Deterministic Defect Generation in few-layer hBN

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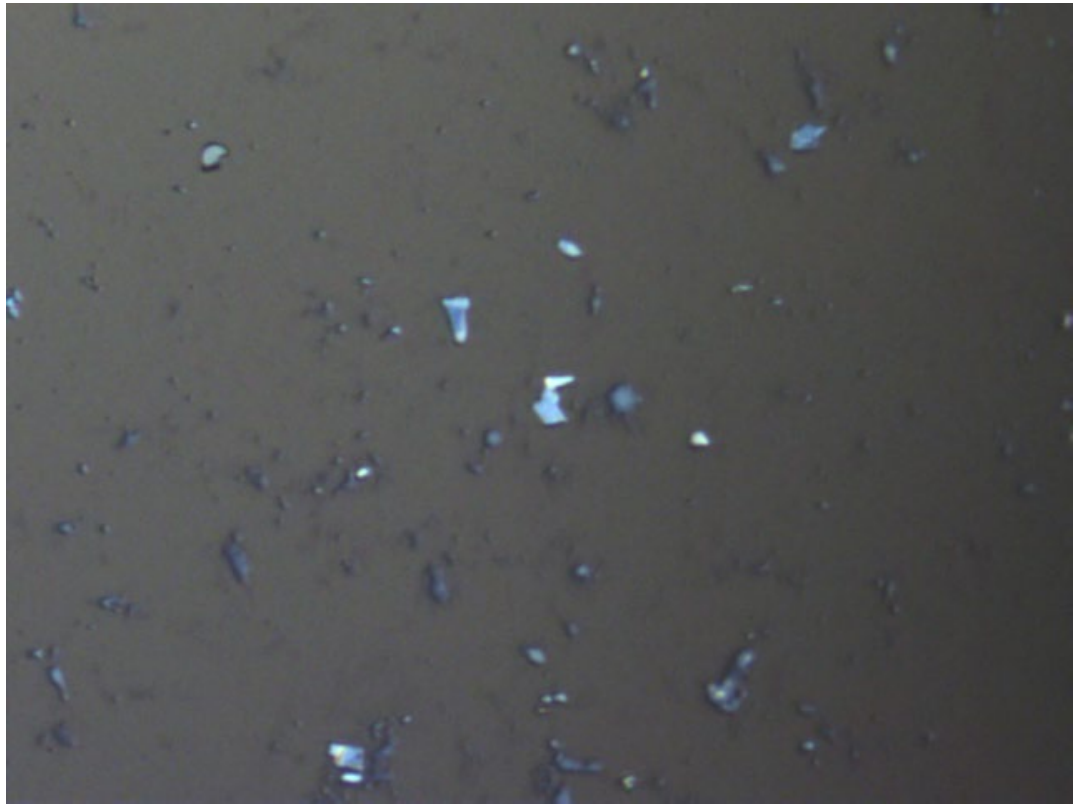
hBN as a host for quantum emitters

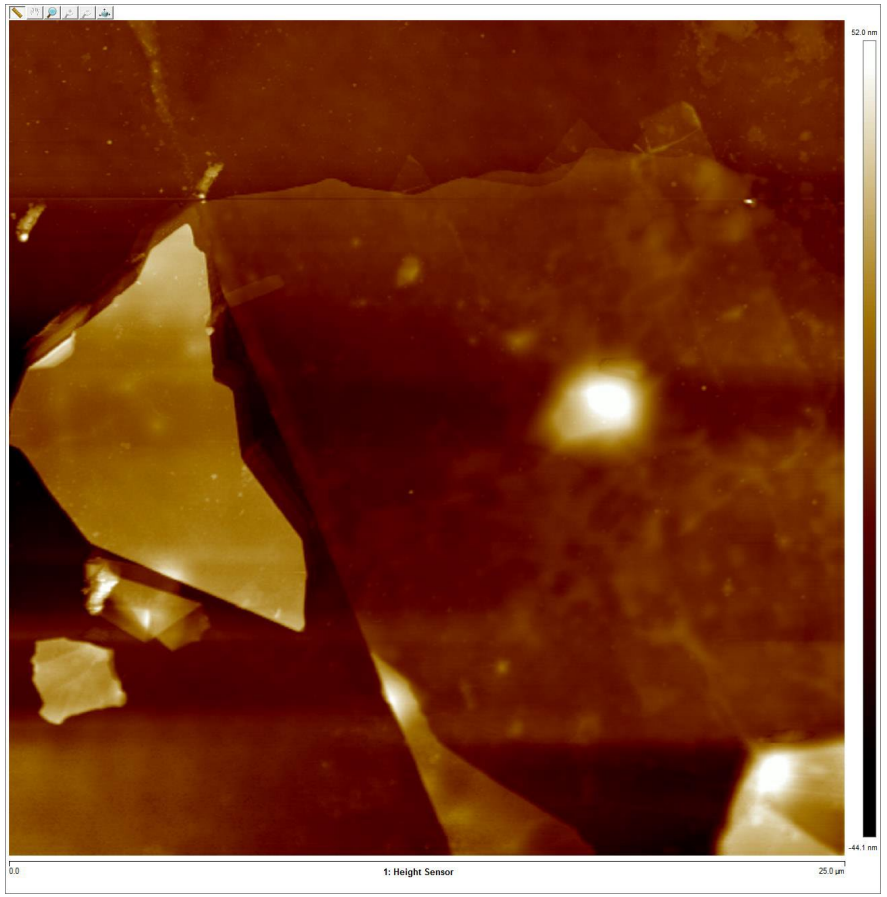
- Point defects in hBN have been seen as a promising quantum emission candidate
- The number of hBN layers plays a role the defect properties
- Generating these defects deterministically is an open field of study



Optical image of a sample of exfoliated hBN flakes

Identifying Few Layer hBN

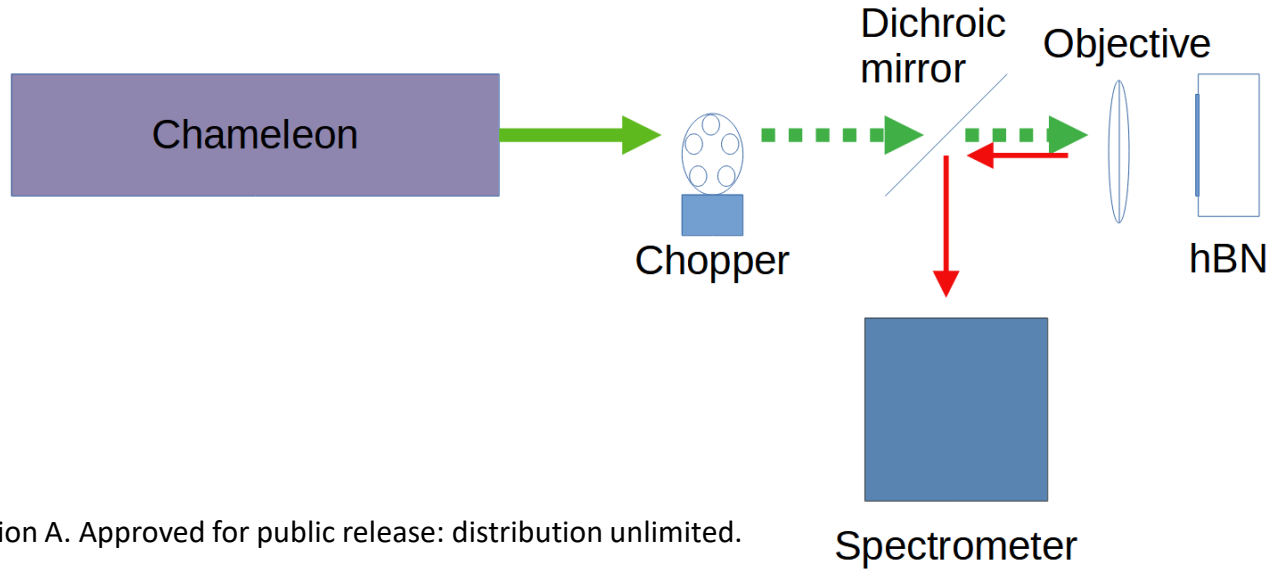
- Used atomic force microscopy (AFM) to try to identify few layer regions in exfoliated hBN samples
- Unable to identify any sufficiently thin regions
- Pivoted to deposited hBN samples grown in RY directorate



AFM image of exfoliated hBN flakes.

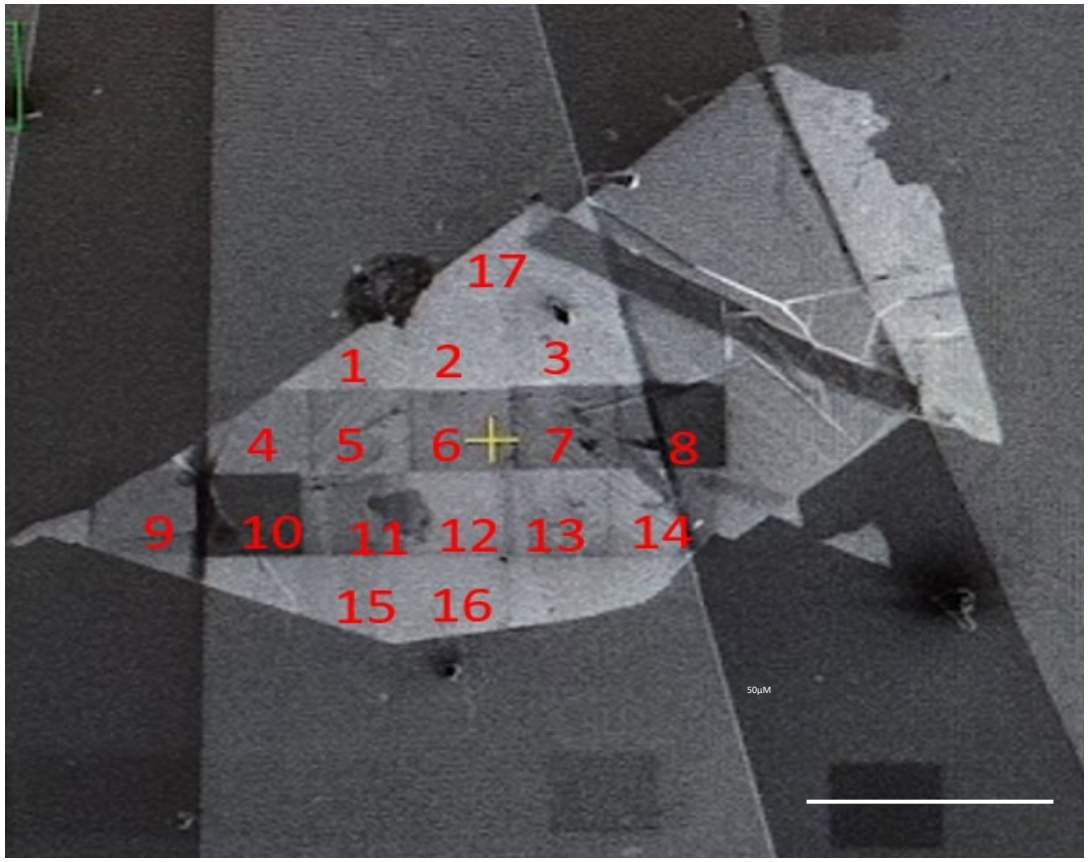
Laser writing hBN defects

- Used tunable wavelength, high power (5 W) Coherent Chameleon laser to attempt defect creation and excitation
- Methods based on results from Gao *et al.* [1], which used significantly higher pulse energies but longer wavelengths.
- Our results have been inconclusive



Writing defects using Gallium ion irradiation

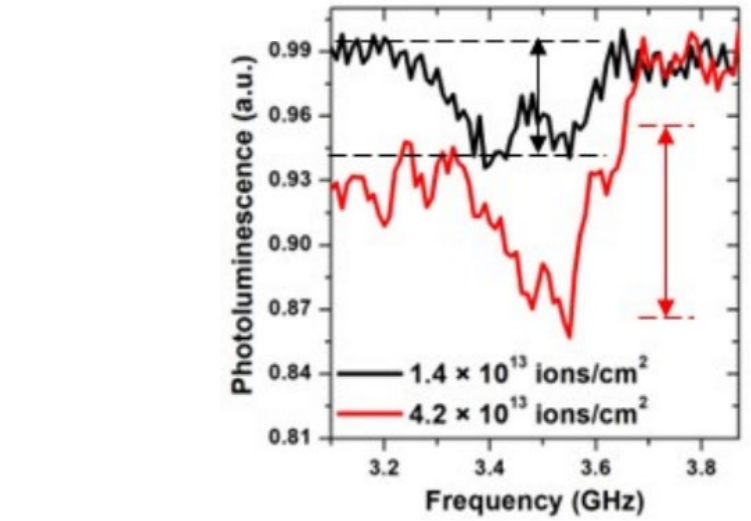
- Using Focused Ion Beam (FIB) to create defects in hBN
- Different sections given different radiation exposures

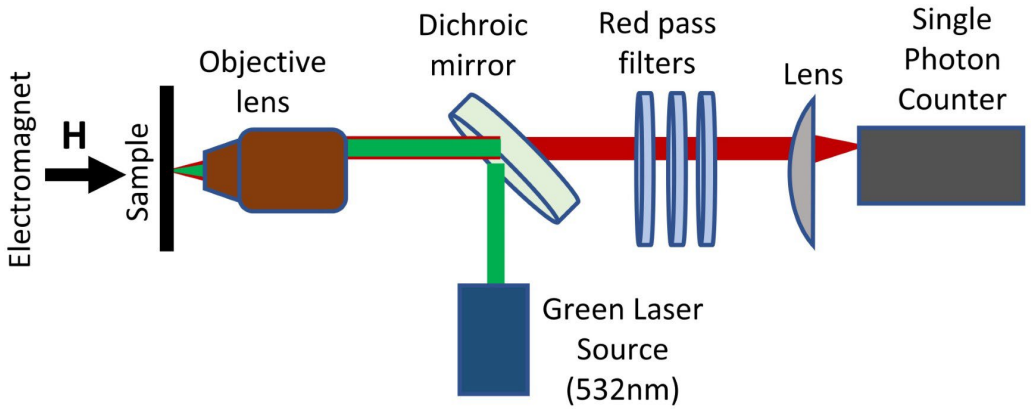


[2] Shekhar Das et al. (Submitted Nov. 2023)

Writing defects using Gallium ion irradiation

- Optically Detected Magnetic Resonance (ODMR) used to identify presence of point defects
- ODMR spectra for different Gallium radiation dosages

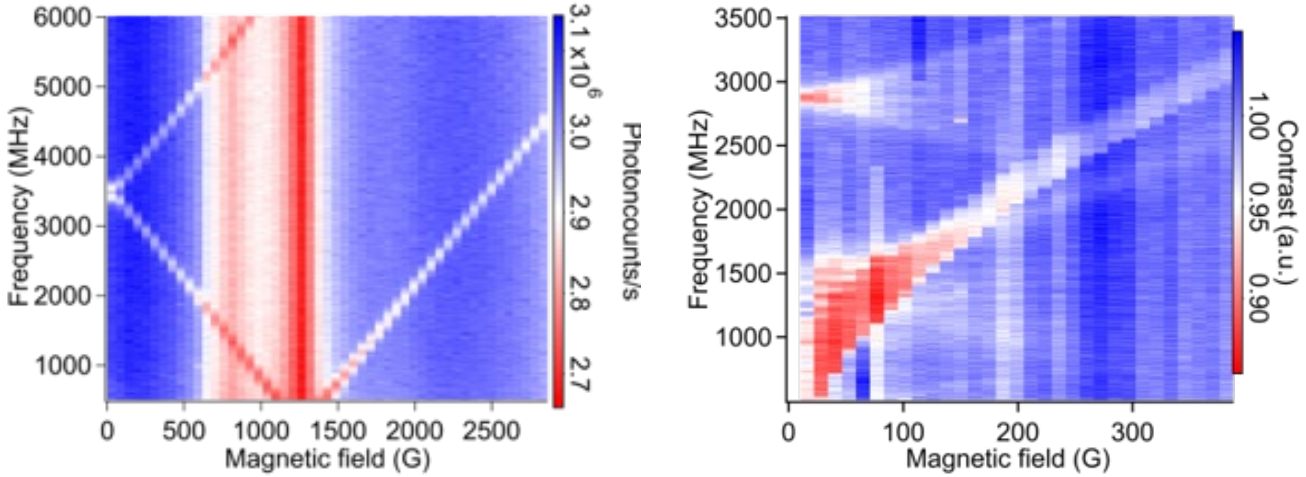




[2] Shekhar Das et al. (Submitted Nov. 2023)

ODMR as a function of magnetic field

- Apply magnetic field out of plane of the sample to analyze presence and orientation of generated defects in the sample
- Draw conclusions on sample damage
- Going forward characterize photoluminescence and antibunching and determine parameters to generate single defects



[2] Shekhar Das et al. (Submitted Nov. 2023)

Summary

- Point defects in hBN are a candidate for quantum emitters
- Laser writing and FIB irradiation are promising methods for deterministic defect generation
- AFRL and OSU are working in collaboration to investigate these creations methods and characterize the resulting emitters

[1] Xingyu Gao, Siddhant Pandey, Mehran Kianinia, Jonghoon Ahn, Peng Ju, Igor Aharonovich, Niranjan Shivaram, and Tongcang Li. Femtosecond Laser Writing of Spin Defects in Hexagonal Boron Nitride. ACS Photonics 2021 8 (4), 994-1000 DOI: 10.1021/acsphotonics.0c01847

[2] Shekhar Das, Alex L. Melendez, I-Hsuan Kao, Janeth Garcia Monge, Daniel Russell, Kenji Watanabe, Takashi Taniguchi, James H. Edgar, Jyoti Katoch, Fengyuan Yang, P. Chris Hammel, and Simranjeet Singh, Quantum sensing of spin dynamics using boron-vacancy centers in hexagonal boron nitride (Submitted Nov. 2023).