Interplay of Plasmonics and Strain for Hexagonal Boron Nitride Emission Engineering

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We investigate single-photon emission from defects in hBN integrated with truncated gold nanocones. While gold activates emission, it also degrades its quantum nature due to overlapping fluorescence. Our findings provide insights for developing tunable single-photon sources in 2D materials integrated with plasmonic platforms.

The fabrication and integration of hBN with Au truncated nanocones were successfully achieved, as illustrated in the fabrication process flow and confirmed by SEM and optical microscopy images. hBN on a bare Si/SiO2 substrate exhibited no significant emission, confirming its high purity, while traces from the edges displayed weak emission. However, integrating hBN with truncated nanocones resulted in PL spectra influenced by background fluorescence from Au nanocones, as demonstrated in the extracted spectra and confocal PL maps.

The second-order correlation function, $g^{(2)}(\tau)$, indicated that most observed emission was not quantum due to Au fluorescence. Fluorescence lifetime measurements further supported this conclusion, showing a decay time of 0.5 ns for Au nanocones and slightly longer for hBN-integrated nanocones. The presence of gold fluorescence negatively impacted single-photon emission (SPE) detection.

A refined PL scan identified a quantum emitter with distinct zero-phonon lines (ZPL) at 611.65 nm and 623.56 nm and phonon side-bands at 664.78 nm and 677.09 nm. Time-resolved fluorescence decay analysis yielded lifetimes of 2.86 ns and 0.66 ns. The $g^{(2)}(0)$ value of 0.44 confirmed quantum emission, potentially arising from a strained defect or an edge defect in hBN. However, the lack of a spacer layer led to non-radiative decay, suppressing some potential SPEs. These findings highlight the challenge of isolating quantum emitters in the presence of metallic fluorescence and suggest the need for improved structural modifications to enhance quantum emission properties in integrated plasmonic systems.

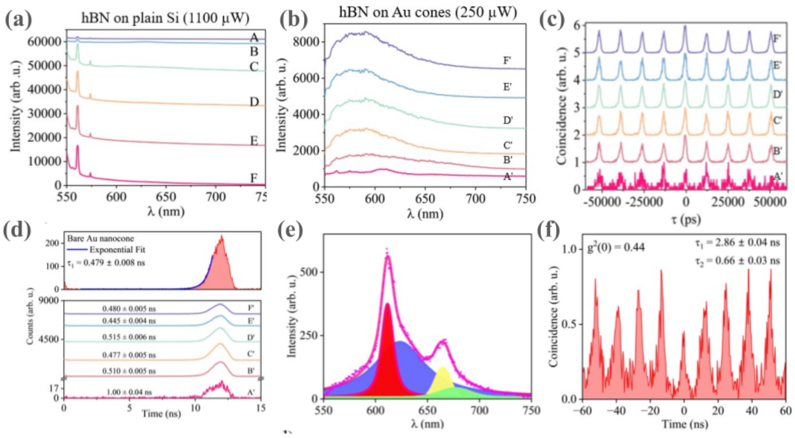

Figure 1: (a) PL spectra of few-layer hBN on Si/SiO$_2$. (b) PL spectra of few-layer hBN on Au nanocones (offset: 2600 in (a), 160 in (b)). (c) Measured $g^{(2)}(\tau)$ for points in (b). (d) Lifetime of a bare Au nanocone and points A'–F' in (b). (e) PL spectrum of an SPE showing ZPL and PSB. (f) Auto-correlation measurement with $g^{(2)}(0) = 0.44$, matching hBN SPE lifetimes. [1] [2].

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