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Programmability of Nanowire Networks

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Extended Abstract

Random networks of nanowires are of growing interest in the field of nanostructured electronic materials, notable examples include transparent conductors (De et al. (2009)), bio-sensors (Weizmann et al. (2011)), and artificial skin (Lipomi et al. (2011)). Networks circumvent challenges associated with placement of single wires and natural property variations that occur from wire to wire. Electrical connectivity in networks of nanoscale junctions must be better understood if these technologies are to be scaled up from single wires to functional material systems. In this work, we build upon our previous study on polymer-coated Ag nanowire networks (Nirmalraj et al. (2012)). We show that the natural connectivity behaviour found in random nanowire networks presents a new paradigm for creating multi-functional, programmable materials. In devices made from networks of Ni/NiO core/shell nanowires at different length scales, we discover the emergence of distinct behavioural regimes when networks are electrically stressed. We show that a small network, with few nanowire-nanowire junctions, acts as a unipolar resistive switch, demonstrating very high ON/OFF current ratios (> 10^5). However, large networks of nanowires distribute an applied bias across a large number of junctions, and thus respond not by switching but instead by evolving connectivity. This emergent property of a large network of resistive switches leads to a fault tolerant material whose resistance may be tuned, and which is capable of dynamically reconfiguring under stress. By combining these two behavioural regimes, we demonstrate that the same nanowire network may be programmed to act both as a metallic interconnect, and a resistive switch device with high ON/OFF ratio. These results enable the fabrication of programmable, multi-functional materials from random nanowire networks.

References

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