Desktop Systems for Manufacturing Carbon Nanotube Films by Chemical Vapor Deposition

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Carbon nanotubes (CNTs) exhibit exceptional electrical, thermal, and mechanical properties that could potentially transform such diverse fields as composites, electronics, cooling, energy storage, and biological sensing. For the United States Navy, composites potentially provide a significant decrease in lifetime maintenance costs of ships by eliminating constant hull corrosion. A stronger composite could also improve naval ship survivability or increase combat payloads by reducing the hull weight of ships and submarines. Further, cooling requirements of shipborne electronics have grown exponentially and represent a significant weight penalty for advanced ship designs. Any improvement in thermal transport could significantly improve future naval ship designs. In order to realize these benefits, methods must be discovered to fully characterize CNT growth mechanisms, consistently produce CNTs in manufacturable quantities, and to integrate CNTs into macroscale structures which reflect the properties of individual CNTs.

While growth of CNTs in laboratory scale chemical vapor deposition (CVD) tube furnaces has shown great promise, existing low cost tube furnace designs limit the researcher's ability to fully separate critical reaction parameters such as temperature and flow profiles and limit the rate of temperature change during the growth process. Conventional tube furnace designs also provide limited mechanical access to the growth site and prevent optical monitoring of the growth site, removing the ability to observe and interact *in situ* during growth. This thesis presents the "SabreTube", a low-cost desktop CVD apparatusthat decouples temperature and flow variables, provides mechanical and optical access to the reaction site during growth, and provides modular fixturing to enable versatile experimentation with and characterization of CNT growth mechanisms. This thesis also presents the Nanosled, a device designed to translate a substrate through a CVD furnace in order to develop a continuous manufacturing process for CNT films for applications in reinforced structural composites.