Linearly-polarized electroluminescence in van der Waals heterostructures

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Germanium sulfide (GeS) is an anisotropic layered material with a direct band gap around 1.78 eV [1]. GeS possesses a low-symmetry orthorhombic crystal structure analogous to that of black phosphorus. The optical response of GeS was systematically investigated using experimental techniques, such as photoluminescence, reflectance contrast, and Raman scattering [2]. Electroluminescence (EL) studies have not been reported in the literature yet. The investigation of EL anisotropy is an innovative aspect of this study.

Here, we investigate the EL response of GeS assembled in two types of structures: with tunnel barriers of thin layers of hexagonal BN (hBN) and without them. The bias voltage was applied to the graphene flakes via metallic contacts. The photos of the samples and the structures schemes are in Figures a) and b).

The EL of the sample with tunnel barriers is apparent at 1.77 eV, which is associated with the neutral excitonic transition in GeS, see Figure c). Moreover, the observed EL signal is linearly polarized along the armchair crystallographic direction, which is in agreement with the corresponding photoluminescence response [2]. It is intriguing that the structure without tunnel barriers does not have EL from the neutral exciton.However, there are observed emissions at higher energies at 2.04 eV and 2.30 eV (see Figure d)), which coincide with higher energy transitions around the Γ point of the Brillouin zone [1].

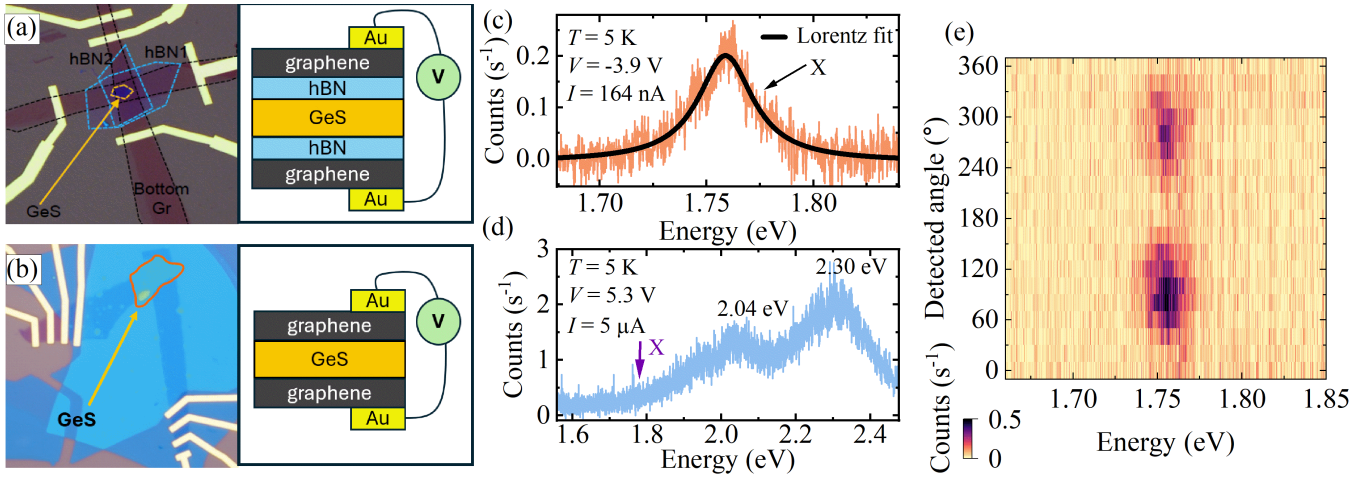

Figure 1: The optical images and schemes of the samples (a) with tunnel barriers and (b) without tunnel barriers. EL spectra measured on sample (c) with tunnel barriers and (d) without tunnel barriers. (e) The false color map of the polarization-resolved EL from the sample with tunnel barriers.

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References

[1] M. Arfoui, and et.al., *Nanoscale* **15**, 17014 (2023).
[2] N. Zawadzka, and et. al., *Nanometerials* **11**, 3109 (2021).

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