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Hybrid Nanostructures Based on Aligned Carbon Nanotubes and Aluminium Nitride Thin Films as Thermal Interface Materials

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Carbon nanotubes (CNTs) possess unique thermal properties. With a thermal conductivity value of ~3000W/m.K or above, CNTs can be exploited for use as thermal interface materials (TIMs) to address thermal management issue in microelectronics. The key issues to be addressed while developing this technology are; low synthesis temperatures, minimum or no contamination of CNTs due to metal nanoparticle used to catalyze CNT growth, and very good contact with target surface for efficient thermal transport. In this work, well-dispersed cobalt or nickel nanoparticles with an average size of < 5nm and narrow size distribution were obtained onto TiN-coated silicon substrates using electrochemical deposition technique through optimization of precursor solution chemistry and electrochemical reduction conditions. Using electron-cyclotron-resonance, plasma-enhanced chemical vapor deposition (ECR-PECVD) process, aligned CNT arrays of single-, double-, or few-walled CNTs were produced in C_2H_2:NH_3 gas mixtures at 600^{o}C or below. In order to achieve good contact with target surface and efficient thermal transport, the vertically aligned CNT arrays were embedded in AlN thin films via high power impulse magnetron sputtering (HiPIMS) technique which offers advantages of better film adhesion, excellent control on film stoichiometry and crystallinity, and low deposition temperatures. The structural, compositional, and interfacial characterization of nanostructures at each processing stage was carried out using advanced characterization tools such as SEM, TEM, AFM, XRD, XPS, and Raman Spectroscopy. The preliminary results from thermal characterization of such hybrid nanostructures will also be presented.

Keywords
AlN thin films
CNTs
HiPIMS
PECVD