# Efficient spin-to-charge conversion and charge transfer dynamics in graphene/$WS_2$ heterostructures at room temperature

**Presenting Author: J. B. S. Mendes[1]**
Co-Authors: R. O. Cunha[1], Y.G. Basabe[2], D. G. Larrude[3], M. Gamino[4], E. N. Lima[5], F. Crasto de Lima[5], A. Fazzio[5], A. Azevedo[6], S. M. Rezende[6]

*[1]Departamento de Física, Universidade Federal de Viçosa, 36570-900 Viçosa, Minas Gerais, Brazil*
*[2]Centro Interdisciplinar de Ciências da Natureza, Universidade Federal da Integração Latino-Americana, 85867-970 Foz do Iguaçu, Paraná, Brazil*
*[3]Escola de Engenharia, Universidade Presbiteriana Mackenzie, São Paulo 01302-907, Brazil*
*[4]Departamento de Física, Universidade Federal do Rio Grande do Norte, 59078-900 Natal, Rio Grande do Norte, Brazil*
*[5]Ilum School of Science, Brazilian Center for Research in Energy and Materials (CNPEM), Campinas, SP, Brazil*
*[6]Departamento de Física, Universidade Federal de Pernambuco, 50670-901 Recife, Pernambuco, Brazil*

Contact@E-mail: Joaquim.mendes@ufv.br

Abstract

The use of graphene in spintronic devices depends, among other things, on its ability to convert a spin excitation into an electric charge signal, a phenomenon that requires a spin-orbit coupling (SOC). We have already reported an investigations of the spin-to-charge current conversion in single-layer graphene deposited on a single crystal film of the ferrimagnetic insulator yttrium iron garnet (YIG-$Y_3Fe_5O_{12}$). [1,2] Here we report an investigation of the combination of WS2 flakes with a single-layer graphene for spin-to-charge current conversion. We report an investigation of the combination of $WS_2$ flakes with a graphene layer for spin-to-charge current conversion. The pure spin current was produced by the spin precession in microwave driven ferromagnetic resonance of pemalloy film (Py-$Ni_{81}Fe_{19}$) and injected into the $WS_2$/graphene heterostructure by the spin pumping process. The spin-to-charge current conversion that occurs in the heterostructure is attributed to Inverse spin Hall effects (ISHE) in $WS_2$ and inverse Rashba-Edelstein (IREE) at the interface of $WS_2$ flakes and the graphene film. The results show that the presence of $WS_2$ flakes improves the current conversion efficiency. Understanding how the interfacial charge transfer and spin-charge conversion process between layered TMDs materials and graphene occur is important for improving the optoelectronic and spintronic device performance. For this purpose, the electron dynamic delocalization and spin-charge conversion in the interface of graphene/$WS_2$ heterostructure was investigated combining the synchrotron-based core hole clock approach and spin pumping process. The results obtained from these methods were supported by density functional theory (DFT) calculations.
This research is supported by CNPq, CAPES, FAPEMIG - Rede 2D and Rede de Nanomagnetismo, and INCT of Spintronics and Advanced Magnetic Nanostructures (INCT-SpinNanoMag).

References

[1] J. B. S. Mendes et al. Phys. Rev. B 99, 214446 (2019).
[2] J. B. S. Mendes et al. Phys. Rev. Lett. 115, 226601 (2015).