2nd Transnational Round Table on Magnonics, High-Frequency Spintronics, and Ultrafast Magnetism

Elastic anisotropy and Surface Acoustic Wave propagation in CoFeB/Au multilayers: influence of thickness and light penetration depth

A. V. Achuthan[1], S. Janardhanan[1], P. Kuświk[2], A. Trzaskowska[1*]

[1] *ISQI, Faculty of Physics and Astronomy, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznan, Poland*

[2] *Institute of Molecular Physics, Polish Academy of Science, Smoluchowskiego 17, 60-179 Poznan, Poland.*

Surface acoustic waves (SAWs) have been a subject of scientific interest for over a century, offering valuable insights into the elastic properties of materials. In this study, we investigate the critical influence of CoFeB layer thickness on SAW propagation in Si/Ti/Au/CoFeB/Au. By examining variations in CoFeB layer thickness from 0.9 nm to 2 nm, we observed significant changes in the propagation characteristics of Rayleigh (R-SAW) and Sezawa (S-SAW) waves, underscoring the sensitivity of acoustic wave behaviour to nanoscale structural modifications. Two effective medium modelling approaches are considered: one treating the entire multilayer as a homogeneous medium and another focusing on the region influenced by light penetration. Light penetration depth analysis revealed that accurate modelling requires consideration of only an approximately 19 nm thick layer, significantly improving the precision of effective medium modelling and addressing a crucial limitation of previous experimental approaches. Neglecting this factor can lead to inaccurate estimations of acoustic wave velocities, highlighting its importance for obtaining reliable and reproducible results.

Brillouin light scattering (BLS), known for its high-frequency resolution and spatial flexibility[1], was employed to examine thermally excited SAWs in Si/Ti/Au/CoFeB/Au heterostructures with varying CoFeB thickness. The Zener anisotropy coefficient of the studied samples exhibited a systematic decrease with increasing CoFeB layer thickness, indicating a progressive homogenization of the material's elastic properties and confirming the moderate elastic anisotropy of CoFeB. Samples were fabricated via magnetron sputtering under controlled conditions[2,3], ensuring high material quality. The integration of finite element method (FEM) simulations with BLS measurements presents a powerful framework for predicting SAW behaviour in complex multilayers. This study enhances the understanding of SAW manipulation in spintronic and acoustic devices, paving the way for advanced material characterization and technological applications.

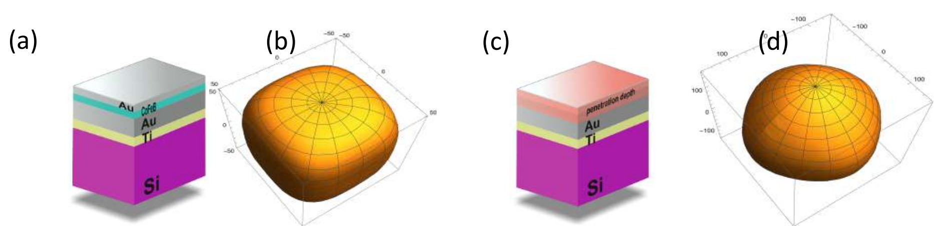

Fig.1. The structure of sample treated as a multilayer (a), 3D view of the calculated Young's modulus (*E*) (b), effective layer in the light penetration region (c) and the Young's modulus which is present only within the penetration depth region (d).

References

1. Farnell G. W. and Adler E. L. *Elastic Wave Propagation in Thin Layers*.; 1972.
2. S. Janardhanan S, Mielcarek S, Kuświk P, Krawczyk M, Trzaskowska A. *High-resolution Brillouin light scattering study on Ti/Au/Co/Ni multilayer.* J Magn Magn Mater. 2023;586:171209. doi:10.1016/j.jmmm.2023.171209