Systematic study to understand the origin of luminescent emitters in hexagonal boron nitride(hBN) generated by irradiation engineering

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Abstract

The two-dimensional(2D) van der Waals material hexagonal boron nitride (hBN) has recently received attention to host luminescent emitters [1]. These luminescent emitters are outstanding from the class of excitonic emitters in 2D transition metal dichalcogenides (TMDs) due to their room temperature magnetic and quantum optical properties [2]. Despite the wide 6 eV bandgap in hBN, photoluminescent emitters are detected upon excitation with visible energy sources (~2eV). The microscopic origin of these emissions is an ongoing research topic, and the most common explanation is founded on the crystallographic defects in the hBN lattice that give rise to energy levels within the bandgap [3]. A recent report also suggests that polycyclic aromatic hydrocarbon (PAH) molecules trapped between flake and substrate are responsible for luminescence and single photon emission [4]. In this work, we systematically study the surface densities of luminescent emitters generated using a combined oxygen irradiation - nitrogen annealing method on exfoliated few-layer hBN flakes in different control processes. Quantitative data from our micro-photoluminescence mapping measurements strengthen the previously reported experimental and theoretical study on irradiation-based luminescent defect generation in hBN [5]. Although we are not discarding the presence of PAH molecules entirely in our method, we argue that the explanation of luminescence based on crystal defects is more likely from the findings. From controlled annealing environments, we also demonstrate carbon's inevitable role in creating luminescent emitters in our process, indicating carbon-based defects.

References

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