Optical Emission Spectroscopy Study of the Plume During Laser Ablation of Boron-Rich Target

John Rodman[1], Shurik Yatom[2], Yevgeny Raitses[2]

[1]Syracuse University, [2]Princeton Plasma Physics Laboratory

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY — Office of Science

Introduction

- Pulsed laser deposition is a method of physical vapor deposition (PVD) used to produce two-dimensional materials[1]
- BN is isoelectronic to C and can form similar allotropes[2]
- BNB is a precursor to formation of BN thin films[2]
- We study the physics and chemical kinetics of the ablation plume from B and BN targets in different gaseous environments with spatial and temporal resolution

Apparatus

- Pulsed Nd:YAG laser of wavelength 355 nm with pulse duration of ~7 ns and fluence of ~9 J/cm^2 the surface of the target
- Evaluation of species by optical emission spectroscopy (OES) , using Horiba IHR550 spectrometer and PI-MAX3 ICCD camera
- Delay generator with ICCD to take exposures at different points in the plume duration
- Dove prism rotates light from ablation plume in order to capture entire plume in single exposure
- BN in 400 Torr He and N_2; B in 400 Torr N_2

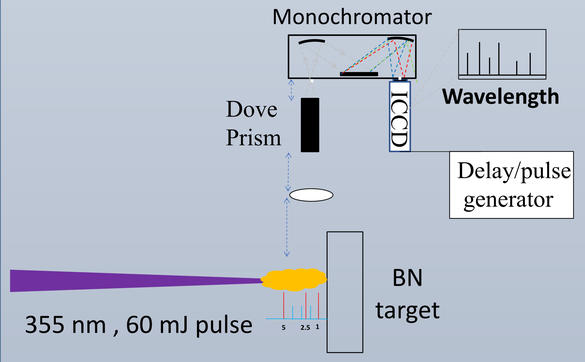


Figure 1. Diagram of ablation apparatus.

Results

Boron Target

- No BN or B_2N molecular spectra
- Molecular spectra all from N_2 systems (mainly 1st positive and 1st negative)
- Atomic lines all from Boron ablated from target
- N_2 not dissociated, only excited

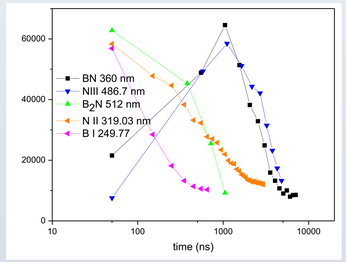
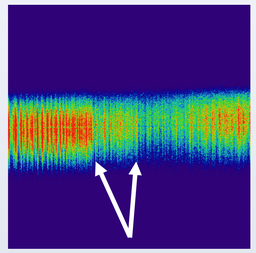


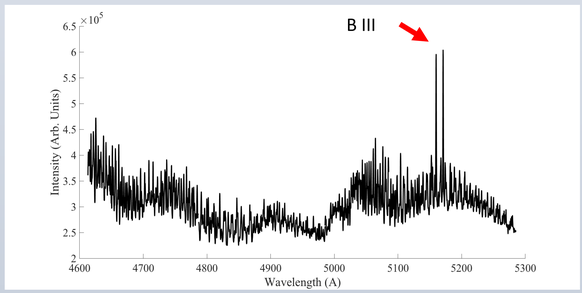
Figure 2. Temporal evolution of emission intensity of B, N, BN, and B_2N.



N_2 1st Positive Band heads (500.8 nm, 504.6 nm)

Figure 3. OES image of Boron in N_2 at 500 nm central wavelength.

Broadband Spectrum of B in N_2 at 1.2 µs



Broadband Spectrum of BN in He at 1.2 µs

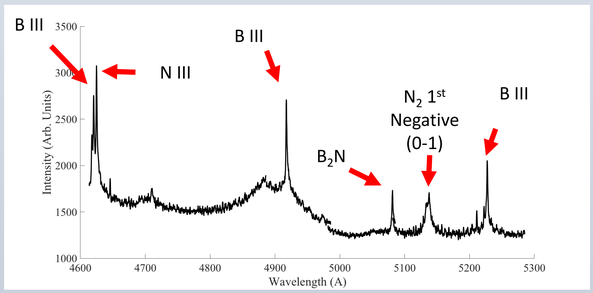


Figure 4. Broadband spectra of B in N_2 and BN in He. Both spectra are taken at 1.2 µs .Note the peaks in the Boron spectrum are all due to either Boron or N_2, while there are peaks for B, N, B_2N, and N_2 in the BN spectrum.

BN Target

- Detected BN and B_2N structure in the plume
- BN, B_2N, and N_2 molecular spectra all present
- Atomic N found only near target, likely ablated from target
- Molecular spectra appear further away from target; chemistry happens in the plume from species ablated from target

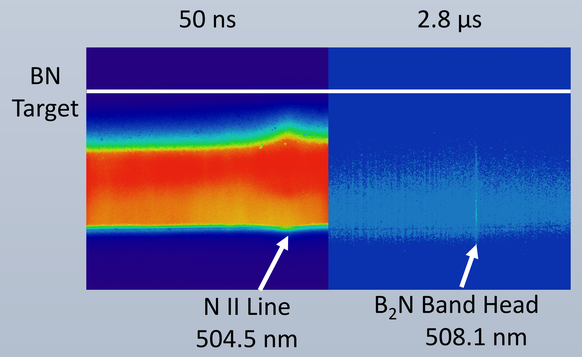


Figure 5. Comparison of images at 510 nm central wavelength of BN in He. Note the atomic line is closer to the BN target than the band head is.

CONCLUSIONS

- There was no dissociation of gaseous N_2 by the laser
- Atomic feedstock for molecular formation originates from the ablation site
- No BN or B_2N formed in the plume of the Boron target in N_2
- Both BN and B_2N formed in the plume of the BN target, regardless of whether the environment was He or N_2
- With BN, atomic species were found near the target, while molecular spectra were found several millimeters away

Future Work

- Further spatial and temporal study of BN target ablation
- Higher resolution OES imaging of BN spectra

References

[1] B. Angleraud , C. Girault, C. Champeaux, F. Garrelie, C. Germain, A. Catherinot, Applied Surface Science 117, 96 (1996).
[2] N. R. Glavin, C. Muratore, M. L. Jespersen, J. Hu, T. S. Fisher and A. A. Voevodin, J. Appl. Phys. 117, 165305 (2015).
[3] A. Lofthus, P. Krupenie. Journal of Physical and Chemical Reference Data 1977 6:1, 113-307
[4] H. Ding , M. D. Morse & J. P. Maier (2007) Vibronic analysis of the band system of BNB, Molecular Physics, 105:9, 1251-1261, DOI: 10.1080/00268970701338874

Acknowledgement

Measurements were supported by the US Department of Energy (DOE), Office of Science, Basic Energy Sciences, Materials Sciences and Engineering Division.