# Electric control of valley polarization in monolayer $WSe_2$ using a van der Waals magnet

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## Research Focus

Electrical manipulation of the valley degree of freedom in transition metal dichalcogenides is central to developing valleytronics. Towards this end, ferromagnetic contacts, such as Ga(Mn)As and permalloy, have been exploited to inject spin-polarized carriers into transition metal dichalcogenides to realize valley-dependent polarization. However, these materials require either a high external magnetic field or complicated epitaxial growth steps, limiting their practical applications. Here we report van der Waals heterostructures based on a monolayer $WSe_2$ and an $Fe_3GeTe_2$/hexagonal boron nitride ferromagnetic tunnelling contact that under a bias voltage can effectively inject spin-polarized holes into $WSe_2$, leading to a population imbalance between ±K valleys, as confirmed by density functional theory calculations and helicity-dependent electroluminescence measurements. Under an external magnetic field, we observe that the helicity of electroluminescence flips its sign and exhibits a hysteresis loop in agreement with the magnetic hysteresis loop obtained from reflective magnetic circular dichroism characterizations on $Fe_3GeTe_2$. Our results could address key challenges of valleytronics and prove promising for van der Waals magnets for magneto-optoelectronics applications.

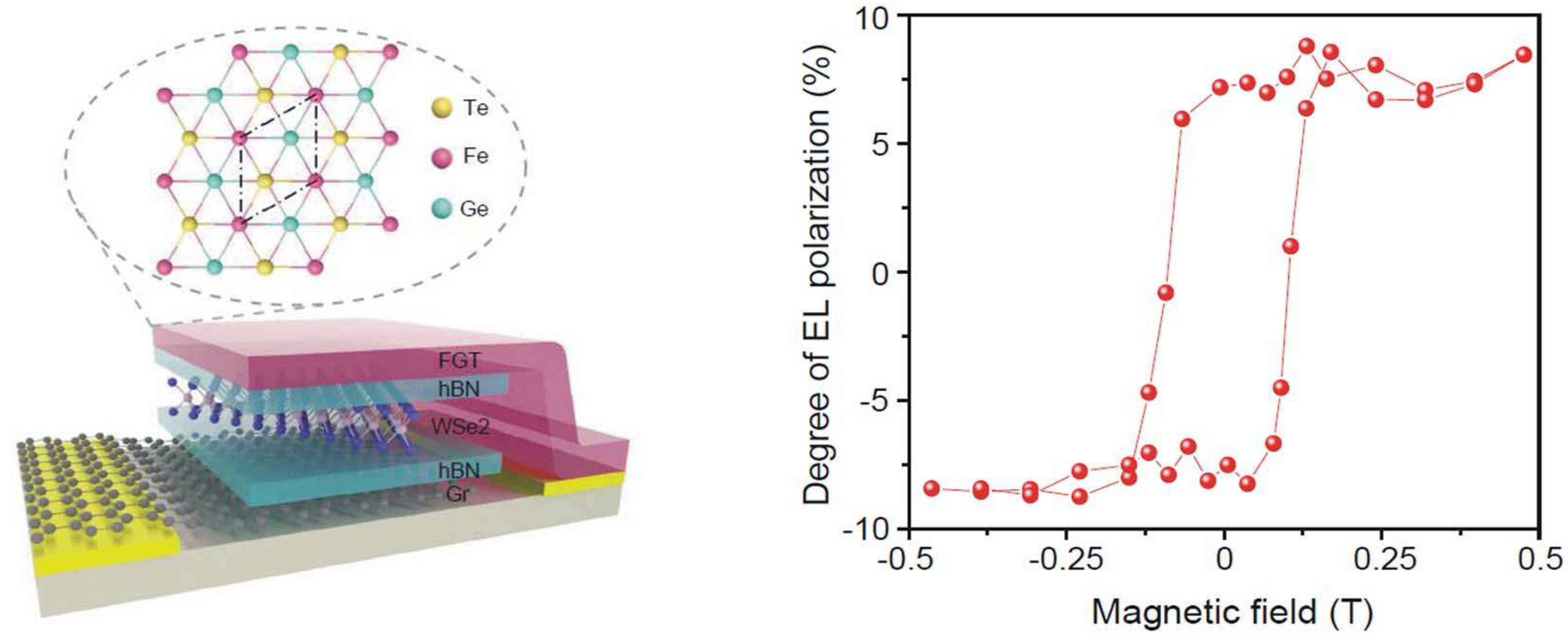


**Fig. 1 Device structure.** (a) Schematic of the top view of the $Fe_3GeTe_2$ crystal structure and the device configuration, composed of vertically stacked $Fe_3GeTe_2$ /hBN/chemical vapour deposited (CVD) $WSe_2$/hBN/graphene (top to bottom) heterostructures. The unit cell of FGT is enclosed by the black dashed lines. Gr, graphene. (b) The change of degree of EL polarization of neutral exciton emission over a cycle of the out-of-plane magnetic field. The result exhibits a hysteresis loop.

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Our work reveals the exciting possibilities of using a ferromagnetic FGT electrode to control the valley pseudospin degree of freedom of TMD. Importantly, our magneto-optoelectronic device structure is entirely composed of vdW materials. Thus, it can be readily integrated with diverse substrates or photonic structures without lattice-matching constraint, greatly enhancing their applicability. On the basis of our framework, we anticipate that electrical control of valley polarization near room temperature could potentially be achieved, considering the recent rapid expansion of the vdW materials library. For instance, the top FGT electrode can be replaced with emerging materials, such as Fe5GeTe2 and MnSex, which are metals with ferromagnetism near room temperature. Additionally, the recently developed chalcogenide-alloyed TMD monolayers can be exploited, as they possess strong spin–valley characteristics at room temperature, confirmed by the helicity-dependent PL measurements. Beyond this, it is also noteworthy that many of the above materials can be synthesized at wafer scale. Such advancement offers tremendous opportunities to realize scalable valleytronics for practical information processing and computing applications.

## Feedback

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