Characterizing the conduction in thin films of 2D materials

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Carrier transport in a wide range of nanomaterial assemblies proceeds by percolation through discontinuous networks of constituents. Improving percolative nanomaterials could enhance transparent conductors, sensors, and electronic devices. A significant obstacle in optimizing percolative materials is the challenge in their characterization. The critical connection pathways which determine a percolative material's conductivity are not easily accessible with existing metrology tools and traditional investigation approaches rely on indirect methods based on many samples and on simplifying assumptions. We here demonstrate the direct extraction of characteristic parameters from a single sample by analyzing the strain-dependent resistance of percolative materials. An analytical model is derived that can explain experimental data for various percolative materials, morphologies, and straining conditions. The relationship of the extracted parameters with previously introduced figures of merit allows us to compare nanostructures of diverse dimensionalities and compositions for applications such as strain gauges and transparent conductors. We furthermore introduce a powerful and user-friendly network-graph based modeling approach that allows the computation of electrical conductivities for arbitrary element shapes and properties. Comparison between simulation and experiments shows good agreement in both percolative and bulk-conduction regimes for different element geometries. and highlights the importance of the junction resistance over other materials' parameters.

References

[1] H.Yao, M.Hempel, YP.Hsieh, J.Kong and M.Hofmann, Nanoscale, 2019,11, 1074-1079

Figures

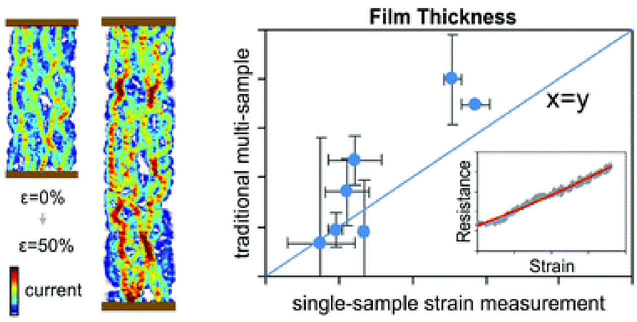

Figure 1: (left) Schematic of the strain-induced changes in percolative films, (right) Relationship between the normalized thickness obtained from strain measurements and multi-sample optical transmittance measurements.