Interface tuneable Charge and Spin Dynamics in 2D heterostructures

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Abstract

Two-dimensional (2D) van der Waals heterostructures, interfaces, and junctions offer promising opportunities for controlled charge and spin transport as well as ordering phenomena [1]. Magnetic interfaces with 2D materials enable spin-resolved transmission and can also host nontrivial magnetic textures. Here, I describe two systems. First, graphene—established for its exceptional spin communication [2], when interfaced with ferromangetic layers, enhances ultrafast demagnetization speeds [3], and ultrafast charge transfer in MoS_2-based van der Waals heterostructures [4]. Second, incorporating MoS_2 into a Cobalt|Platinum heterostructure introduces additive interfacial Dzyaloshinskii–Moriya interactions (DMI) from both the MoS_2/Co and Co/Pt interfaces. This additive DMI stabilizes chiral spin textures [5] and enables the observation of the topological Hall effect (THE) [6]. Our findings of interface-tuneable charge and spin dynamics in 2D heterostructures underscore their significance in advancing the performance and functionality of emergent spintronic and opto-spintronic devices.

References

[1] J.-F. Dayen, S.J. Ray, O. Karis, I.J. Vera-Marun, M.V. Kamalakar, Appl Phys Rev 7 (2020) 011303. https://doi.org/10.1063/1.5112171.
[2] J. Panda, M. Ramu, O. Karis, T. Sarkar, M.V. Kamalakar, ACS Nano 14 (2020) 12771–12780. https://doi.org/10.1021/acsnano.0c03376.
[3] D. Muradas-Belinchón, S. Mukhopadhya, F. Foggetti, S.N. Panda, O. Karis, P.M. Oppeneer, A. Barman, M. Venkata Kamalakar, 2025 (Unpublished)
[4] R. Sharma, H. Nameirakpam, D.M. Belinchón, P. Sharma, U. Noumbe, D. Belotcerkovtceva, E. Berggren, V. Vretenár, L. Vanco, M. Matko, R.K. Biroju, S. Satapathi, T. Edvinsson, A. Lindblad, M.V. Kamalakar, ACS Appl Mater Interfaces 16 (2024) 38711–38722. https://doi.org/10.1021/acsami.4c07028.
[5] C. Kumar, R. Sharma, S. Pal, G. Datt, T. Sarkar, M.V. Kamalakar, A. Barman, Phys Rev Appl 22 (2024). https://doi.org/10.1103/PhysRevApplied.22.064088.
[6] R. Sharma, G. Datt, S. Ershadrad, H. Nameirakpam, D. Muradas Belinchón, C. Kumar, T. Sarkar, A. Barman, B. Sanyal, M.V. Kamalakar 2025 (Unpublished)