

EDITORIAL

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Research highlight: an optical all-round van der Waals crystal

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Over the past decade, van der Waals (vdW) materials have steadily redefined the frontiers of nanophotonics. Their remarkable optical properties—from extraordinary anisotropy to record-breaking refractive indices—have inspired visions of next-generation photonic devices capable of guiding, confining, and manipulating light at unprecedented scales. Despite these promising advances, a critical obstacle has persisted: the absence of a vdW material having both high refractive index and broad-band transparency across the visible spectrum.

In a recent publication in *Light: Science & Applications*, Slavich et al. introduced germanium disulfide (GeS₂) as a compelling new candidate to overcome such an obstacle [1]. Through detailed analyses of its structural, vibrational, and optical properties, they demonstrated the GeS₂ flake simultaneously achieving a remarkably high refractive index, strong biaxial optical anisotropy (in-plane birefringence of 0.12, out-of-plane birefringence of 0.63), and nearly lossless transparency from the ultraviolet (UV) to visible range. This performance not only surpasses any existing vdW competitors such as hBN and NbOCl₂ but also challenges conventional optical materials like TiO₂. Moreover, GeS₂ retains the intrinsic

layered flexibility typical of vdW materials, highlighting its potential as an "all-round player".

GeS₂ stands out among optical materials by achieving a rare combination of high refractive index and low optical loss across the UV to visible spectrum. This performance is primarily attributed to its relatively large bandgap (> 3.4 eV), which effectively suppresses intrinsic absorption in the visible range. At the same time, its low-symmetry crystallography enhances electronic polarizability, enabling a high refractive index without introducing significant optical loss. In contrast, as shown in Fig. 1, conventional materials such as TiO₂, despite their high refractive indices, are limited by their optical isotropy, constraining their use in polarization-dependent applications [2]. NbOCl₂, while exhibiting notable in-plane anisotropy, suffers from a smaller bandgap and noticeable absorption in the visible range [3, 4]. Meanwhile, although hBN is transparent in the UV region, its relatively low refractive index (1.8–2.2) limits its potential for high-performance optical applications [5, 6].

While GeS₂'s breakthrough in UV–visible nanophotonics is highly encouraging, significant challenges remain on the path to practical implementation. Current synthesis methods primarily rely on mechanical exfoliation, limiting large-area production. Moreover, the material's performance under high-power operation and dense optical integration remains to be thoroughly evaluated to ensure low losses in real-world devices.

In summary, the emergence of GeS₂ undoubtedly injects renewed momentum into the UV–visible nanophotonics field. Yet, there is still a long way to go toward flexible, high-index, low-loss, and printable photonics, together with mass manufacturing readiness. For example, it is of high value to explore the synthesis of GeS₂ nanoparticles and load them with a polymer matrix to

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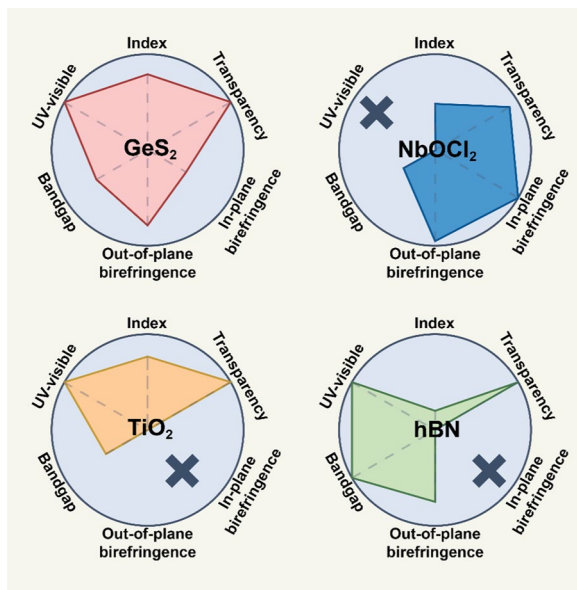


Fig. 1 Comparison of UV-visible photonic materials. Performance metrics of GeS₂, NbOCl₂, TiO₂, and hBN are evaluated across six key criteria: refractive index, broadband transparency, in-plane birefringence, out-of-plane birefringence, bandgap, and spectral coverage in the UV-visible range. GeS₂ demonstrates the most balanced and excellent performance across all categories, highlighting its potential as an “all-round” photonic material

create high-refractive index nanocomposites. With the proper formulation of photoinitiators and crosslinkers, the nanocomposites could be optimized for optical nano-printing technologies, i.e., nanoimprint lithography and two-photon lithography, making a big difference in materials innovation. The future of photonic materials, from inorganic to organic, from singular materials to composites, holds great promise and challenge, signaling a true revolution in materials science.

Author contributions

C.-W. Q. conceived the initial idea. X.B.L. led the figure preparation and manuscript writing. All authors contributed to the discussion and revision of the manuscript.

Data availability

The data supporting the figure and other findings in this paper are available from the corresponding author upon reasonable request.

Declarations

Competing interests

Cheng-Wei Qiu serves as an Editor for the Journal, no other author has reported any competing interests.

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