Carbon Nanotube Emitters Grown by Low-Temperature CVD for FED Application

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Carbon nanotube-based field emission displays (CNT-FEDs) have been considered as a wining technology for large area (above 40”-60” diagonal) flat panel displays. In present CNT-FED prototypes, CNTs are mainly deposited onto the cathodes by using the screen-printing technique. However, owing to the difficulty in handling the thick film pastes, emission uniformity is always a key problem with the technology. In this work, we report on the selective growth of CNT-based emitters by using microwave-heating chemical vapor deposition (MH-CVD) over patterned Ni layers on Si substrates. The process provides a good control over emission uniformity and is also compatible with the well-developed silicon IC technology.

Shadow masks as well as conventional photolithography and lift-off patterning technique were employed to produce various arrays of Ni square blocks with side lengths of 1-88 μm at pitch distances of 3-40 μm on p-type Si substrates. The Ni blocks are either freestanding or isolated by 0.8-μm-thick SiO_2. For all growths, only methane (CH_4) gas with 200 sccm flow rate was admitted to the deposition chamber and the chamber pressure was maintained at 1 atm. The field-emission behavior of the emitters was characterized by a diode setup.

Figure 1 shows the SEM image of the CNT emitter grown on freestanding Ni square blocks with side length of 2 μm at a pitch distance of 5 μm. Uniform growth of CNTs is clearly seen from the image; moreover, there is no amorphous carbon (a-c) deposited on areas where the Ni catalyst is absent. Figure 2 shows the emission current density vs. applied filed (J-E) curves obtained from CNT emitters grown on freestanding Ni square blocks with side lengths of 2 μm and 1 μm. Figure 3 shows the J-E plots of the CNT emitter grown on SiO_2-isolated Ni blocks of 2 μm by 2 μm upon three consecutive voltage scans.

The CNT emitters grown on SiO_2-isolated Ni square blocks of 2 μm by 2 μm has exhibited an emission behavior as excellent as the un-patterned CNT film [1]. Both emitters demonstrate very low turn-on and threshold fields being respectively at ~0.1 V/μm and ~1.50 V/μm, and can emit current density exceeding 120 mA/cm^2. Our results show that the present microwave-heated CVD process is suitable for the growth of high-quality CNTs emitters for application to the FED technologies.

References:

1. J. H. Huang. C. C. Chuang, C. H. Tsai, and W. J. Chen, *15th Int. Vac. Microelectron. Conf. & 48th Int. Field Emission Symp.*, July 7-11, 2002, Leon, France.

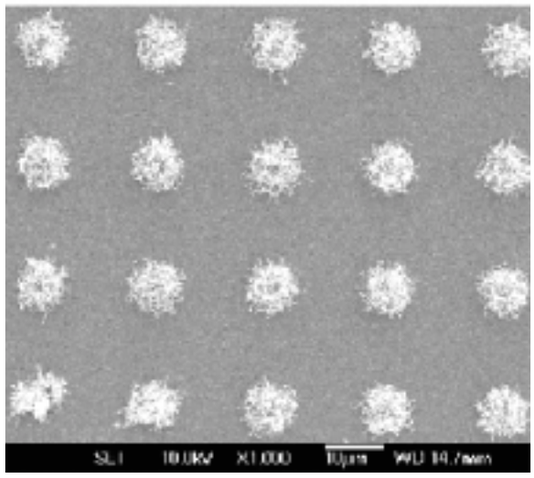

Fig. 1. SEM image of carbon nanotubes emitter grown on freestanding Ni blocks with side lengths of 2 μm by 2 μm at a pitch distance of 5 μm.

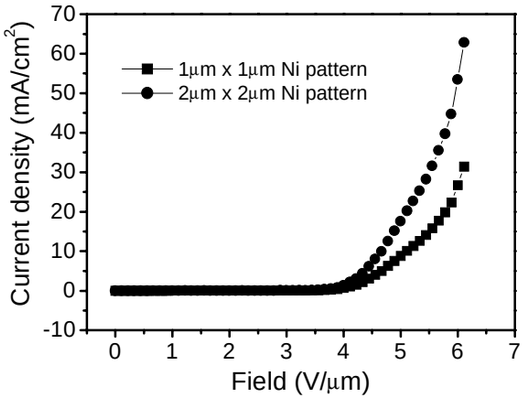

Fig. 2. J-E plots obtained from CNT emitters that were grown on freestanding Ni blocks with side lengths of 2 μm by 2 μm and 1 μm by 1 μm.

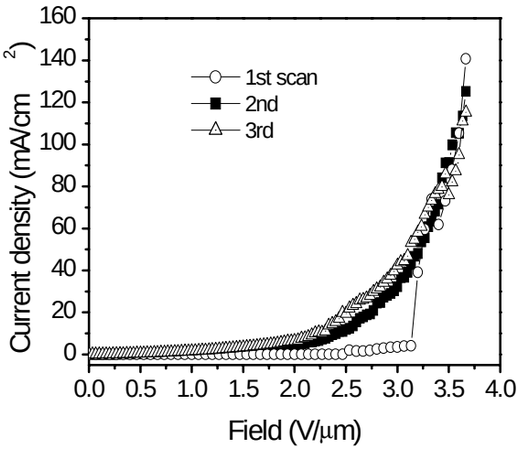

Fig. 3. J-E plots of the CNT emitter grown on SiO_2-isolated Ni blocks with side lengths of 2 μm by 2 μm upon three consecutive scans.