World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:10, No:01, 2016

Highly Conducting Ultra Nanocrystalline Diamond Nanowires Decorated ZnO Nanorods for Long Life Electronic Display and Photo-Detectors Applications

Authors : A. Saravanan, B. R. Huang, C. J. Yeh, K. C. Leou, I. N. Lin

Abstract : A new class of ultra-nano diamond-graphite nano-hybrid (DGH) composite materials containing nano-sized diamond needles was developed at low temperature process. Such kind of diamond- graphite nano-hybrid composite nanowires exhibit high electrical conductivity and excellent electron field emission (EFE) properties. Few earlier reports mention that addition of N2 gas to the growth plasma requires high growth temperature (800°C) to trigger the dopants to generate the conductivity in the films. High growth temperature is not familiar with the Si-based device fabrications. We have used a novel process such as bias-enhanced-grown (beg) MPECVD process to grow diamond films at low substrate temperature (450°C). We observed that the beg-N/UNCD films thus obtained possess high conductivity of σ=987 S/cm, ever reported for diamond films with excellent Electron field emission (EFE) properties. TEM investigation indicated that these films contain needle-like diamond grains about 5 nm in diameter and hundreds of nanometers in length. Each of the grains was encased in graphitic layers about tens of nanometers in thickness. These materials properties suitable for more specific applications, such as high conductivity for electron field emitters, high robustness for microplasma cathodes and high electrochemical activity for electro-chemical sensing. Subsequently, other hand, the highly conducting DGH films were coated on vertically aligned ZnO nanorods, there is no prior nucleation or seeding process needed due to the use of BEG method. Such a composite structure provides significant enhancement in the field emission characteristics of the cold cathode was observed with ultralow turn on voltage 1.78 V/μm with high EFE current density of 3.68 mA/ cm2 (at 4.06V/μm) due to decoration of DGH material on ZnO nanorods. The DGH/ZNRs based device get stable emission for longer duration of 562min than bare ZNRs (104min) without any current degradation because the diamond coating protects the ZNRs from ion bombardment when they are used as the cathode for microplasma devices. The potential application of these materials is demonstrated by the plasma illumination measurements that ignited the plasma at the minimum voltage by 290 V. The photoresponse (Iphoto/Idark) behavior of the DGH/ZNRs based photodetectors exhibits a much higher photoresponse (1202) than bare ZNRs (229). During the process the electron transport is easy from ZNRs to DGH through graphitic layers, the EFE properties of these materials comparable to other primarily used field emitters like carbon nanotubes, graphene. The DGH/ZNRs composite also providing a possibility of their use in flat panel, microplasma and vacuum microelectronic devices.

Keywords : bias-enhanced nucleation and growth, ZnO nanorods, electrical conductivity, electron field emission, photo-detectors
Conference Title : ICDCMT 2016 : International Conference on Diamond, Carbon Materials and Technology
Conference Location : Zurich, Switzerland
Conference Dates : January 12-13, 2016