Micro-scale “air-gap” circuitry with conducting carbon nanotube-copper composite

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The ability of water-assisted CVD to produce aligned close-packed single wall carbon nanotubes (CNT) with superior thermal and mechanical properties make them ideal materials for use in microelectronics. However, their poor electrical conductivity has been a major obstacle in realizing this. To overcome this, we report the synthesis of conducting CNT-copper composite (conductivity $\sigma = 10^5 \text{ Scm}^{-1}$) through a novel organic phase electrodeposition. The conductivity enhancement ($10^3$ times over CNT) is due to the high, uniform filling of Cu in the aligned CNT matrix. Micro-scale, three-dimensional lithographic engineering of CNT-Cu, involving fully suspended CNT-Cu beams, is achieved for microelectronic applications. Multi-tier CNT-Cu circuits are also fabricated, with the constituent lines separated by air (replaceable with vacuum). This “vacuum-separation” exists in the horizontal and vertical directions providing unique multi-tier “air-gap” circuits. This realization of dielectric-less, air-gap circuits with CNT-Cu is thought to be a breakthrough for developing faster and efficient microelectronic devices.