiles extracted from the micromagnetic simulations and TR-STXM results together with the FMR spectra allows for analyzing the excitable spin waves in the strips and helps revealing the relation between the FMR spectrum and the spin-wave excitations as a function of the external field. Furthermore, under the uniform excitation only SW eigenmodes with an odd number of nodes are expected. This results in a symmetric interference pattern. Changes in the geometry of the structure, such as a presence of an additional rectangular microstrip, can cause symmetry breaking [2]. Therefore, the asymmetry quantification by an asymmetry parameter (AP) of SW dynamics is suggested. The AP indicates a deviation of a central profile of an interference pattern from the mirror-symmetric state. This indicates an asymmetry in the interference pattern itself. A mirror-symmetric profile here is a profile, which is invariant under a reflection about the central axis. An AP for a profile consisting of normalized data values $\{x_n\}_{n=1}^{N}$ is calculated as follows:

$$AP = \frac{C}{[N/2]} \sum_{n=1}^{[N/2]} \mid x_n - x_{N-n+1} \mid, \tag{1}$$

where one half of the profile is subtracted from the other one point by point. Then the mean of the absolute values of all differences is taken. If the profile is symmetric, $AP = 0$. Both, for overviews and the AP parameter calculations, profiles of the out-of-plane component of the dynamic magnetization are analyzed [5]. The central region of the strips is used to calculate the profiles. For the excitation, a uniform microwave field at a frequency of 9.43 GHz was considered, while the external static magnetic field was varied. Although under uniform excitation in a single confined microstructure typically standing spin waves are expected, all imaged spin waves have shown a nonstationary character both, at and off resonance, the latter being additionally detected with FMR. Moreover, a higher asymmetry for double microstrips indicating the influence of the additional microstructure placed in close proximity to the analyzed structure.

References

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