Broadband Photon-Pair Generation in a Semiconducting van der Waals Material via Relaxed Phase-Matching

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Van der Waals (vdW) materials have emerged as a promising platform for miniaturized, on-chip quantum-correlated photon-pair sources, offering superior optical nonlinearities and integration capabilities with diverse photonic architectures compared to traditional bulk crystals [1]. In this work, we report efficient spontaneous parametric down-conversion (SPDC) across the telecommunication bands using a novel ferroelectric vdW material, SnP_2S_6. This material exhibits a second-harmonic generation conversion efficiency of 0.07% within a few-micrometer thickness under 1560 nm pulsed pumping. Remarkably, this performance is comparable to that of artificially quasi-phase-matched 3R-MoS_2 stacks, which comprise a few alternating layers, each several hundred nanometers thick, with 180° orientation rotations [2]. Coupled with this, a broad SPDC bandwidth of up to 400 nm is observed, attributed to the minimal refractive index dispersion between the 782 nm pump and the near-infrared signal-idler wavelengths [3]. To validate practical scalability, we integrate the material onto optical fiber ferrules via a dry transfer method. The in-line device exhibits robust SPDC without performance degradation, simultaneously achieving a maximum coincidence-to-accidental ratio (CAR) on the order of 10^4 (Fig. 1). Our findings highlight the potential of vdW materials as versatile quantum light sources, enabling a scalable, design-flexible pathway to circumvent the engineering bottlenecks of conventional structures for next-generation quantum photonic applications.

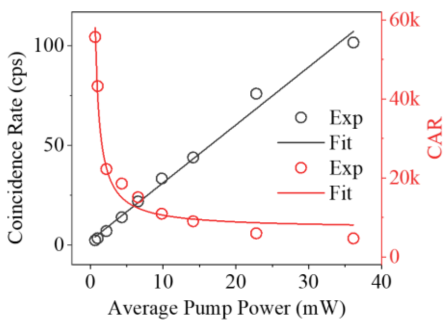

Fig. 1: *Coincidence rate and CAR of SPDC from our in-line device, when pumped by 782 nm continuous wave laser and measured with 1500 nm long-pass filter.*

References

[1] Guo, Q., et al., *Nature* 613, 53-59 (2023)

[2] Chiara, T., et al., *Nature Photonics* 19, 291-299 (2025)

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