Engineering Quantum Defects in h-BN for Single Photon Source Applications

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Single photon sources are the ultimate choice for many quantum technologies. For practical applications, a single photon emitter (SPE) should emit a single indistinguishable photon at an arbitrary user defined time, where the emission is controlled via an external electrical trigger. Single-photon emitters currently made using different approaches all have certain limitations, such as low single-photon purity, operation at cryogenic temperatures and low identical-emitter production yields.

The discovery of two-dimensional (2D) materials is attracting a great interest in science and technology, thanks to their unique optoelectronic properties. Using photoluminescence (PL) studies, certain structural defects have been identified in one such 2D material, hexagonal boron nitride (h-BN), which exhibit good single-photon emission characteristics. [1]. In our study, we explore defect engineering approaches in h-BN with the aim of overcoming the current limitations of SPEs. [2, 3]. The ultimate objective of this project is to fabricate electrically controlled SPEs from the luminescent quantum defects in h-BN, thus demonstrating the first QLEDs based on this 2D material.

Our approach to engineering luminescent defects in hBN flakes combines thermal annealing and electron beam irradiation (Fig. 1). In this work, we present the results of a study of the optical properties of a series of hBN samples fabricated under different thermal annealing conditions and electron beam irradiation doses. Photoluminescence (PL) imaging and photon correlation measurements were obtained to study the characteristics of our generated SPEs. Fig. 2 compares a secondary electron microscope (SEM) image of a processed hBN flake and a room-temperature PL map of the same flake, where the influence of the fabrication process on PL intensity along the flake can be clearly seen. A summary table of emitter characteristics as a function of processing conditions will be presented.

We also plan to design h-BN based tunnel junctions (Fig. 3) using the 2D materials layer assembly technique which will be characterized by electrical transport and electroluminescence studies. This part of the work aims to better understand the link between transport-accessible electronic states and the luminescent states governing the single-photon emission process.

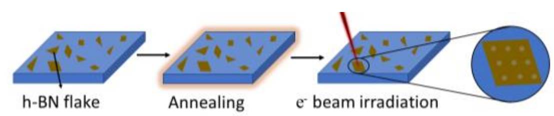

Fig 1. Schematic for defect engineering process

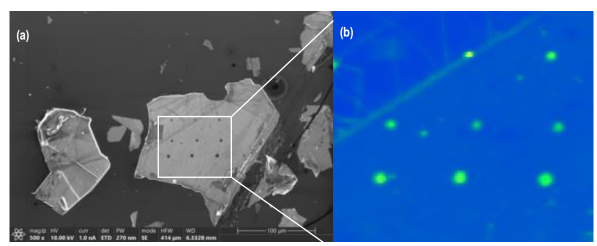

Fig 2. (a)SEM image of h-BN flakes after irradiation and (b) room-temperature PL map of the indicated region (in (a)) of the central flake.

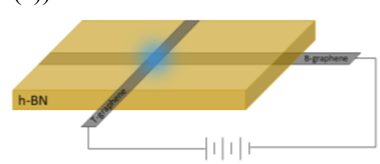

Fig 3. h-BN based tunnel junction

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