



Effect of Graphene Incorporation on Spin Dynamics of Permalloy Thin Film

Rahul Gupta^{1*}, Akash Kumar¹, Saroj Dash², Sujeet Chaudhary¹ and Pranaba Kishor Muduli¹

¹Department of Physics, Indian Institute of Technology, Hauz Khas, New Delhi-110016, India

²Department of Microtechnology and Nanoscience, Chalmers University of Technology, SE-41296, Göteborg, Sweden

*E-mail: rahulguptaphy@gmail.com

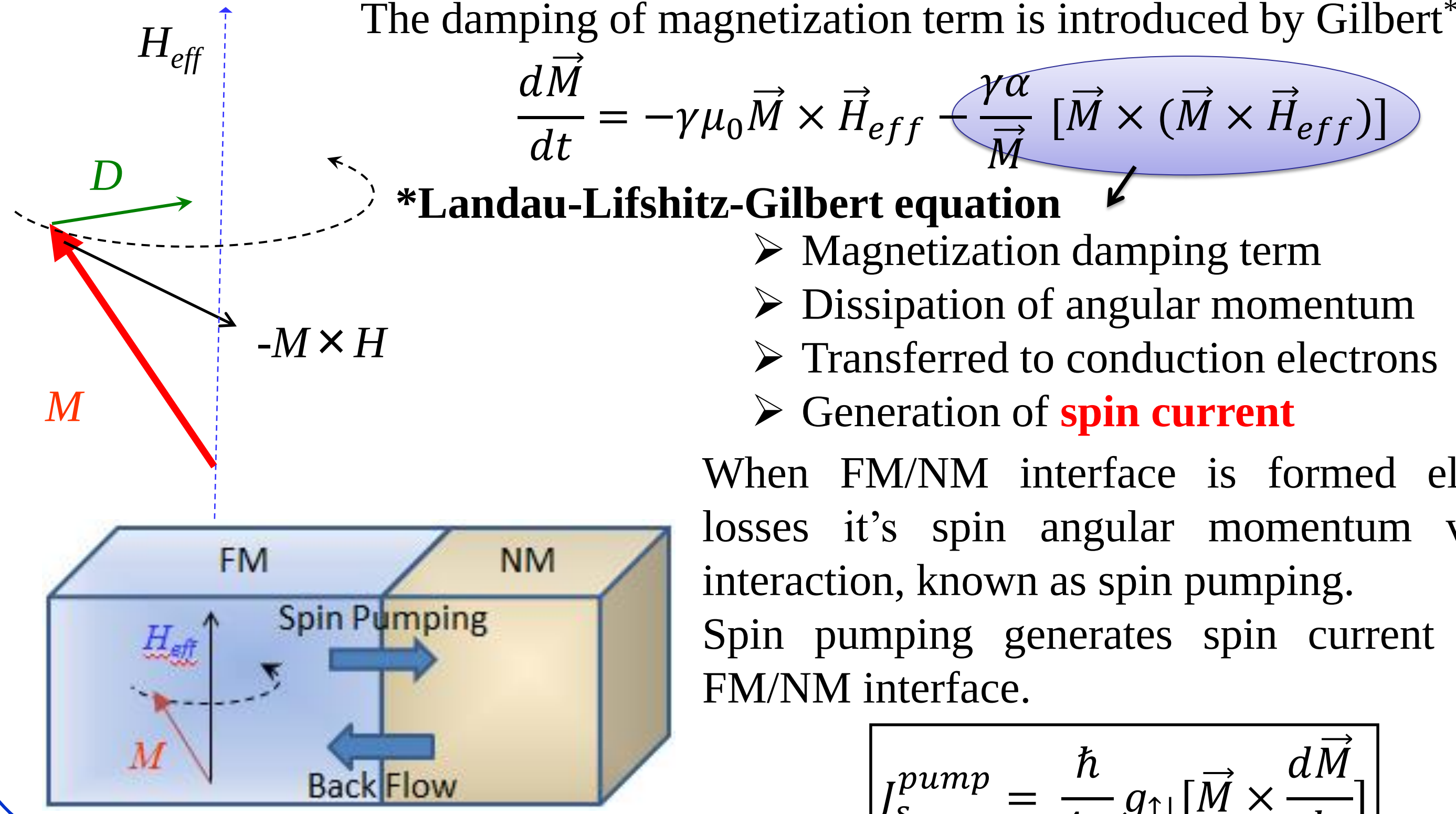


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Abstract:

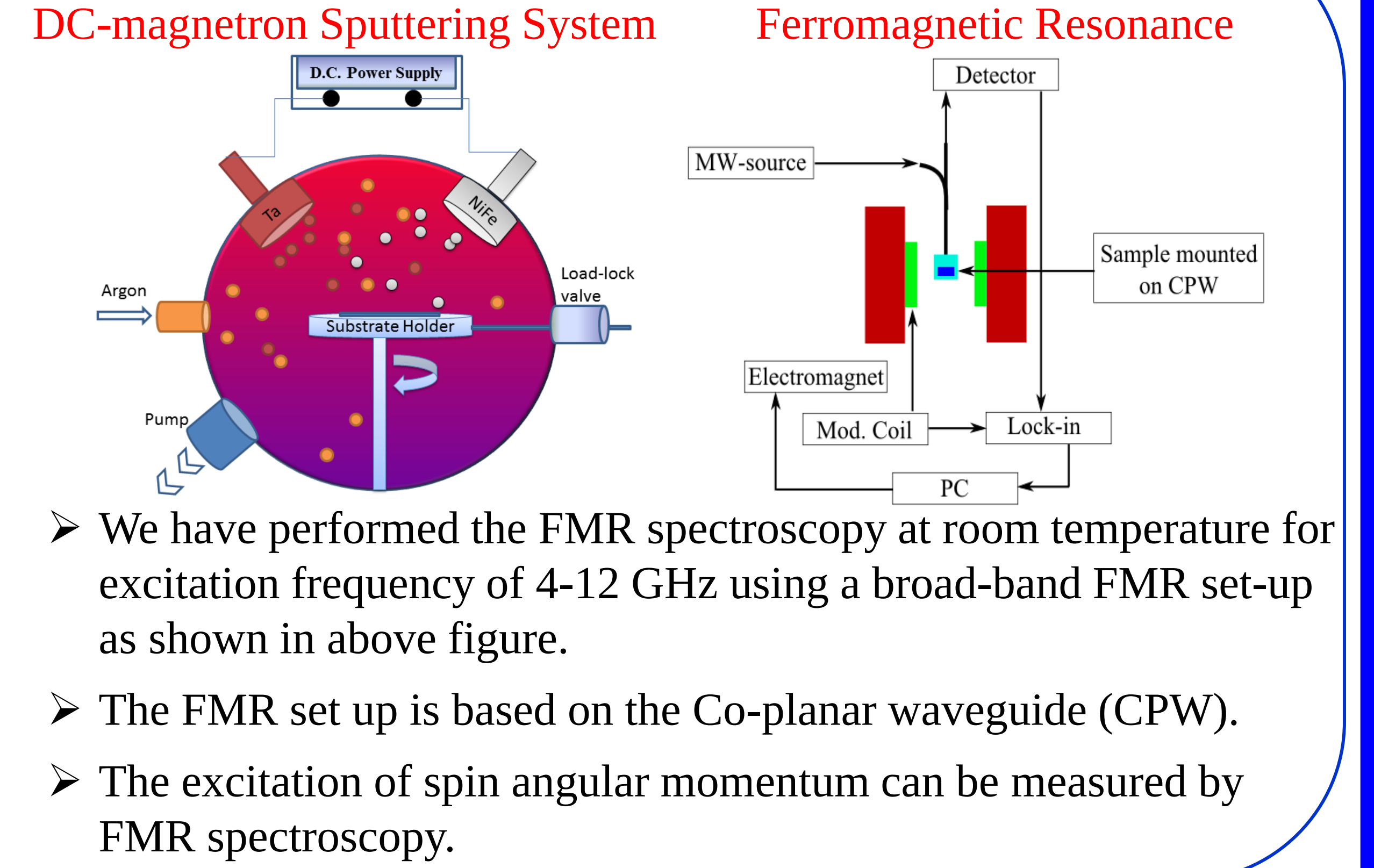
We report on the ferromagnetic resonance (FMR) spectra of Permalloy (Py)/ Graphene (Gr) and pure Py thin films grown under identical conditions to study the phenomena of spin pumping into Graphene. An enhancement of Gilbert damping constant is observed for Py/Gr bilayer structure. Using detailed thickness dependence study we show an enhancement of spin mixing conductance of Ta/Py/Gr/SiO₂/Si compared to Ta/Py/SiO₂/Si, which can be attributed to spin pumping. This study is important for successful integration of graphene with commonly used ferromagnetic materials for spintronics applications.

Introduction



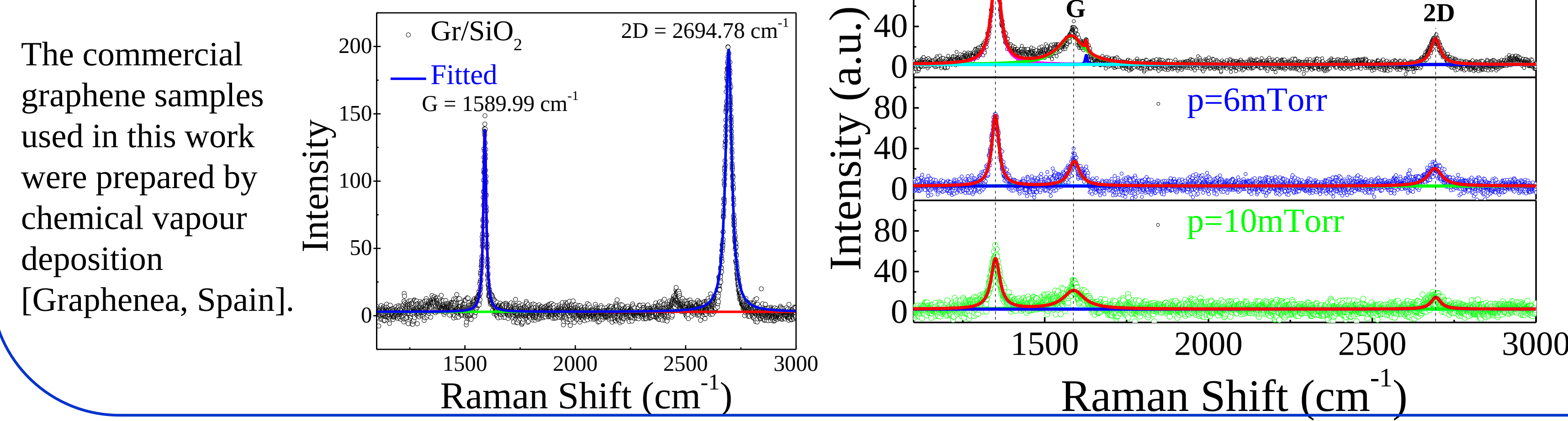
- Here, we have prepared a series of samples; bare Py and Py/Gr by varying thickness of ferromagnetic films (Py) on the SiO₂/Si and Gr/SiO₂/Si substrates.
- We grow Py thin films by using DC-magnetron sputtering at 2 mTorr Argon working pressure. A 2 nm of Tantalum (Ta) capping layer is also deposited for protection of samples from oxidation.

Experimental set-up



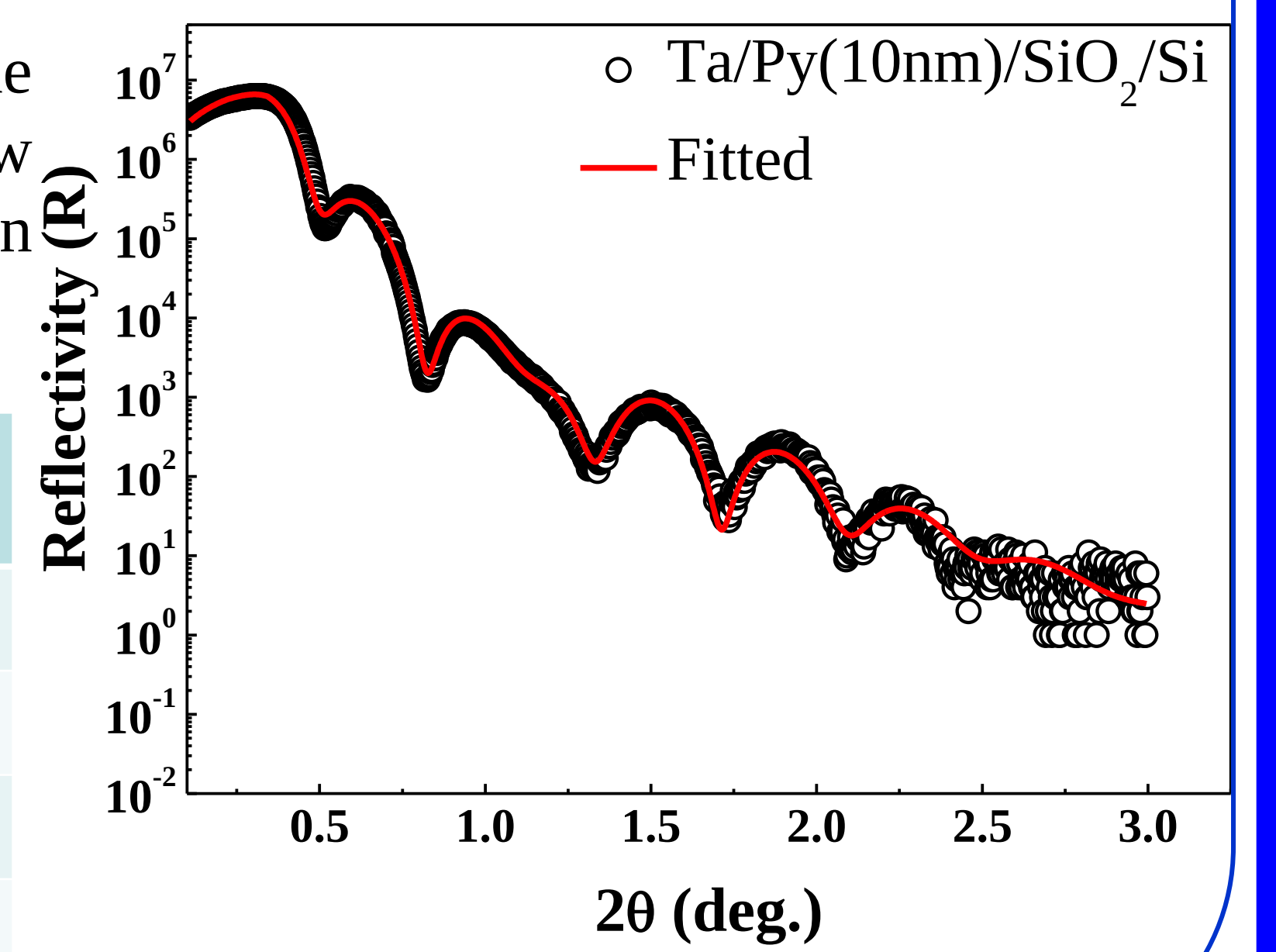
Raman Spectroscopy

- The Raman Spectra of monolayer graphene is show that the G-peak (=1589.99 cm⁻¹) and 2D-peak (=2694.79 cm⁻¹) is observed as cited in the literature.
- The Raman spectra of Py deposit on the top of Graphene at different Argon working pressure is shown in figure. The G-peak and 2D-peak still observed whereas an additional peak, called Defect-peak (= 1351.54 cm⁻¹), is also observed. The intensity of D-peak increases as the Argon working pressure decreases.

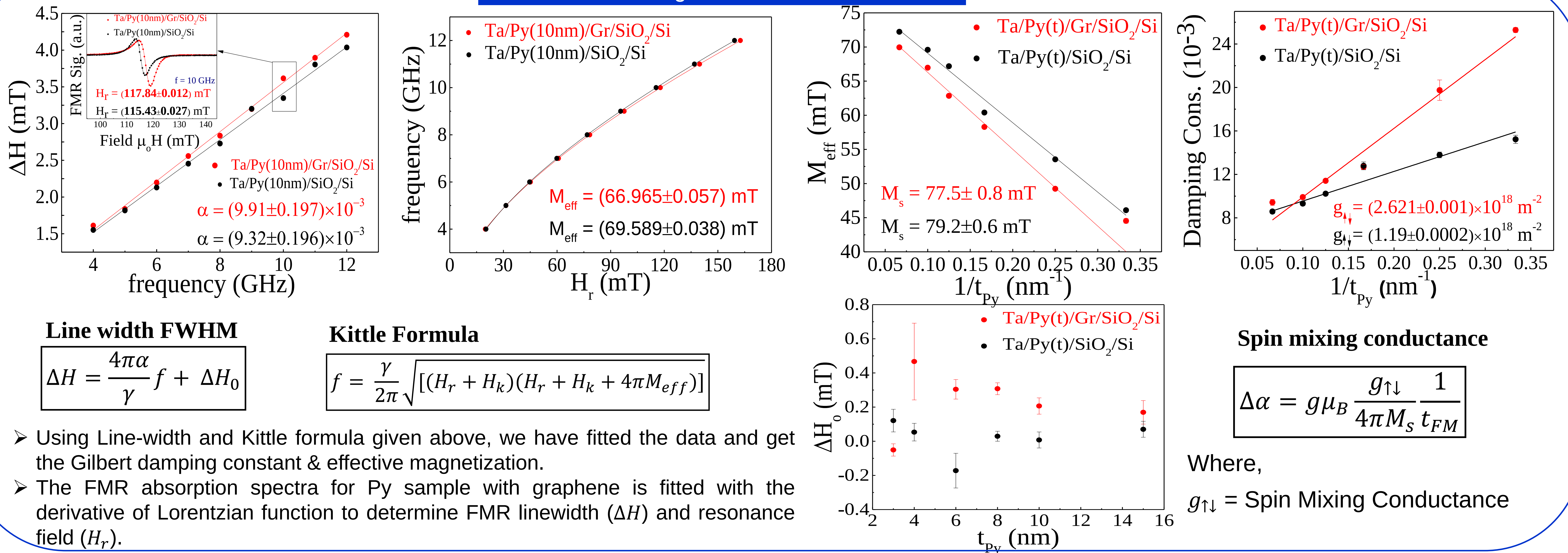


X-ray Reflectivity

- The X-ray reflectivity tells the thickness and roughness of thin film.
- Here, we have taken the XRR for the Ta/Py/SiO₂/Si sample. The table given below tells thickness and roughness of thin films in the bilayer structure.



Ferromagnetic Resonance



Conclusion

- A large increase of Gilbert damping constant in Ta/Py/Gr/SiO₂/Si as compared to Ta/Py/SiO₂/Si thin film was observed which signifies spin pumping into graphene. The calculated value of spin mixing conductance ($g_{\uparrow\downarrow}$) of Ta/Py/Gr/SiO₂/Si is found to be $(2.621 \pm 0.001) \times 10^{18} \text{ m}^{-2}$.
- We also find that the quality of Py films on graphene and without graphene to be very similar as determined from their material properties. This indicates that CVD grown graphene can act a good material for spin pumping studies.

Acknowledgement

I would like to acknowledge Nano Research Facility (NRF) and Central Research Facility (CRF), IIT Delhi and Thin Film Laboratory, IIT Delhi for facilities.

References

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