GeS_2: Finding the Missing Color in the van der Waals Palette

The "flat land" of van der Waals (vdW) materials has become a thrilling playground for nanophotonics, offering a toolkit of atomically thin crystals with record-breaking optical properties. Yet, for all their exotic behaviors in the infrared, a frustrating gap remained in their color palette. The entire visible spectrum—the most critical range for applications from imaging to displays—remained the domain of conventional bulk materials like TiO_2, hindering the development of truly all-vdW photonic circuits.

Our work introduces germanium disulfide (GeS_2) as the missing piece.[1] We have identified and comprehensively characterized GeS_2 as the first vdW material to combine the three essential properties for visible-light photonics: a very high refractive index ($n > 2.5$), negligible optical loss across the entire visible range (down to 360 nm) and giant, intrinsic biaxial anisotropy. This unique combination, verified through spectroscopic ellipsometry, near-field optical microscopy and first-principles calculations, positions GeS_2 to finally challenge the dominance of traditional dielectric materials.

To move this discovery from scientific curiosity to technological reality, we leveraged GeS_2's unique properties to design a device with record performance. By creating an interface between GeS_2 and TiO_2, we engineered a highly efficient polarizing beam splitter. The material's specific anisotropy, where one axis is perfectly index-matched to TiO_2 while others are not, allows near-perfect transmission for one polarization and strong reflection for the other. This results in a calculated extinction ratio exceeding 10^6, surpassing existing commercial solutions in the near-UV range.

The addition of GeS_2 to the vdW family is more than just a new material: It completes the photonic palette. It unlocks the potential for ultra-thin, high-performance components such as metasurfaces, waveguides for augmented- and virtual-reality headsets and on-chip polarization optics that can now operate with unprecedented efficiency across all wavelengths, from the UV to the infrared. This work opens the door to a new era of nanophotonic design built entirely from the rich and diverse vdW toolkit. Notably, the material was recently highlighted as an optical all-round van der Waals crystal.[2] OPN

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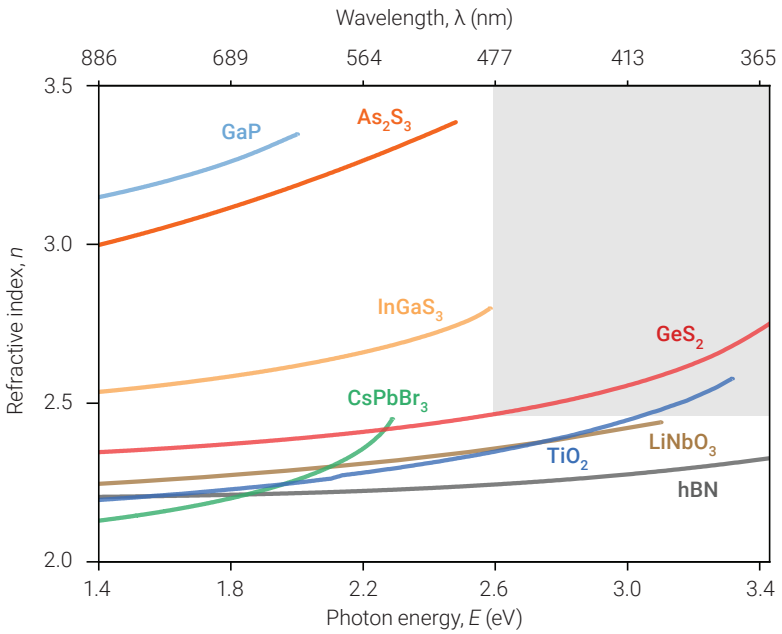

Germanium disulfide (GeS_2) fills a critical gap in the photonic materials landscape. This chart compares the refractive index and transparency window of GeS_2 against other key van der Waals and conventional materials, demonstrating its unique combination of a high refractive index and transparency across the entire visible spectrum.