Wafer-Scale Deposition of Boron Nitride Thin Films *via* Low-Temperature PECVD Process

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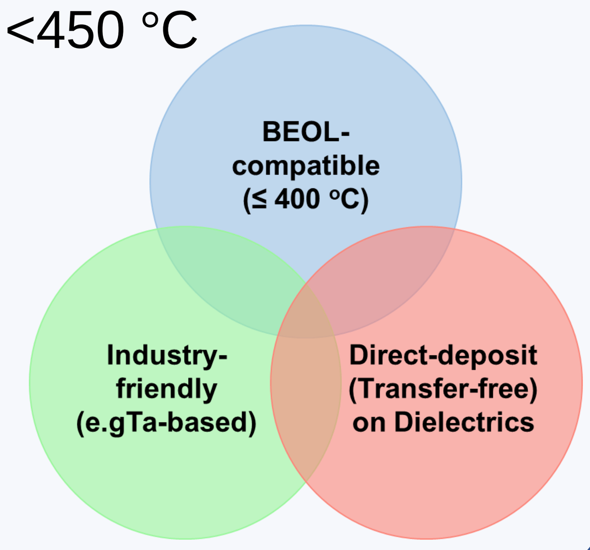
Introduction

- **2D materials** have drawn significant attention for thickness scaling due to the wide range of unique electrical properties at a few-atomic-layer thicknesses.
- **Boron Nitride (BN)** is particularly interesting as an insulator for integration in back-end-of-line (BEOL) circuitry in **CMOS technology**.
- However, the lack of **precise control over BEOL-compatible**, **large-scale film growth**, limits its practical realization.
- We demonstrate a new process that addresses these challenges, compatible with large-scale deposition and BEOL requirements.

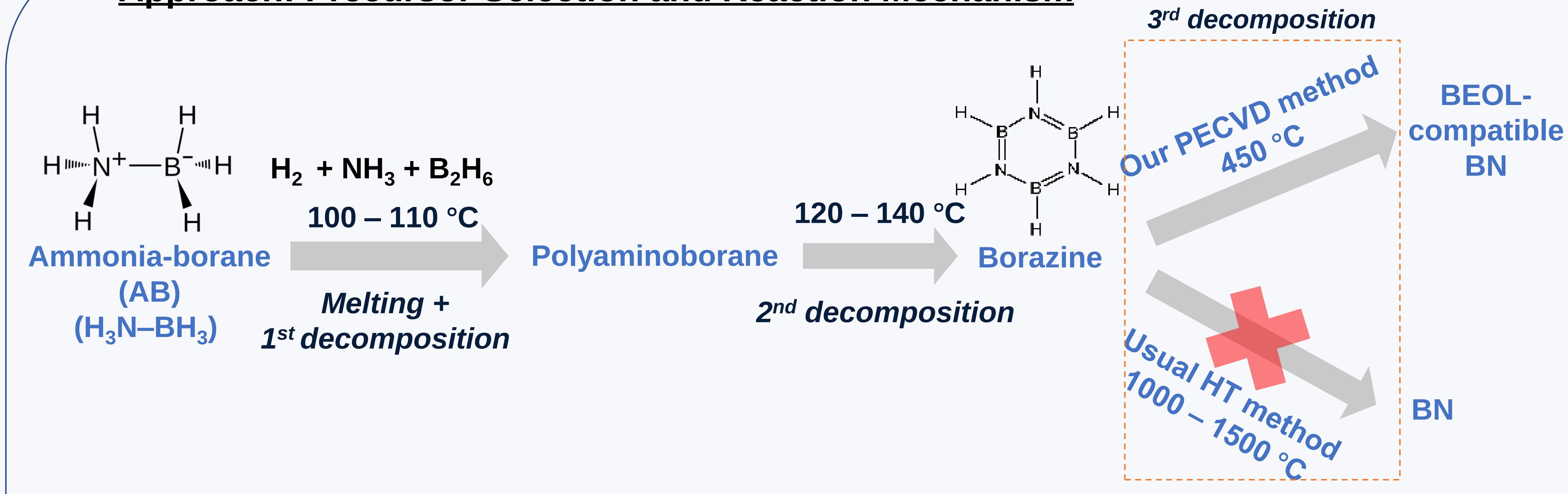
Requirements for BEOL integration:

- Low-temperature growth: <450 °C
- Controllable thickness
- Low defect density
- Conformal
- Halide-free
- Carbon-free



Experimental Methods

Approach: Precursor Selection and Reaction Mechanism

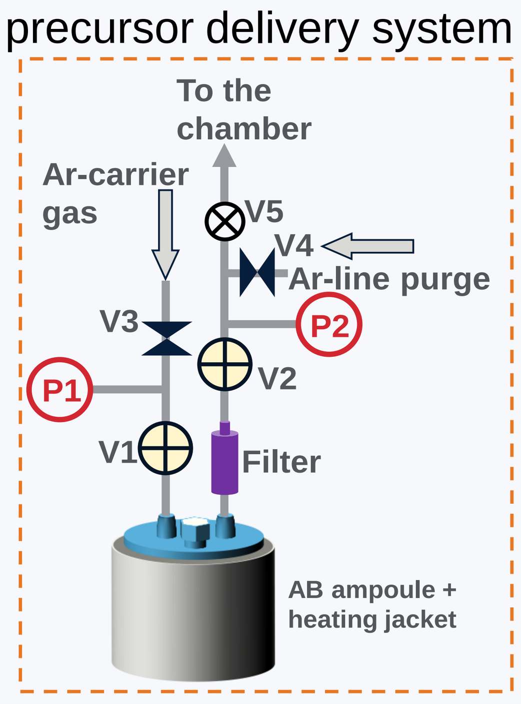


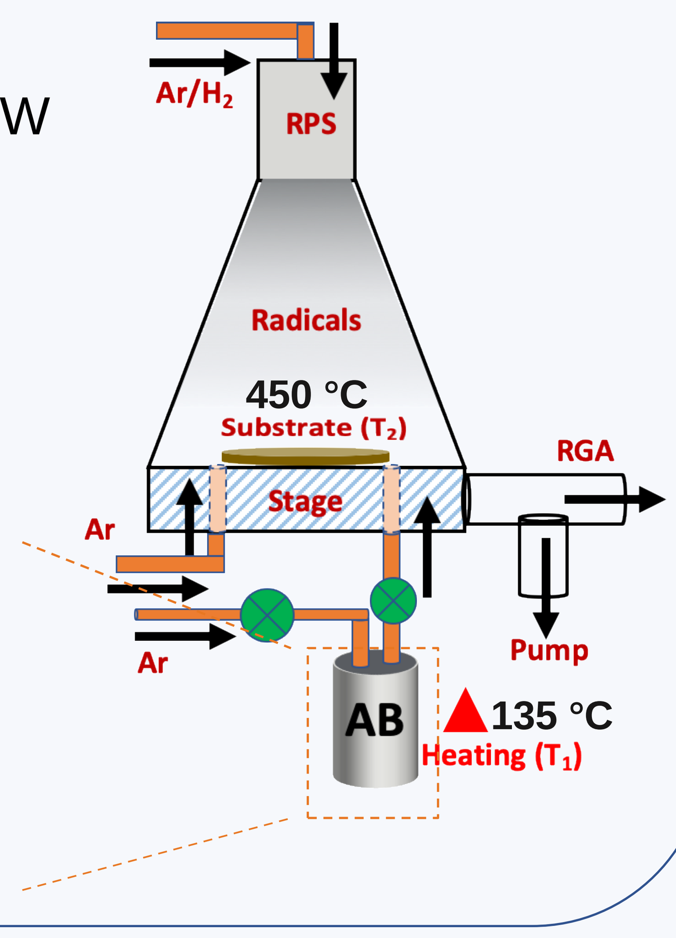
- High temperature required for the final step → **instead use low-temperature PECVD**
- Two decomposition steps of AB was monitored in real time by residual gas analysis (RGA)

PECVD Process and Tool Setup

- **ICP-CVD** process
- Plasma power 1000 W

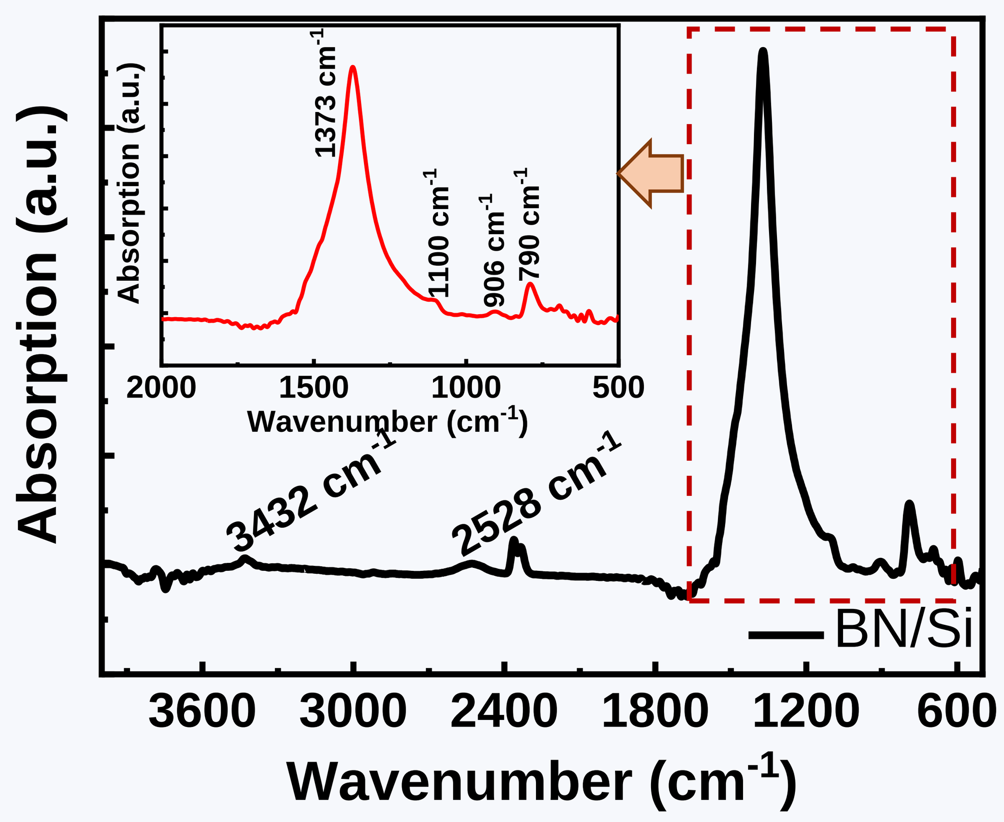
Customized precursor delivery system

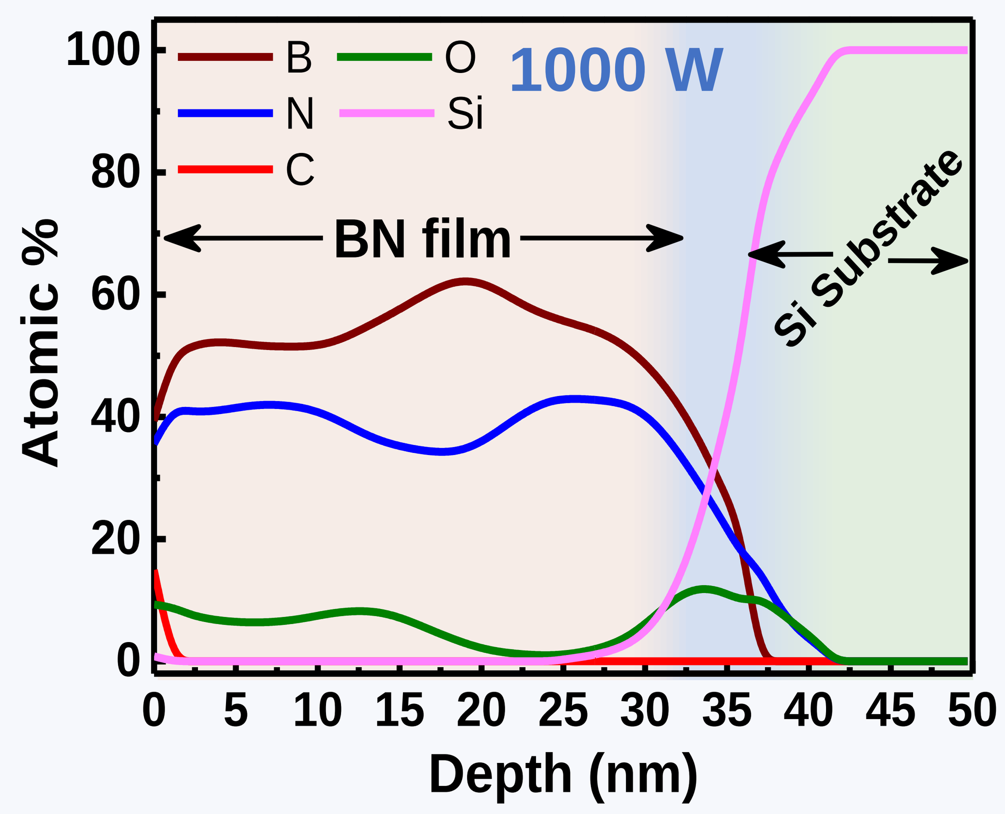




Film Deposition and Characterization

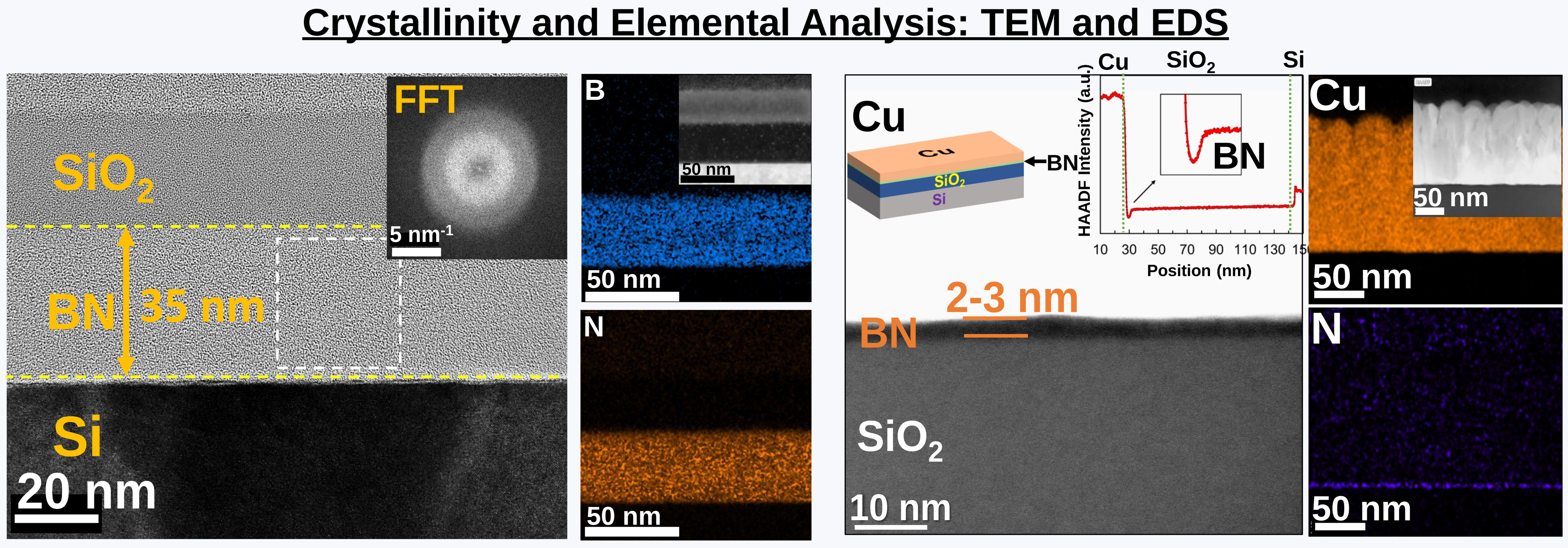
Chemical Analysis: FTIR and XPS study





- **Confirm film deposition** and presence of sp^2 B–N bond in with boron-rich film

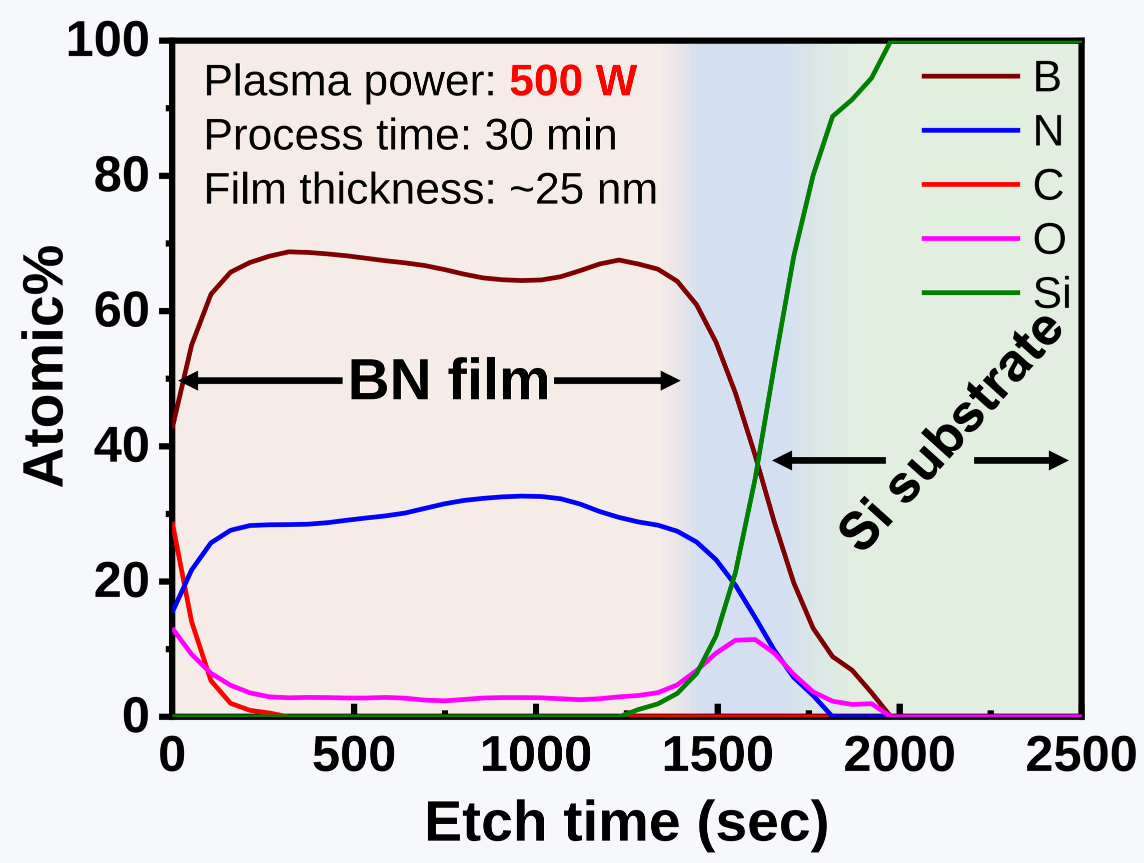
Crystallinity and Elemental Analysis: TEM and EDS



- Achieved a **controllable uniform film thickness** down to a few-nanometer thickness.
- Films **consist of B and N** from EDS analysis, however, they are **amorphous** in nature.

Future Work

- Film deposition with lower plasma power
- Using H_2/Ar plasma



- **Change in film stoichiometry** – evident from XPS depth profile
- Improvement of B:N ratio in the deposited film.
- Precise control over B:N stoichiometry using other N-contain plasma gasses, like NH_3, N_2/H_2, etc.
- Achieve thinner film with improved stoichiometry for diffusion barrier/liner application in BEOL circuitry.

Conclusions

- We have demonstrated **large-area film** deposition *via* **low-temperature** (BEOL-compatible) **PECVD** process with controllable thickness at the nanometer scale
- FTIR and XPS analyses revealed the presence of sp^2 B–N bond in the deposited film with slightly **B rich**.
- Films are **amorphous** and EDS confirms the uniform distribution of B and N in the film.

References

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