Fabrication of high-performance carbon nanotube field emitter using Thermal Chemical Vapor Deposition

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Carbon nanotubes(CNTs) have many application points, which are field emission devices, composites, hydrogen storage, nanodevices, supercapacitor and secondary battery. The most promising application point is emitter tip arrays of field emission devices. Furthermore, it may be also useful as a vacuum device for high frequency and high power. But, there are some obstacles to fabricate carbon nanotube field emission device. One is that CNTs grown by CVD method has weak adhesion with substrate and the other is non-uniform length of them. These problems are very crucial in aging property and reliability of device in the field emission.

Here we report a CNTs fabricated diode type field emitter using conventional well-developed semiconductor processes were fully used, such as photolithography, etching, lift-off, and chemical-mechanical planarization processes. The catalytic Fe metal layer was deposited on the bottom of trenches by lift-off process. The CNTs were grown at 900oC in NH3/C2H2 mixture gases flow for 10min by thermal chemical vapor deposition. After the CNTs are synthesized in trenches, the adhesion of the CNTs on Si is improved by coating with silicon-on-glass (SOG). The SOG coated CNTs are planarized by mechanical polishing to trim the over-grown CNTs in the trench and the length of CNTs is aligned uniformly. SOG is removed by HF etching process for protruding CNTs. After these processes, emission properties and images are studied in diode type field emitter.

The measured emission property of the diode structured carbon nanotube emitters showed remarkably enhanced performance. Current density was 40mA/cm^2 at 4.5 V/μm. Aging property is very stable. In the F-N plot, field enhancement factor is also calculated at the value of ~ 10^5 cm^{-1}. These efficient properties can be originated from uniform length and good adhesion of CNTs on the Si substrate through mentioned process.

Keywords : Carbon nanotube(CNTs); Emission; FED