Angular and Spatial Dependence of Impedance of Hydrogenated Boron Carbide Films

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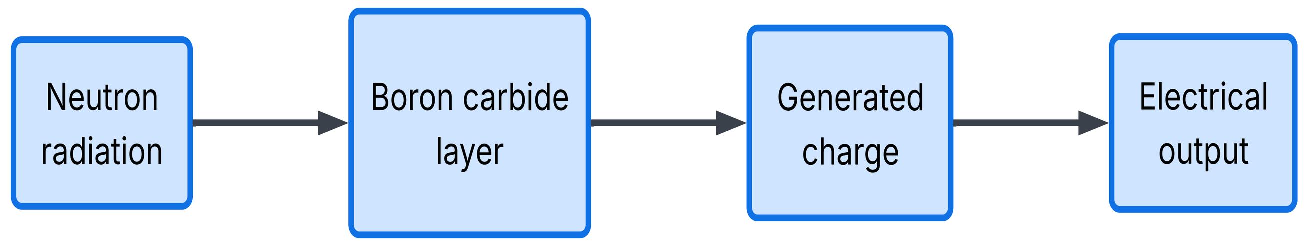
Motivation

- Semiconducting hydrogenated boron carbide
- Potential neutron-voltaic and neutron-detection applications
- Conversion of neutron radiation energy into electrical output
- Charge extraction controlled by carrier transport
- Previously observed directional and spatial conductivity variation



Research Question

Does the measured impedance of hydrogenated boron carbide thin films depend on probe orientation or measurement location?

- Compare impedance between different probe configurations
- Examine magnitude and phase as functions of frequency

Expected Behavior

- Resistive response: phase near 0
- Capacitive response: phase near $-\pi/2$
- Combined resistive and capacitive behavior in real samples
- Contributions from contact resistance, parasitic capacitance, sample geometry and probe quality

$$R_{contact} + (R_{sample} \parallel C_{sample})$$

→ **Simplified equivalent circuit representation**

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Experimental Setup and Measurement Method

Boron Carbide thin-film samples BC33 and BC34 were measured using a Keysight E4990A impedance analyzer and a probe station. Impedance magnitude was recorded over a frequency range of approximately 50 kHz – 10 MHz.

Procedure:

1. Open and short compensation
2. Tungsten-probe placement on selected Cr/Au contacts
3. Impedance-magnitude and phase measurement from 50 kHz to 10 MHz
4. Repetition across six probe configurations
5. Geometric correction for diagonal measurements

Configurations:

- 2-4
- 2-3
- 2-1
- 1-4
- 4-3
- 1-3

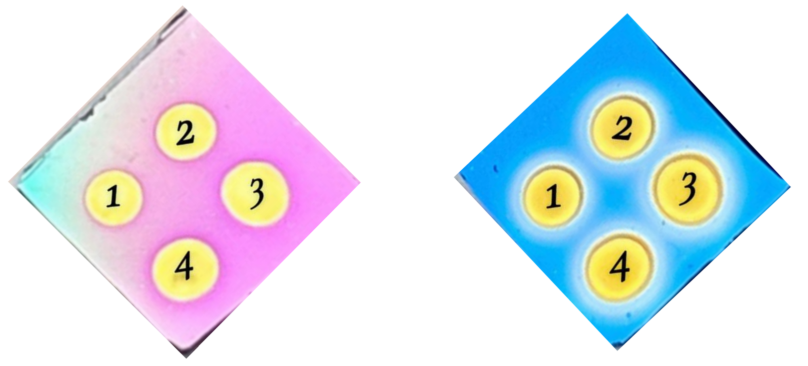


Figure 1. Cr/Au contact numbering and probe configurations.

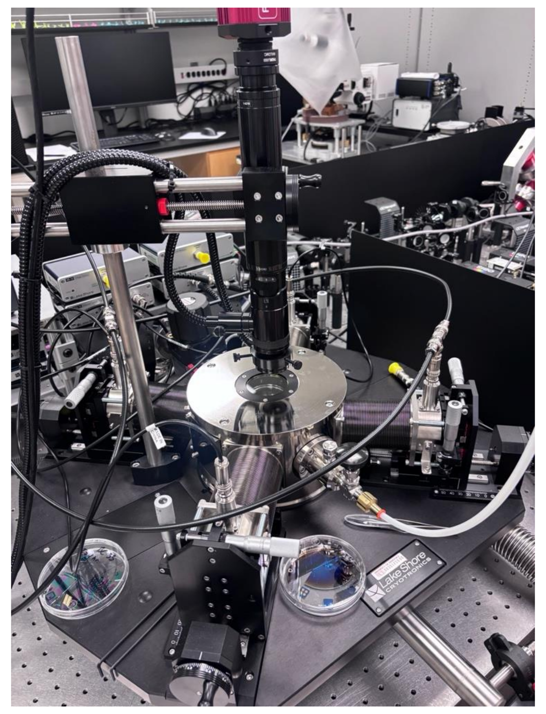
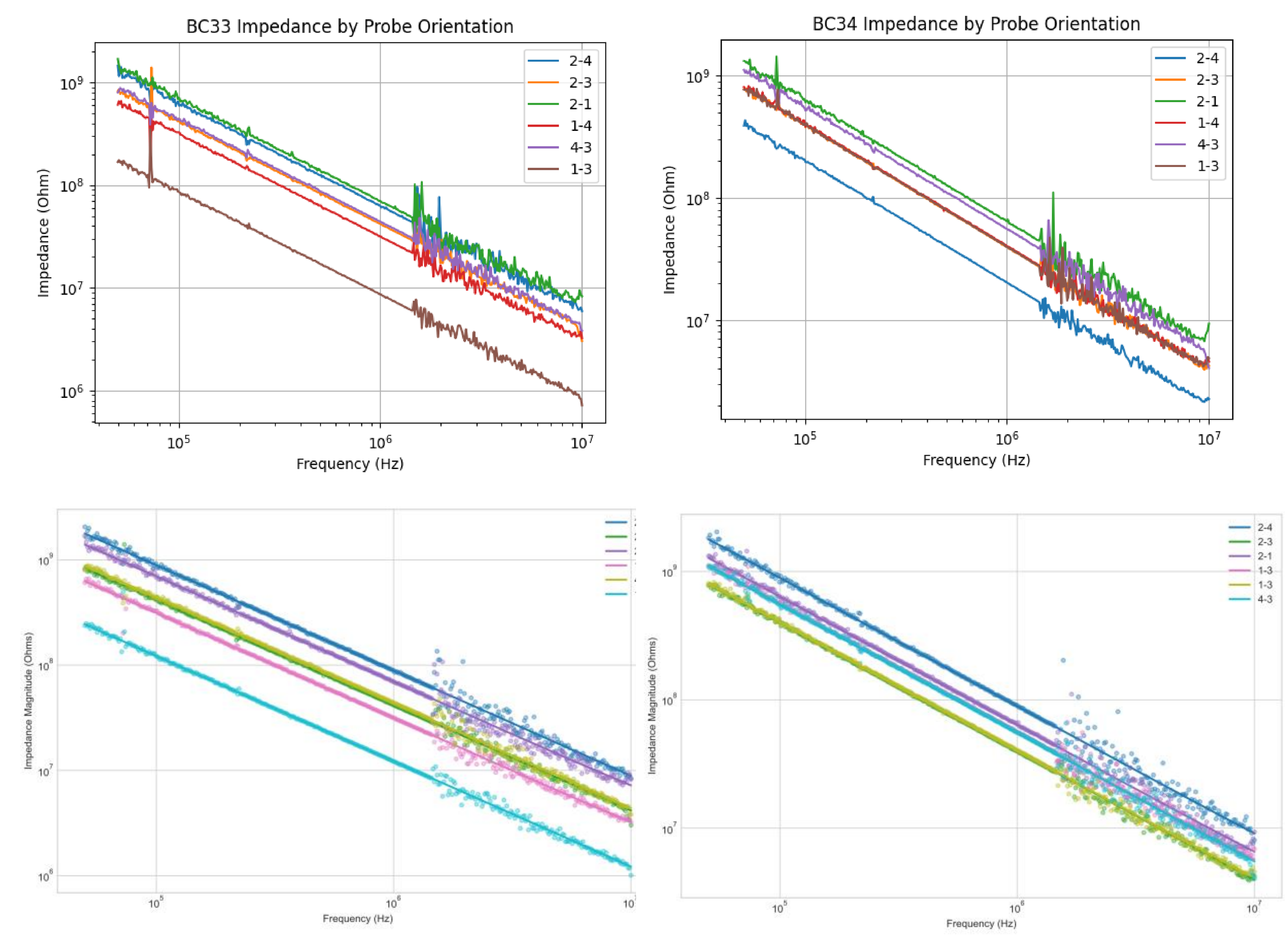


Figure 2. Probe-station setup used to contact the boron carbide films and measure impedance.

Results and Discussion

Measured Impedance and Corresponding Power-Law Fits



Key Findings

- Impedance decrease with increasing frequency
- Similar power-law exponents across configurations
- Configuration-dependent vertical offsets
- Different effective capacitances by orientation and location
- Increased scatter above approximately 1 MHz
- Strong capacitive contribution from oxidized tungsten tips

Power-law fits show similar frequency dependence across probe configurations, while vertical offsets indicate different effective capacitances. The results support orientation and spatial dependence in BC33 and BC34, although tungsten-tip oxidation likely contributes to the measured capacitive response.