

Design and Operation of an Advanced
Laser Chemical Vapor Deposition System with On-Line Control

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220 Pages

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The LCVD process has the potential to fabricate multiple material objects with complex geometries. In the past, the LCVD process has been plagued with control problems, resulting in irregular deposits. The bulk of the deposit irregularity was due to changes in the laser spot temperature, which was difficult to sense and control due to the small size of the focused laser.

The primary goal of the research presented in this dissertation was to control the LCVD process. The control was based on a novel sensing and control method, using a thermal imager to record a temperature map of the laser spot. This allowed the laser power to be automatically adjusted based on the temperature field in the heated laser spot. Uniform walls of carbon were deposited from multiple lines. The dimensions of the carbon walls were approximately 170 μm wide and 230 μm tall, composed of 20 layers. This research represents the first time that uniform walls of material have been deposited of significant height and composed of many layers.

Uniform carbon fibers were also grown using constant temperature control. Some simple structures were fabricated by growing two angled fibers together to form a “ Λ ” shape. The kinetics of fiber growth was studied, using both methane and propylene as precursor gases. The “volcano effect” was also examined, and the most likely cause was determined to be an etching reaction triggered by the high temperature at the center of the laser spot.

The successfully grown carbon walls and fibers serve as the building blocks for complex structures with intricate geometries and multiple materials.