III-Nitride Quantum Dot- and Boron Nitride Defect-Based Single Photon Emitters

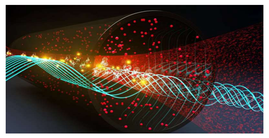
Syed M N Hasan[1], Shantanu Saha[1,2], and Shamsul Arafin*[1]

[1]Department of Electrical and Computer Engineering, The Ohio State University, Columbus, OH, 43212*

[2]currently with Department of Electrical, Electronics and Communication Engineering, GITAM School of Technology, GITAM, Hyderabad-502329, Telengana, India

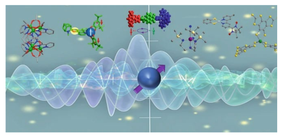
*arafin.1@osu.edu

MOTIVATION



Quantum Sensing

Quantum Internet



Wasielewski *et al.*, Nature (2020)

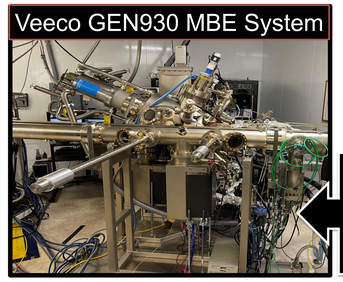
Quantum Biology

Vandersypen *et al.*, IISSC, IEEE (2017)

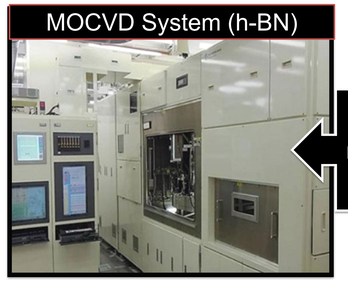
Quantum Computing

Quantum Information Science

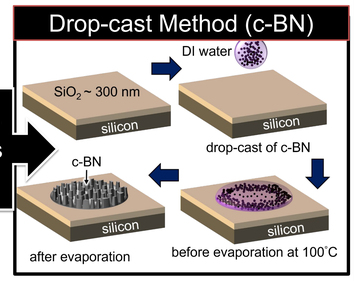
MATERIAL GROWTH



III-nitrides

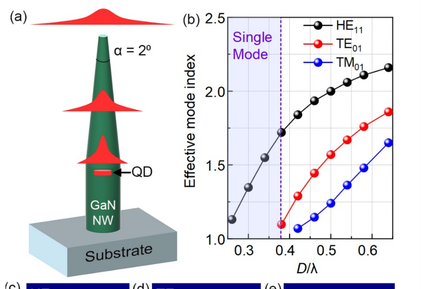


Boron-nitrides

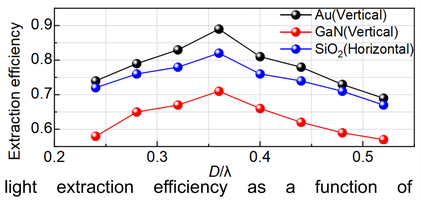


Nanowire-Quantum Dots for Quantum Emitters

Numerical Simulation

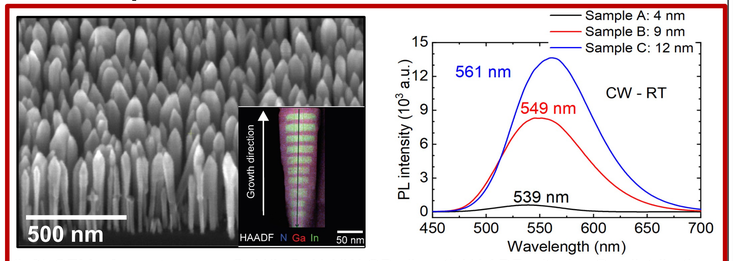


(a) cylindrical GaN NW with α = 2º. (b) Eff. refractive indices of first guided three modes. (c) HE_{11}, (d) TE_{01} and (e) TM_{01} mode distribution



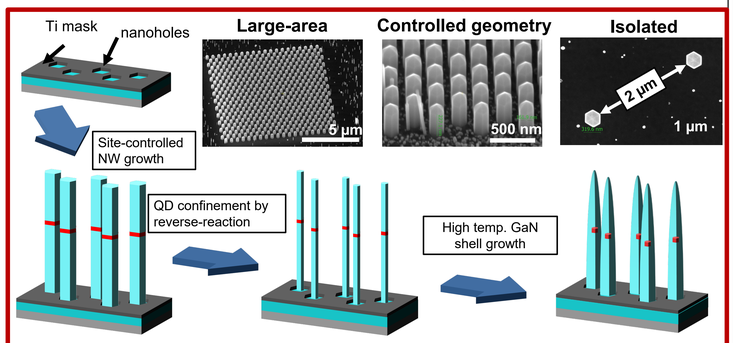
light extraction efficiency as a function of diameter/wavelength for different substrates,

Spontaneous Nanowire-Quantum Dots



(left) SEM of spontaneous GaN/InGaN NW-QD, (inset) HAADF with In, Ga distribution around the QD. (right) PL spectroscopy with different QD thickness.

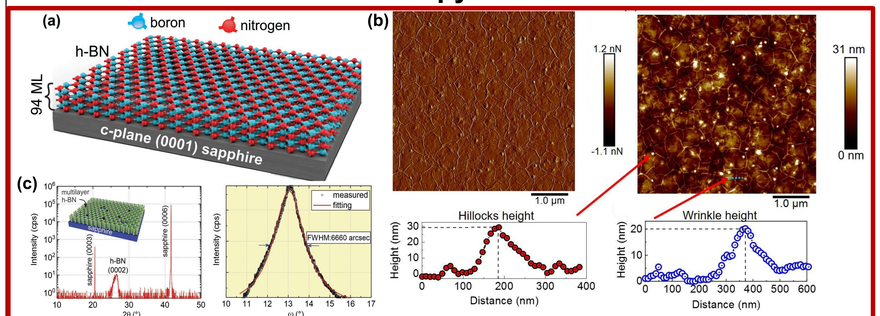
Site-Controlled Nanowire-Quantum Dots



(anticlock-wise) (left-top) Schematic process flow for developing site-controlled placed GaN NW-QD. SEM images (left to right): SAG-GaN NWs grown at OSU MBE facility

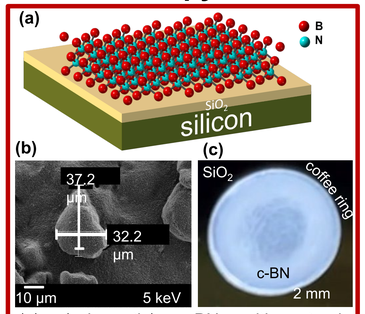
Hexagonal-BN and Cubic-BN for Quantum Emitters

Microscopy of h-BN



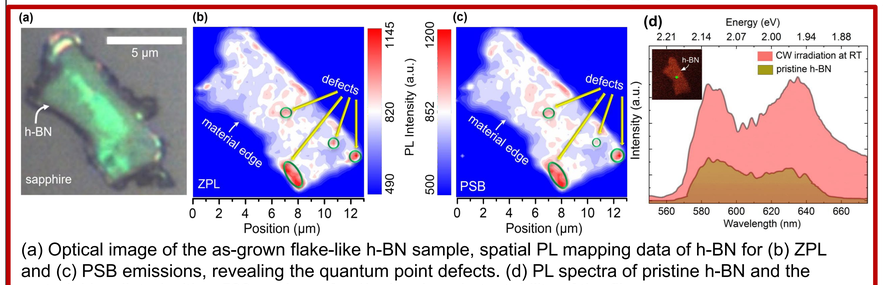
(a) (Schematic) multilayer h-BN thin films on c-plane sapphire. (b) AFM of h-BN films under peak force and height scans. (c) XRD pattern of h-BN films with rocking curve of the (0002) reflection

Microscopy of c-BN



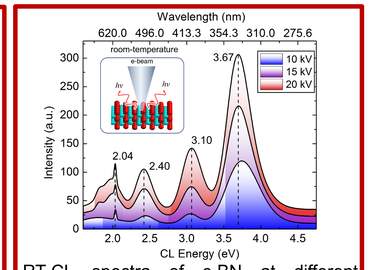
(a) (schematic) c-BN with atomic geometry. (b) SEM and (c) optical image.

Spatial Photoluminescence Mapping of h-BN



(a) Optical image of the as-grown flake-like h-BN sample, spatial PL mapping data of h-BN for (b) ZPL and (c) PSB emissions, revealing the quantum point defects. (d) PL spectra of pristine h-BN and the material irradiated with a 532 nm laser for 1h showing photostability of the film

Cathodoluminescence of c-BN



RT-CL spectra of c-BN at different electron energies

CONCLUSION AND OUTLOOK

- ❑ Optical emission tailored even without changing In compositions
- ❑ Thicker InGaN/GaN active regions implemented to achieve high quantum efficiency and tune emission wavelengths
- ❑ Further confinement via reverse-reaction growth allows precise control of QD geometry and position
- ❑ In-depth analysis of h-BN growth on sapphire using carbon-free precursor Borazine
- ❑ Achievement of zero phonon line and phonon sideband from two-types of quantum point defects
- ❑ Observation of sub-bandgap level emission by CL study provides the insights of defect luminescence of c-BN

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