Solid-state fabrication of ultrathin carbon nanotube – graphene hybrid cathodes for electron field emission

H. H. Van and M. Zhang
High-Performance Materials Institute, Florida State University
Department of Industrial and Manufacturing Engineering, FAMU-FSU College of Engineering, 2005 Levy Avenue, Tallahassee, FL 32310
vhh10@my.fsu.edu

Carbon nanotubes (CNTs) and graphene have been proved to be the outstanding emitters for electron field emission (FE) because these materials exhibit superior high aspect ratio and excellent physical properties such as high electrical conductivity, high thermal conductivity, and high mechanical strength. It is known that the structure of the emitters plays an important role in FE efficiency. For achieving high FE performance, we developed a solid-state methodology to fabricate the ultrathin CNT – graphene nanoribbon (GNR) hybrid emitter arrays. We used a laser beam to irradiate a freestanding 200 nm-thick CNT films, in which the alignment and the orientation of the CNTs were well-controlled. By controlling the laser beam energy and the scanning speed, we were able to create emitters, which comprised of both CNTs and GNRs. The GNRs were formed from the partially unzipped CNTs due to the thermal interaction between the CNTs and the laser beam. The hybrid emitters were distributed uniformly along the millimeter-long and nanoscale-thick array. Because the thickness of the arrays was much smaller than their length, the hybrid emitter arrays could be considered as one–dimensional arrays. For that reason, they functioned as line electron sources and generated flat electron beams. When they were used as the cathodes in FE devices, the screening effect was effectively reduced. As a result, the performance of the FE devices was significantly improved. The threshold field (at which the emission current density reached 1 mA/cm^2) was noted at 1.15 V/µm. The current density of 57 A/cm^2 was achieved at 2.5 V/µm. The detail fabrication process and the performance of the FE devices will be presented.