Low-frequency noise in Au/*h*-BN/Au cross-bars

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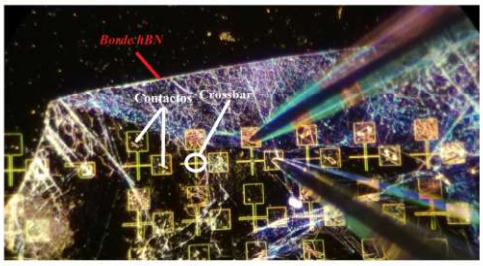
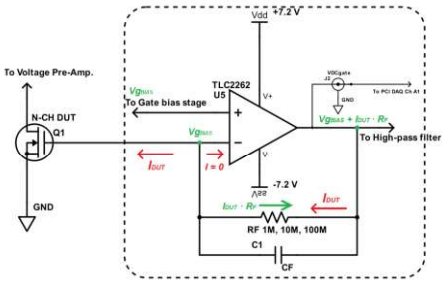
Motivation

- **Hexagonal boron nitride (*h*-BN) is an attractive candidate as insulator for 2D materials based nano-electronics due to its excellent electrical, thermal, optical and mechanical properties.[1]**
- **Thanks to resistive switching behavior present in chemical vapor deposited (CVD) *h*-BN sheets, the fabrication of synapses in the form of cross-bar devices potentially enables the large scale integration of neuromorphic circuits based on 2D materials. [2]**
- **Low frequency noise current is widely accepted as a defect-related mechanism in thin films and appears as both a threat and an opportunity in cross-bar applications [3], hence its analysis is of utmost importance at both the materials and device levels.**

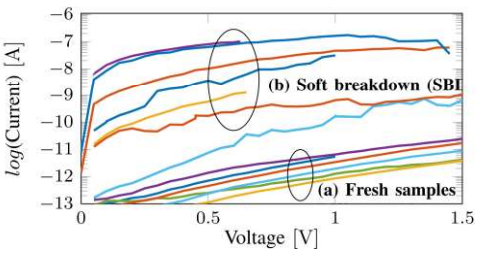
Experimental

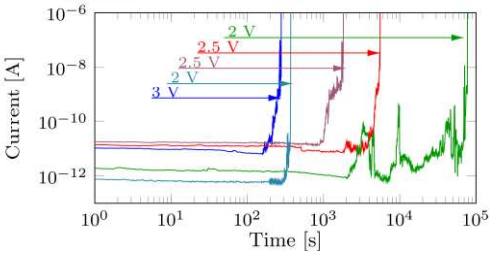


- 5 μm x 5 μm Au/multilayer *h*-BN/Au cross bar devices, courtesy of LanzaLab.
- *h*-BN films deposited via CVD between conformed electrodes (see wrinkles and boundaries)[4].
- DC measurements performed with SMU. Low frequency noise measured using a calibrated, custom, low-noise transimpedance amplifier (TIA) @ 10^8 V/A, 100 Hz BW.

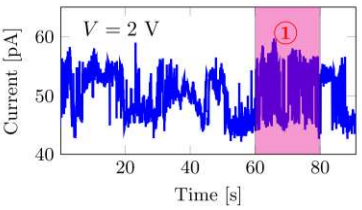


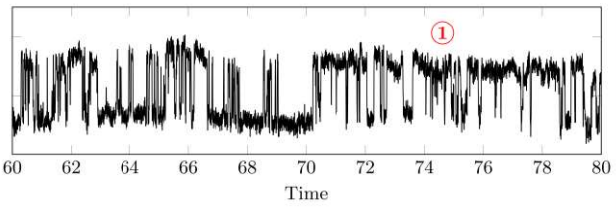
Measurement Results

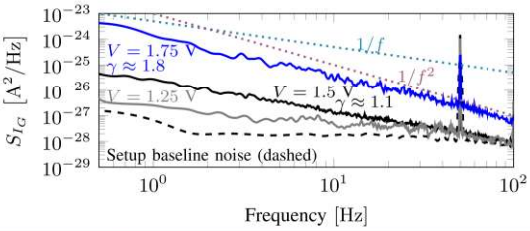


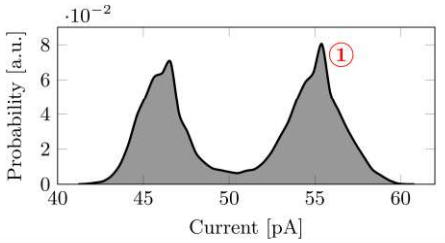


- I-V and I-t measurements show good agreement with the literature for similar devices, showing different conduction levels and a progressive current increase under constant voltage stress.
- Pristine (fresh) devices showed $1/f$ (*flicker*) noise at voltages up to 1.75 V.
- Random telegraph noise (RTN) appeared in the range 1.75V∼2V with clear two-level sections in acquisitions as long as 5 minutes. Similar to behavior in CAFM experiments.[5]

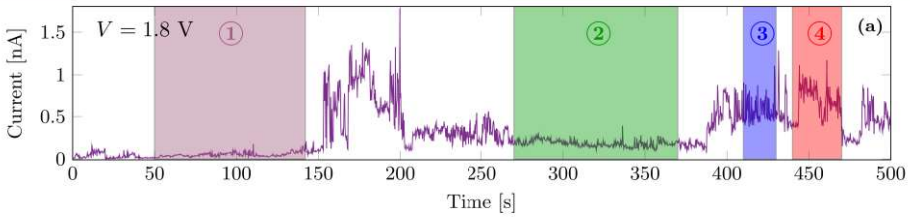


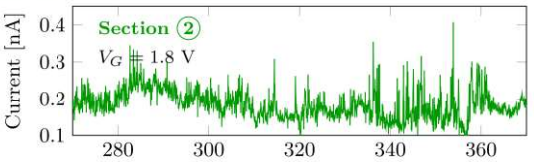


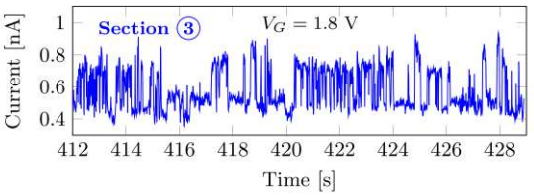




RTN vs. flicker noise competition under soft breakdown (SBD)







- Under SBD, current is highly unstable at constant voltage (volatile switching regime).
- Different sections show competition between $1/f$ and RTN behavior. This can be linked to the presence of point-defects near the main conduction path.
- Results are important for the application of cross-bars in complex circuits, such as neural networks, physically unclonable functions or random number generators.

Conclusions

- At low currents (< 1 μA), noise in Au/*h*-BN/Au cross-bars can be ascribed to the presence of (most likely) boron vacancies diffusing across the insulator.
- In pristine devices, RTN-like signals are present in the 1.75V∼2V range, while noise is mostly *flicker* at lower voltages.
- Migration of boron vacancies in the vicinity of stress induced conduction paths through the dielectric result in the competition of *flicker* vs. RTN noise under constant voltage.

References

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