TS07 P21TS07_0762

Improved Field Emission Performance of CNT Paste Emitters with Their Cohesion and Adhesion Enhanced by Metal Silicide Reaction

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Carbon nanotubes (CNTs) have drawn much attention as one of the ideal materials for field emitters due to their unique properties such as sharp tip geometry and large aspect ratios, excellent mechanical strength, superior chemical stability and high melting point. Their outstanding field emission performance and commercial mass production have led CNTs to be most promising for various industrial potential applications including x-ray tubes, flat lamps, flat electron sources, electron microscopes, field emission displays, etc. Among several approaches for fabrication of CNT field emitters, a screen-printing technology is most preferred due to scalability, low cost and design flexibility of field emitters. In this work, we investigate optimal design of CNT pastes for best field emission performance and, for this purpose, fabricate CNT pastes based on a Ni-Si-Al_2O_3 filler system. Performance of screen-printed CNT emitters greatly is affected by adhesion and cohesion strength of the pastes because large electrostatic forces are generated on them during operation of field emitters. If the pastes have low adhesion and cohesion strengths, CNT emitters may be pulled out, causing catastrophic electric arc. To improve cohesion and adhesion strength, screen printed CNT emitters were annealed at 865 °C in a high vacuum condition. At high temperature, Si nanoparticles formed strong covalent bonds with Ni nanoparticles to enhance cohesion strength of the CNT paste. In addition, Si nanoparticle chemically reacted with Fe in the Kovar (Ni29Co17 ferrous alloy) substrate, forming strong covalent bonds and improving the adhesion strength. In this work, we fabricate high-performance CNT paste emitters having a capability of generating high current density of 14 Acm^{-2} in a diode configuration.