Hexagonal Boron Nitride for Quantum and Nonlinear Optics

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Photonic integrated circuits that process information encoded in particles of light are poised to revolutionize information processing, communications and sensing. A promising, emerging class of quantum technologies is based on solid-state, on-demand, single photon emitters (SPEs) coupled to optical resonators and waveguides that serve as building blocks for high density, on-chip quantum photonic circuits [1]. Nevertheless, despite years of research, existing systems are inadequate for real-world applications, and there is a significant effort to find high performance emitters hosted by materials that enable integration in photonic devices. Recently, the SPE family expanded upon the discovery of quantum emitters in two-dimensional (2D) materials [2]. These materials are atomically thin and hence offer new possibilities for scientific exploration and device engineering. Later, hexagonal boron nitride (h-BN) emerged as a compelling 2D host of SPEs offering bright single photon emission and robust operation [3].

Another important sphere of 2D material applications is nonlinear optics (NLO). Most widely used integrated photonic platforms do not possess quadratic optical nonlinearity, which significantly limits NLO applications such as wavelength conversion and all-optical switching. Integrating 2D materials with strong NLO response into photonic circuits resolves this problem [4]. Here, h-BN is particularly well positioned, since unlike other popular 2D materials, it offers both significant NLO susceptibility and transparency in the visible range. This presentation will focus the latest advances in h-BN nonlinear and quantum optics.

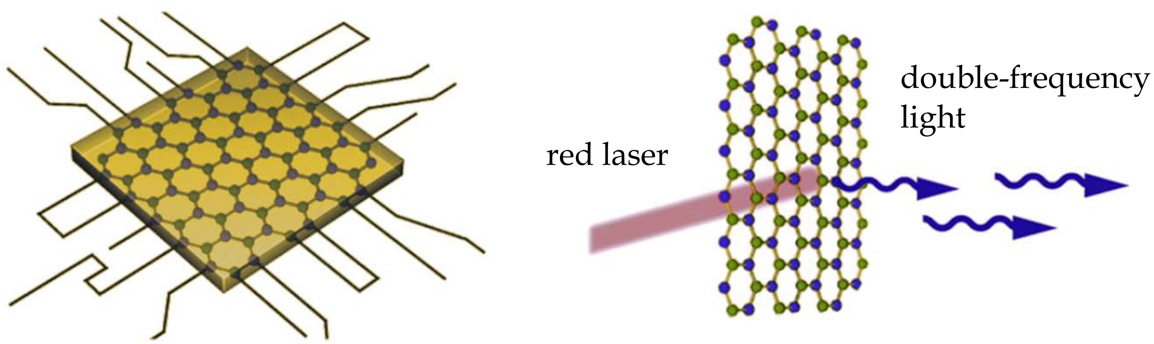

Figure 1. (Left) Hexagonal boron nitride based quantum emitters as building blocks for integrated quantum network schemes. (Right) Nonlinear wavelength conversion in hexagonal boron nitride.

[1] P. Lodahl, S. Mahmoodian, & S. Stobbe, "Interfacing single photons and single quantum dots with photonic nanostructures," Reviews of Modern Physics **87**, 347-400 (2015).
[2] "Single photons for all," Nature Nano., **10**, 481-481 (2015).
[3] T. T. Tran, K. Bray, M. J. Ford, M. Toth, & I. Aharonovich, "Quantum emission from hexagonal boron nitride monolayers," Nature Nano. **11**, 37-41 (2016).
[4] A. Autere, H. Jussila, Y. Dai, Y. Wang, H. Lipsanen, Z. Sun, "Nonlinear Optics with 2D Layered Materials," Adv. Mater. **30**, 1705963 (2018).

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