Artificial Meteor and Chelyabinsk Ablation Test using Arc-heated Wind Tunnel

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Introduction

From a scientific point of view, the attempt to understand the nature of meteors is of importance because the atmospheric composition, the presence of water and the life on Earth are affected or originated by space material even today. However for natural meteors, the mass, composition and the density of the meteoroids are all unknown. Since the meteor is unexpected transient phenomenon on the sky it is rather difficult to determine these physical parameters with high precision. Since 1963 the NASA Langley Research Center and the Smithonian Astrophysical Observatory conducted a series of sounding rocket flights to simulate natural meteor conditions [1]. There still exists a controversy about luminosity coefficient that is important parameter to estimate the meteor brightness. In recent years observations of re-entry capsules from the interplanetary space were performed by using Stardust comet sample return and Hayabusa asteroid sample return capsules [2,3,4]. Several unknown emission lines were identified by the re-entry of Hayabusa spacecraft [4]. We scheduled to launch a small commercial satellite by which artificial meteoroids are ejected and are de-orbited to enter the atmosphere [5]. Thus laboratory experiment is important for testing materials to make bright artificial meteors, which takes a new step toward understanding the meteor ablation.

Fig 1 Meteor ablation by arc-heated wind tunnel. 2 Meteorites (left) and 3 artificial meteor samples (right).

Method

In order to observe details of a meteor ablation process such as temperature, emitting composition ratio, fragmentation phenomenon and their time variations, the artificial meteor ablation experiment was carried out using the arc-heated wind tunnel operated by JAXA/ISAS (Japan Aerospace eXploration Agency / the Institute of Space and Astronautical Science). An arc-heated wind tunnel is widely used for ground-based experiments to simulate environments of the planetary atmospheric entry under hypersonic and high-temperature conditions. To simulate hypersonic entry velocity over 12 km/s, high-heating rate, ~30 MW/m^2, and high-enthalpy conditions, ~10,000 K arc-heated air-flow at velocity ~6 km/s (0.6MPa), were achieved. For this laboratory experiment, we developed artificial meteor samples composed of metallic materials with controlling internal porosity. Real meteorites such as Chelyabinsk (*LL5*) and Jbilet Winselwan (*CM2*) were also used for ablation test. Table 1 summarizes the test samples shown in this paper.

Table 1 Test pieces for meteor ablation test.

Composition	Mixing ratio	Porosity [%]
FeO	–	20.0 – 31.5
Fe, SiC	1:1	23.9 – 37.3
Fe, Mg	1:1	34.5
$(Mg,Fe)_2SiO_4$	*Olivine*	13.7 – 24.2
Fe, Mg, Al, C	1:1:1:1, 9:9:1:1	17.7 – 44.4
Chelyabinsk	*LL5*	~6
Jbilet Winselwan	*CM2*	~23

Shapes; cylinder & bullet types. Size; Φ10

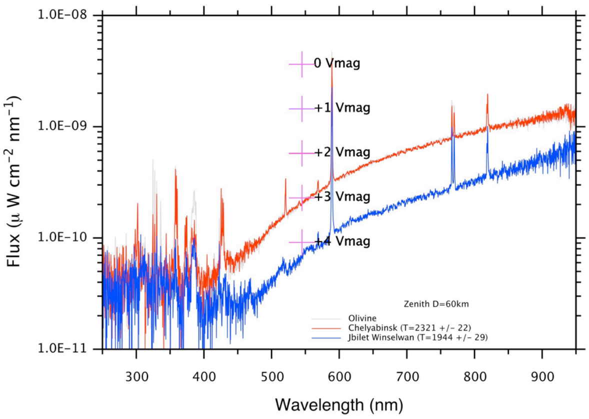

Fig 2 UV-VIS spectra of meteor ablation plasma. Chelyabinsk, Jbilet Winselwan and Olivine artificial meteors are compared.

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