Nanocarbon field emission devices and their applications

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The attractive material properties of carbon-derived materials, such as low electron affinity of diamond or the high aspect ratio of carbon nanotubes (CNT), coupled with practical chemical vapor deposition (CVD) processing of deposited nanocrystalline diamond and CNT on a variety of substrates prompts interest in their use as cold cathodes. In this work, various configurations of nanocarbon-derived vacuum electronic devices are examined. The material properties, device structure and fabrication process, and the electrical performance of these devices are presented.

Nanocarbon-derived vacuum field emission devices, specifically, nitrogen-incorporated nanodiamond field emission triodes, transistors and integrated CNT amplifiers are new configurations for robust micro- and nanoelectronic devices. These novel micro/nanostructures provide an alternative and efficient means of accomplishing electronics that are impervious to temperature and radiation. For example, nitrogen-incorporated nanocrystalline diamond has been lithographically micropatterned to utilize the material as an electron field emitter. Arrays of laterally arranged nanodiamond emitters constitute the cathode in a versatile diode configuration with small interelectrode separation. Sub-micron emission gap lateral field emission diodes derived from nanocarbon, specifically nanodiamond, provide an alternative means of accomplishing electronics that operate at very low power. Electron beam lithography (EBL) approach for realizing the nano gap structure of the CVD diamond lateral diode is presented. In three-terminal configuration, we have realized distinct triode and transistor devices. Also, field emission integrated amplifiers based on self-align gated CNT arrays with low turn-on voltage and negligible gate leakage current and high performance differential amplifier characteristics have been achieved. The ruggedness of these devices has been demonstrated by their operation at high temperatures (400°C) and radiation hardness to > 20Mrad(SiO_2) and total fluence of 4.4×10^{13} neutrons/cm^2. The frontier research in nanocarbon-derived field emission micro- and nanoelectronic devices will be discussed.