OVER-ESTIMATION OF ATOMIC OXYGEN FLUENCES DUE TO UNDECOMPOSED OXYGEN MOLECULES INCLUDED IN HYPERTHERMAL BEAMS

Masahito Tagawa(1), Kazuki Kita(1), Ryota Okura(1), Yusuke Fujimoto(1), Ryo Shirakawa(1), Teppei Shimizu(1), Minoru Iwata(2), Kumiko Yokota(3)

(1) Kobe University, Rokko-dai 1-1, Nada, Kobe 657-8501 Japan, tagawa@mech.kobe-u.ac.jp
(2) Kyushu Institute of Technology, Sensui-cho 1-1, Tobata, Kitakyushu 804-8550 Japan, iwata@ele.kyutech.ac.jp
(3) Kobe University, Rokko-dai 1-1, Nada, Kobe 657-8501 Japan, yokota@mech.kobe-u.ac.jp

ABSTRACT
Atomic oxygen beams formed by laser-detonation sources contains not only atomic oxygen (AO), but also undecomposed molecular oxygen. The effect of molecular oxygen on the material degradation, which is exposed to sample surface simultaneously with AO, has never been considered. In our previous study using dual-beam laser-detonation system, an acceleration effect of material degradation with simultaneous exposure of AO and Ar was clearly confirmed, i.e., erosion yield of polyimide under simultaneous AO and Ar exposure is more than three times greater than AO exposure without Ar exposure [1]. This phenomenon was analyzed due to collision-induced desorption of oxidative reaction products by Ar collisions. The AO+Ar simultaneous exposure condition simulates the sub-LEO space environment where AO and N2 collide material surfaces, simultaneously. However, it is rather “special” environment, and not for the cases on conventional LEO where many samples have been tested their AO resistance.

On the other hand, AO resistance has also been evaluated using laser-detonation AO sources. For many cases, material exposure missions aboard ISS includes ground-based AO exposures for comparison purposes. Both in-orbit and on-ground results have been normalized/compared with Kapton erosion yield of 3.00E-24 cm³/atom. Many AO researches performed by laser-detonation system with mass spectrometer indicated that AO beam formed by laser-detonation sources contains undecomposed molecular oxygen as high as 30-50%. The undecomposed molecular oxygen with collision velocity of 8 km/s may provide similar effect to N2 in sub-LEO (or Ar in AO+Ar simultaneous exposure) which accelerates desorption of reaction products.

In this presentation, role of undecomposed molecular oxygen contained in ground-based AO tests was evaluated quantitatively. The experiment was carried out by adding Ar beam at the same collision energy as molecular oxygen component in the AO beam. The addition of Ar beam was made by the one-nozzle two-beam laser detonation system developed in our group [2].

The experimental results clearly indicated that erosion of Kapton in the laser-detonation system was promoted by the presence of molecular oxygen in the beam. This result suggests that Kapton-equivalent AO fluence measured in the “ordinary” laser-detonation system, which includes 30-50% molecular oxygen, is over-estimated 1.5 - 2 times (AO-induced material risks evaluated based on ground-based AO tests have been under-estimated to be 1/2 to 2/3).

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