Comparison of TR-LII sizing for pure carbon and hydrogen-containing carbon particles

A. Eremin[1], M. Falchenko[1], E. Gurentsov[1*], B. Kock[2], R. Starke[2], C. Schulz[2]
[1]Institute for High Energy Density RAS, Moscow, Russia
[2]IVG, Universität Duisburg-Essen, Duisburg, Germany

Time-Resolved LII (TR-LII) particle sizing was performed for the pure carbon particles and for the particles holding some amount of hydrogen. These particles were formed from supersaturated carbon vapor and from carbon vapor with the addition of hydrogen atoms, by the laser photolysis of C_3O_2 or C_3O_2+H_2S. The current particle sizes were measured by TR-LII, while the final count median diameter of particles and the particle size distribution were analyzed by Transmission Electron Microscopy (TEM). The value of thermal accommodation coefficient for argon at the carbon-hydrogen particle surface was extracted by the comparison of TR-LII particle sizing with the TEM data and was found to be 0.3.

Introduction

The aim of this work is to study the influence of hydrogen on the formation of carbon particles. In previous work [1] the carbon particle formation was investigated during pure carbon vapor condensation at room temperature. Here, we analyze the influence of hydrogen atoms on carbon vapor on condensed particle properties using TR-LII and TEM.

Experimental

The method of laser-induced photo-dissociation of C_3O_2 [1] with addition of H_2S was applied as a source of carbon and hydrogen atoms for the study of particle formation. A quartz cell (10×10×5 mm) was evacuated and filled with 10 mbar C_3O_2 + 1 mbar H_2S diluted by Ar at pressure of 1 bar. The photo-dissociation of this mixture leads to the generation of 1 mbar C and 0.4 mbar H. Additionally, 0.4 mbar HS, 2 mbar CO and 9 mbar C_3O_3 remained in the mixture as impurities.

The equipment for TR-LII measurements consisted of a pulsed Nd:YAG laser (1064 nm), two photo-multipliers for the detection of particle emission at 694 and 550 nm. LII signals were evaluated using a updated Melton model included the changing heat capacity of carbon with temperature, particle-size distribution, and particle evaporation. The material properties of conventional soot were used for data analysis. The thermal energy-accommodation coefficient α for pure carbon particles was taken 0.44 in accordance to [1].

The particle samples of pure carbon particles and particles with addition of hydrogen were analyzed by TEM. Assuming a log-normal particle-size distribution, the count median diameter (CMD) and the standard deviation σ of final particles were extracted from the TEM micrographs and were found to be CMD = 11.5; σ = 1.3 for the pure carbon particles (a good agreement with [1]) and CMD = 9; σ = 1.2 for the hydrogen-containing particles.

Results

Figure 1 shows the observed temporal variation of particle sizes for pure carbon hydrogen-containing carbon particles. A difference between the final LII and the TEM sizes was found for the hydrogen-containing particles, which was attributed to the variations in thermal energy-accommodation coefficient due to different properties of the particle surfaces. Thus, the value of α for the hydrogen-containing particles was found to be 0.3, i.e. close to soot data (0.23 – 0.38) [2].

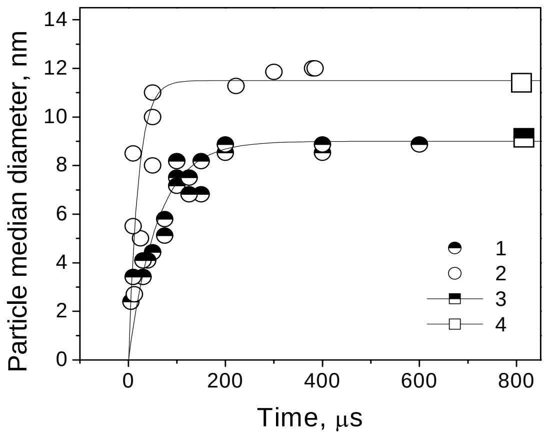

Fig. 1: Carbon and hydrogen/carbon nanoparticle growth in Ar. 1,3 – data for hydrogen-containing particles; 2,4 – data for pure carbon particles; 1,2 – TR-LII data; 3,4 – TEM data.

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* Corresponding author: gurentsov@ihed.ras.ru
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