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Nonlinear current response to applied voltage in nanoscale devices and circuits

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The breakdown of Ohm's law exhibiting nonlinear response to applied voltage has been observed in graphene, silicon, and other semiconducting materials. The current response to external stimulus does follow Ohm's law below the critical voltage that depends on the length of the sample as well as material properties. However, the major departure from this Ohmic behavior arises when voltage applied is above the critical voltage that is proportional to the length of a sample. As length enters nanometer dimensions, the critical voltage can be as low as fraction of a volt. At this scale, many published works are debating whether or not the resistance or mobility has any meaning. We show that resistance becomes a strong function of applied dc voltage that rises dramatically under differential conditions for signal propagation. This rise in resistance is accompanied by the current saturation as voltage goes far beyond the critical voltage. We show that this saturation arises from stochastic velocity vectors being transformed to streamline unidirectional vectors. The focus is on extreme non-equilibrium distribution that is discussed extensively. The onset of quantum emission (photon or phonon) inhibits this saturation even further. The current response to applied voltage is discussed on two basic premises: transformation of 3D material to low-dimensional one in a quantum domain with length of the sample in any of the three Cartesian directions below the de Broglie wavelength resulting in low dimensionality; and the response to voltages that exceed the critical voltage. Contemporary applications to low-dimensional nanomaterials are discussed.

Biography

Vijay K. Arora completed Ph.D. in Physics from the University of Colorado. He has held distinguished appointments at the University of Tokyo, National University of Singapore, Nanyang Technological University, University of Western Australia, and Universiti Teknologi Malaysia. He is an IEEE-EDS distinguished lecturer and has been invited to give keynote papers internationally. He has published more than 100 papers in reputed journals and many uncounted publications in conference proceedings. He serves on the editorial board of a number of journals. He was chair of NanoSingapore2006, NanotechMalaysia2010, and EscienceNano2012 conferences.

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Graphene covalently functionalized with polymer for nonvolatile rewritable memory

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The data storage performance, stability and reliability of the graphene memories have advanced significantly towards practical information storage applications. A number of essential strategies can be employed to control and optimize the switching characteristics of graphene memories for practical information storage applications. In comparison to inorganic materials-based memory devices, polymer memories are proposed to revolutionize electrical applications by providing extremely inexpensive, lightweight, and transparent modules that can be fabricated onto plastic, glass, or the top layer of CMOS hybrid integration circuits. Covalent functionalization of graphene oxide (GO) or, reduced graphene oxide (RGO) with electroactive polymers is an effective and versatile approach to tuning the electronic properties of graphene. The facile engineering of GO/RGO energy bandgap through polymer functionalization also provides an alternative route to supplement the lithographical patterning of graphene sheets into low dimensional nanostructures and chemical modification of graphene nanoribbons. By using the "grafting to" or "grafting from" method, we have prepared a new series of soluble polymer-covalently grafted graphene oxide/reduced graphene oxide functioanl materials. Bistable electrical switching effects and non-volatile rewritable memory effects were observed in the ITO/graphene-based polymer/Al sandwiched devices, with small switch-on voltage of about -1~-2 V and the ON/OFF current ratio of more than 10^3. The non-volatile nature of the ON state and the ability to write, read and erase the electrical states fulfilled the functionality of a rewritable memory. Both the ON and OFF states were stable under a constant voltage stress for more than 10^4 s and survived up to 10^8 read cycles at a read voltage of -1.0 V.

Biography

Yu Chen is Full Professor at East China University of Science and Technology, Shanghai. He received his Ph.D. in Organic Chemistry at Fudan University in July 1996. Starting from February 2000, he took four-month-German language Course in Geothe-Institute at Schwaebisch Hall. He then joined Prof. Dr. Michael Hanack's group at the Institute of Organic Chemistry, University of Tuebingen, as Alexander von Humboldt Research Fellow. He has published more than 140 papers in the international peer-review journals such as *Chem. Soc. Rev., Angew. Chem. Int. Ed., J.Am. Chem. Soc., Adv. Mater., Adv. Funct. Mater.,* and others, and cited over 2300 times (self-citation is excluded).

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