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Experimental Investigation and Analysis of High-Enthalpy Nitrogen Plasma over Graphite

Researchers have continually improved heat shield materials for hypersonic flight applications since the advent of space exploration, yet many significant challenges remain. A particularly difficult problem is to isolate the assorted rate-based processes occurring within the flow, which independently impact the total heat flux on the vehicle. In this investigation, I determine the reaction rates for carbon nitridation and nitrogen recombination. Using the Plasma Diagnostics and Test Laboratory at the University of Vermont, I used various optical diagnostic techniques to measure the properties of high-energy nitrogen flow directed towards graphite samples. These experiments determined the relative concentrations of several chemical species within the flow, which provided a means to calculate the reaction rates. Although previous studies have estimated these values, this campaign represents the first set of quantitative results determined experimentally. This campaign revealed that the nitrogen recombination rate was two orders of magnitude greater than that of carbon nitridation. These data constitute a significant advancement in the field of hypersonics by providing valuable information about two pervasive chemical reactions in the atmosphere as well as a new method with which to determine them.