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Modeling the dynamics of self-assembled network in Ag-hBN platform

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DAAD

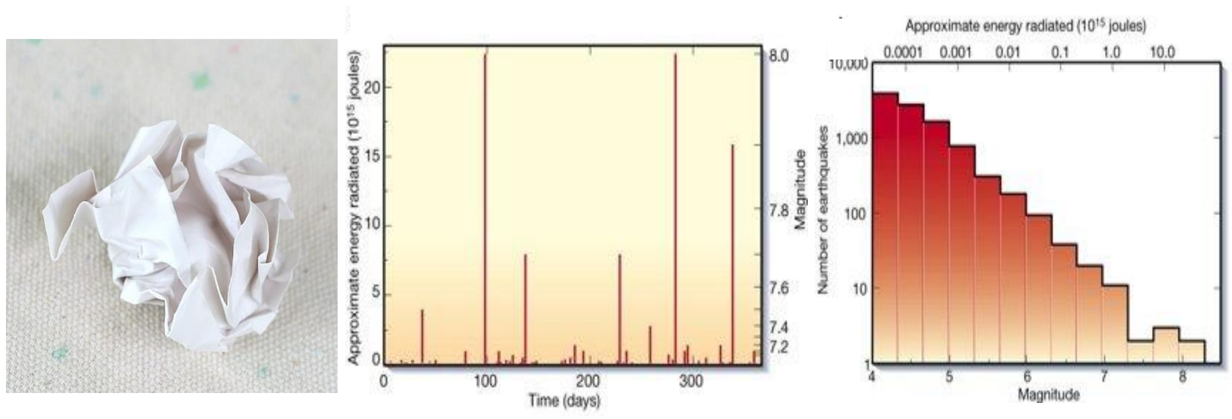
Introduction

Human Brain

- ❑ Parallel processing
- ❑ Natural Language processing
- ❑ Audio-visual recognition
- ❑ Efficient (~20W)

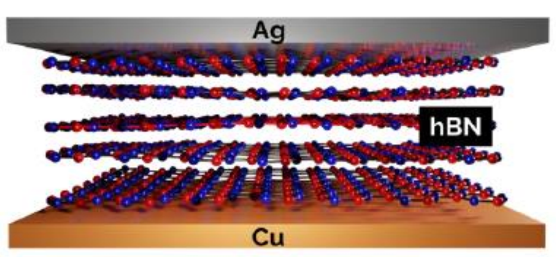
~ 10^{11} neurons
~ 10^{15} synapses

- Signals travel as avalanches in the brain.
- Information processing is optimum at criticality[1].



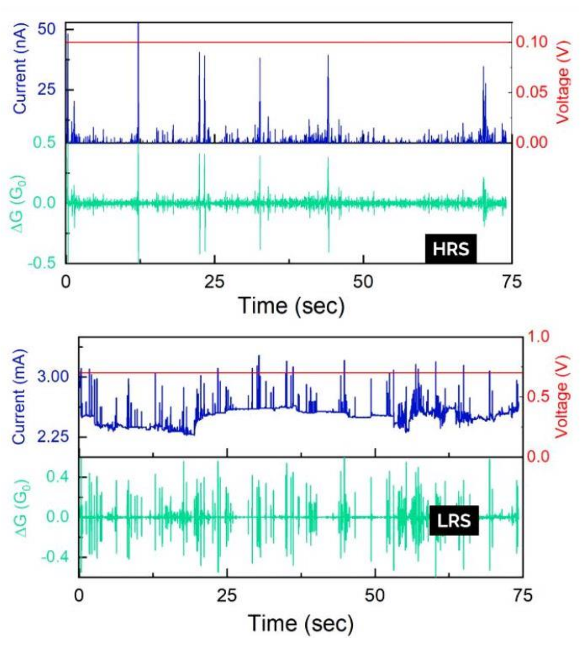
Crackling noise in Ag-hBN system

h-BN grown by CVD method

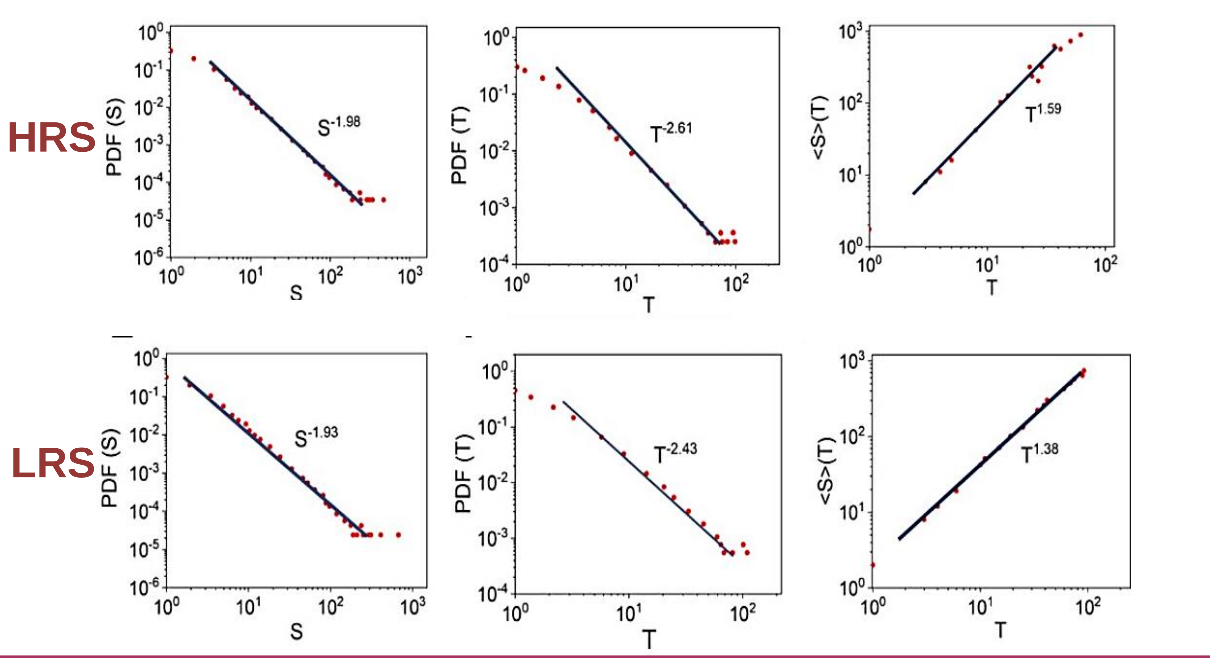


- Ag-hBN memristor is bistable.
- Device exhibits spatio-temporal avalanches at both HRS and LRS.
- The networks at both states crackles.

Stochastic spiking events

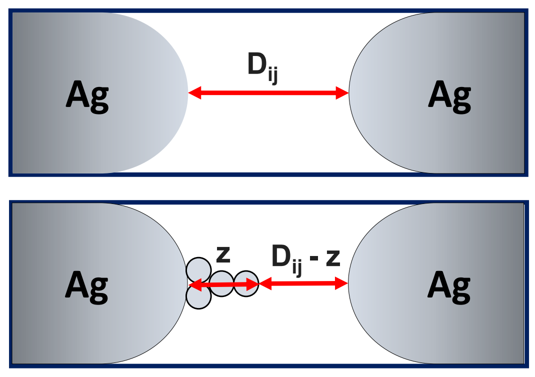


Distribution functions of avalanche size (S) & duration (T)



Physical model

A



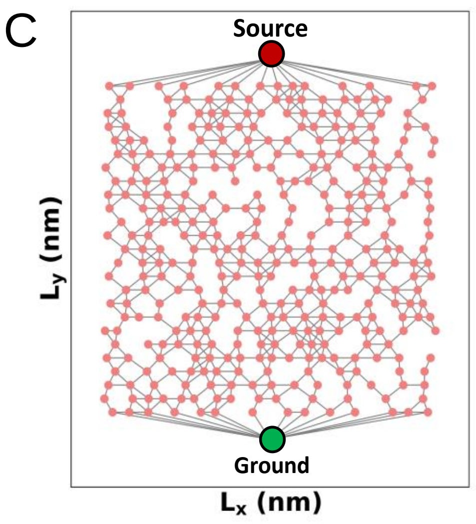
B

$$\frac{dz_{ij}}{dt} = \mu\frac{V_{ij}}{D_{eff} - z_{ij}} - \kappa z_{ij}$$

$$z'_{ij,t} = z'_{ij,t-1} - \frac{1}{RF},$$

if I_{cut}-I_{joule} < I_{ij} < I_{cut}

C



D

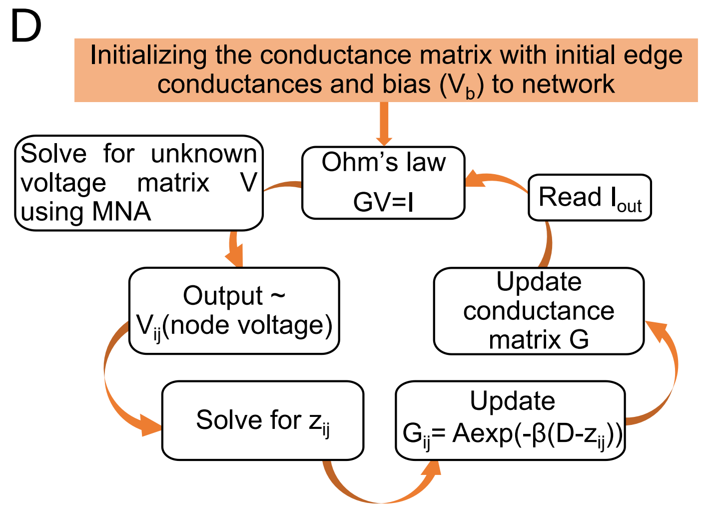
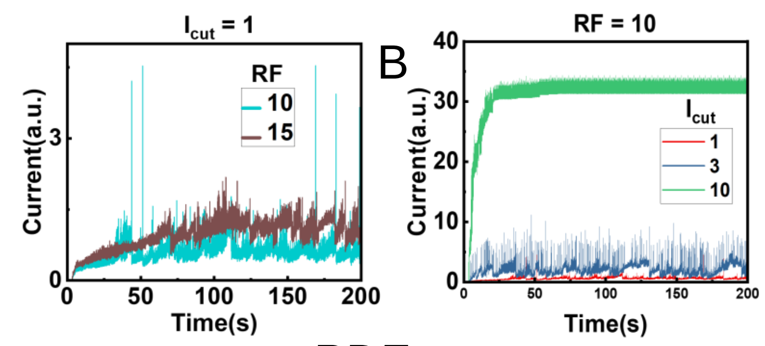


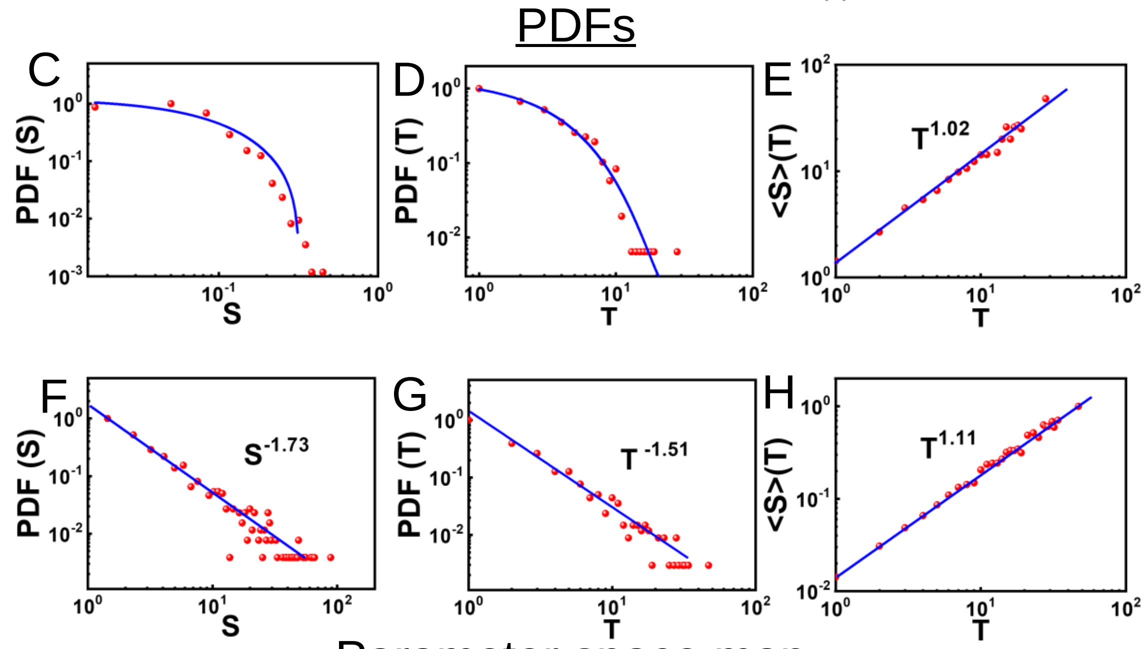
Fig: A) Schematic of edge filament growth, B) equation governing growth of filament, C) graphical representation of connected graph, and D) computational flowchart.

Results

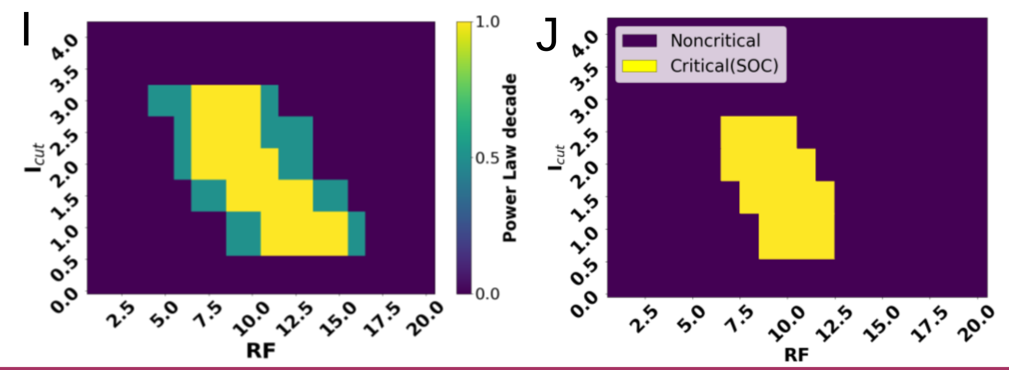
Current vs time recording



PDFs



Parameter space map



Conclusion

- The physical model emulated the experimental observations of crackling behavior.
- The model can be further scaled and implemented to develop in-material computing.

References:

1. A. Rao, S. Sanjay, V. Dey, M. Ahmadi, P. Yadav, A Venugopalrao, N. Bhat, B. Kooi, S. Raghavan, P. Nukala, Mater. Horiz., 10, 5235-5245 (2023).
2. J. B. Mallinson, S. Shirai, S. K. Acharya, S. K. Bose, E. Galli, and S. A. Brown, “Avalanches and criticality in self-organized nanoscale networks”, Sci. Adv.5, eaaw8438(2019)