Emergent optical functionalities of van der Waals heterostructures of transition metal dichiacogenides

Yoshihiro Iwasa
University of Tokyo, Hongo 7-3-1, Bunkyo-ku, Tokyo, Japan
RIKEN Center for Emergent Matter Science, Hirosawa 2-1, Wako, Japan
iwasa@ap.t.u-tokyo.ac.jp

Van der Waals (vdW) heterostructures form a rich platform which enables us to fabricate a variety of combination of materials without any constraint of lattice mismatch, sequence, and twisted angles, and consequently to create rich properties and functionalities. Here we introduce our attempts in exploring optoelectronic functions of vdW heterostructures based on the transition metal dichalcogenide (TMD).

One noticeable advantage of vdW heterostructures is that its symmetry can be controlled depending on how and what materials researchers stack. This is in marked contrast with the bulk single crystals, where symmetry is uniquely determined by the space group. When we construct a vdW heterostructure of C_3 symmetric WSe_2 and C_2 symmetric black phosphorous (BP), the combined system becomes C_1 symmetric because three-fold and two-fold rotational symmetries can not coexist. Consequently, the heterostructure system becomes in-plane polar despite that both WSe_2 and BP are nonpolar materials. This allows the occurrence of bulk photovoltaic effect in WSe_2/BP with a relatively large photocurrent density in comparison to the bulk polar crystals [1].

Another example is the exciton/magnon interaction at the vdW interface of $MoSe_2$ and yttrium iron garnet (YIG). YIG films support long-lived magnons that can be coherently driven by microwaves. Magnons play a major role in spintronics circuits as a low-loss information carrier, and in quantum hybrid systems as a macroscopic quantum interface to superconducting quantum bits. Realizing an interfacial coupling between magnons and excitons offers a promising way forward to connect spintronic and quantum technologies to optics. Here we report unambiguous evidence of a dynamical coupling between mangnons in YIG and excitons in TMDs through the interfacial exchange interactions [2].

References

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[2] A. Gloppe, K. Usami et al., *arXiv* 2006.14257 (2020).