Laser Annealing of Cokes and Chars

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A Q-switched Nd:YAG laser and a continuous wave CO_2 laser are used to anneal anthracene coke and sucrose char. Anthracene coke and sucrose char were selected for laser annealing because they represent a model graphitizable and non-graphitizable carbon, respectively. Lasers provide rapid heating and cooling with high temporal control. The extent of transformation is kinetically controlled by time above the threshold temperature for transformation, enabling the annealing trajectories from these two very different carbon materials to be followed with respect to time above temperature. To resolve the nanostructure changes HRTEM is employed.

The Nd:YAG Q-switched laser heats carbon above graphitization heat treatment temperature within nanoseconds and material ablation is the dominant effect. The material transformation trajectory is altered verses traditional furnace heating at these rapid heating rates ~330,000,000,000 °C/s. In comparison, a continuous wave CO_2 laser heats carbon samples to graphitization heat treatment temperature with a ramp rate of ~1,840,000 °C/s and brings the sample to 2,600 °C in 1.4 ms. At this heating rate samples followed the traditional furnace annealing pathways as based upon the equivalent end structures obtained from matching temperatures. Pulsing the CO_2 laser with a pulse generator allowed for the annealing trajectories with respect to time above temperature to be followed. Graphitizable anthracene coke anneals faster than non-graphitizable sucrose char. Sucrose char passes through a structural state of completely closed shell nanoparticles that open upon additional heat treatment and give rise to the irregular pore structure found in the end product.