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Defect Activation and Stabilization in Hexagonal Boron Nitride for Room-Temperature Single-Photon Sources

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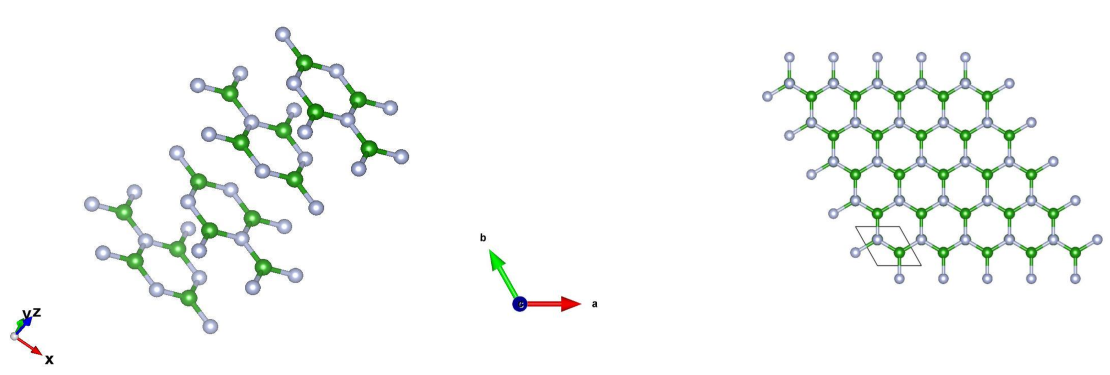
Abstract

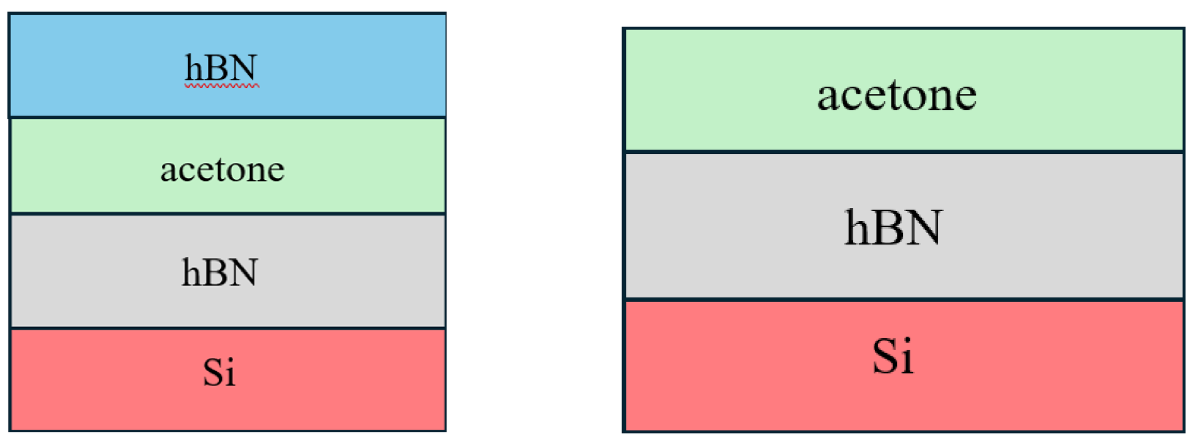
Single-photon emitters (SPEs) are key building blocks for next-generation quantum communication and information technologies. Hexagonal boron nitride (hBN), with its graphene-like layered structure, wide bandgap, and van der Waals bonding, has emerged as a promising host material for stable, room-temperature single-photon emission. In this study, we significantly enhance the density and stability of defect-based quantum emitters in thin hBN layers by immersing the material in selected organic solvents, followed by thermal annealing in an argon (Ar) gas environment. Comprehensive photoluminescence (PL) spectroscopy and surface analyses confirm the activation and improved emission stability of defect centers. This approach provides a robust and scalable route toward the fabrication of bright and reliable single-photon sources based on hBN.

Introduction

hBN

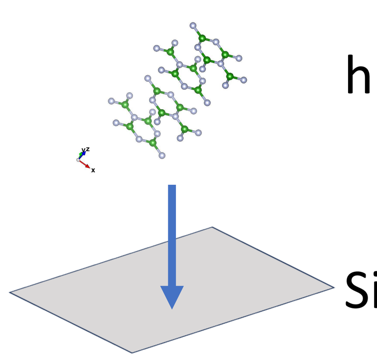


The structure of hBN in two dimensional(2D)

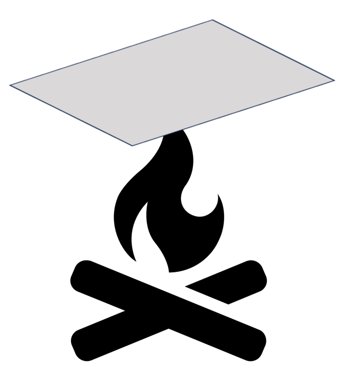


Left side is the layers of hBN capping on the sample and right is hBN without capping.

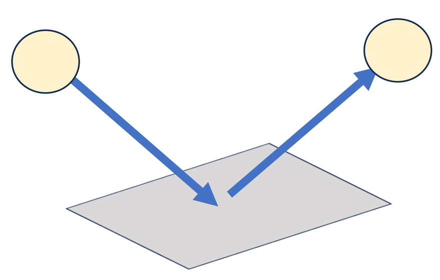
Materials and Methods



Transfer the hBN onto the Si substrate to obtain an hBN/Si sample.



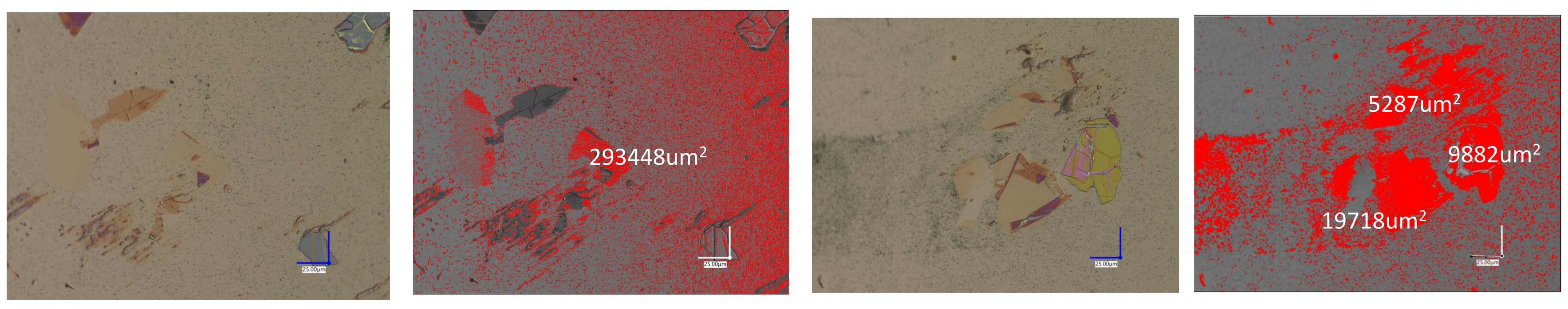
Annealing the hBN/Si sample with 850°c 30min/120 min

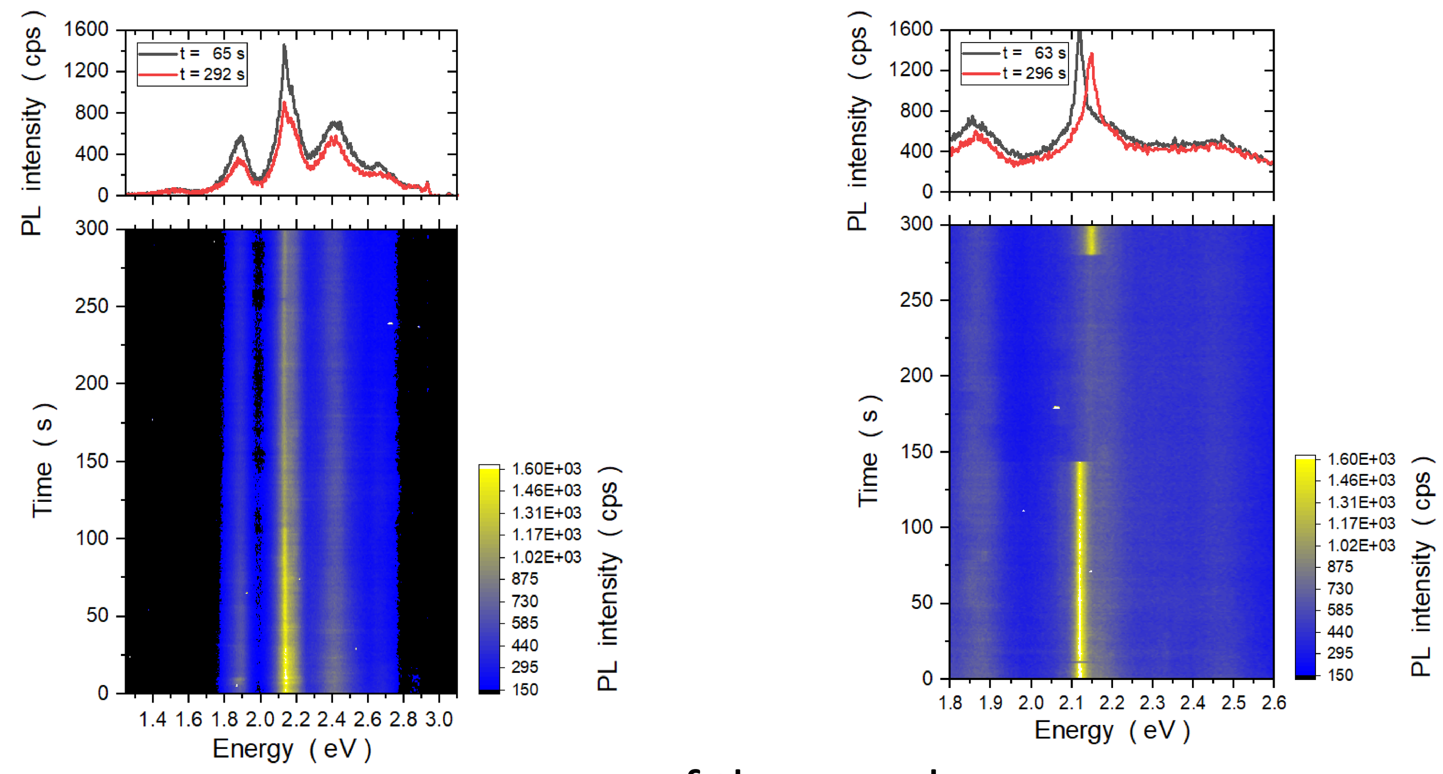


Using PL(Photoluminescence) on the hBN/Si sample. Make sure to observe the defect signal.

Result

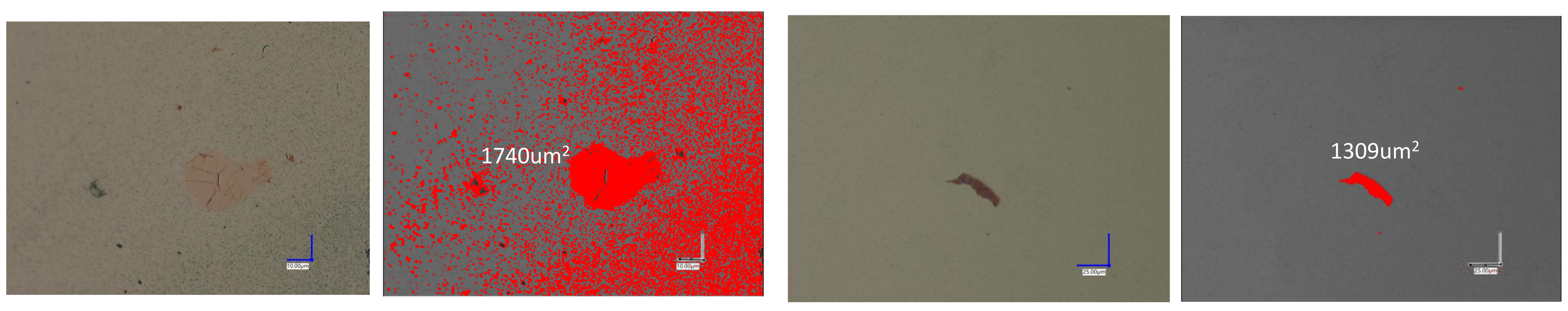
120min

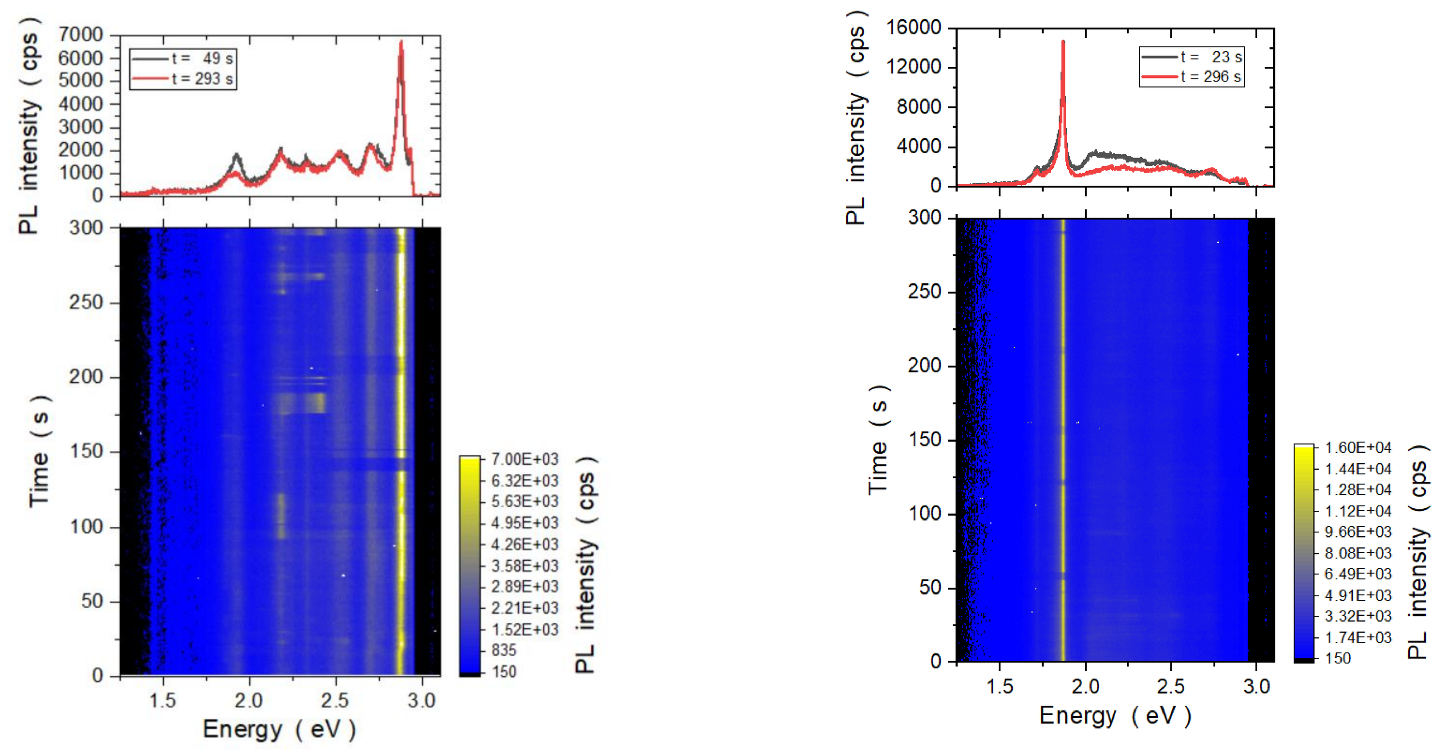




Upper left：Microscope image of the sample.
Upper right：Measured area of the selected region.
Bottom：PL spectra recorded from 0 s to 300 s (blue to yellow).
Top plot：Time-dependent PL peak shift.

30min





Conclusions

1.Quantum emitters were successfully observed in samples without a capping layer at short time.
2.The emitters show intense and narrow Zero-Phonon Lines (ZPLs), indicating high optical quality.

Future work

1. Optimize the emitter performance using different post-processing methods.

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