Infrared spectra of titanium carbide grains

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Origin of 20.1 micro meter absorption feature in carbon star was long-standing problem in astrophysics. One of the origins was considered to be the TiC grain. Metal carbides are indeed expected to from in the winds of carbon-rich AGB stars. In addition, metal carbides (Ti, Mo, and Zr) were identified by transmission electron microscopy (TEM). By synthesizing TiC grains in the laboratory, G. Von Helden and co-authors measured their infrared spectra, and comparing their spectra to those of various kinds of giant star. But the experimentally condition is indistinct, moreover the morphology and structure is not confirmed. Since TiC grains in meteorite have graphite mantle, production of the grains in laboratory were important for the determination of spectra.

One of the best methods of producing TiC grains with a same size (about 50 nm) of pre-solar grain in the laboratory is the gas evaporation method. We have been produced by the use of gas evaporation methods, metallic, oxide and sulfide particles. And growth mechanism of these particles has been elucidated. Therefore, the TiC grain can be produced to make good use of these experiences. In this experiment, we produced the titanium carbide particles with a 50 nm in size by progress of coalescence growth. Therefore, we can compare with amount factors of 'morphology, size' and 'spectra'.

If the arc-discharge is initiated by the method in inert gas, the rise of the smoke from the evaporation source can be seen. The evaporated vapor is subsequently cooled and condensed in the gas atmosphere, i.e. solid grains are obtains directly from the gas cloud. The grains flow by convection produced by heating, and look like those of the smoke. The coalescence growth is regarded as an important process in this method. The coalescence in the smoke particles was explained in terms of two stages: a surface melting coalescence and a liquid-like coalescence. These two stages depend mainly on grain size and temperature. The morphology and size of grains are controlled by the mass density and temperature in the smoke, which depend on the atmospheric gas and gas pressure.

The specimen was examined using Hitachi H-7100 electron microscope. High resolution electron microscopic (HREM) images were obtained using a Hitachi H-9000NAR electron microscope. The infrared spectra of these samples, embedded in KBr pellets, were measured with a Fourier-Transform Infrared Spectrometer (Horiba Inc. FT210). The wavelength resolution was 2 cm-1.

Since for the carbide particles was refractory material, it have not been produced except one and only SiC particle. Therefore, novel method was used for production of TiC grains. Pre-heat treated Ti wire was set around carbon electrode. And Ti heater was set above evaporation source, due to acceleration of coalescence growth. By the heating of carbon electrodes in argon gas at 13.3 kPa, smoke particles of TiC can be obtained.

The size distribution of TiC grains was 40-50 nm. This grain size agreed with discovery pre-solar TiC grain. TiC grains were cubic shape of typical NaCl-type. The TiC grains were covered with amorphous carbon layer of about 2 nm. When TiC particles were produced without heater, the size of TiC particles were less than 20 nm. By the use of Ti heater, we succeeded that the produced of TiC core-carbon mantle grains with the proper size for measurement of infrared spectra. As the results, broad feature of 9.5 and 12.5 micro meter absorption can be seen. Absorption of 20.1 micro meter feature by G. Von Helden never appeared. Appearance of the absorption peak at 240 nm showed that the carbon layer on TiC grains was contained the amorphous graphite structure.