Evaluation of MoS2 Bonded Film Degradation on ISS SM-SEED Experiment

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This paper describes upon the on orbit degradation of the MoS2 Bonded Film which are applied to external mechanism of Japanese Experiment Module (JEM) of International Space Station (ISS). The Test articles were launched and kept on orbit for 1 year, 2 year and 3 year. Evaluation are performed by measuring adhesive property, friction property and surface properties of the MoS2 bonded film, HMB-34. Also ground environment exposure test were conducted to compare the degradation against on orbit exposed environment effect.

Keywords: MPAC&SEED, ISS Service Module, JEM, ELM-ES, PAM, HMB-34

1. Introduction

As when the ISS program has been approved by Japanese government, IHI Aerospace (formerly NISSAN Motor Co., LTD.) has proposed to develop Payload Attach Mechanism (PAM) to carry the external payloads to Japanese Experiment Module (JEM) on ISS by Space Shuttle. Due to the external environment effect to the solid lubricant, Space exposure experiment has been expected to evaluate its durability compare to ground exposure experiment, such as Atomic Oxygen, Ultra-Violet and Electron Beams.

Authors has been joining JAXA's space exposure programs , EFFU, ESEM and SM-SEED upon MoS2 bonded film, HMB-34.

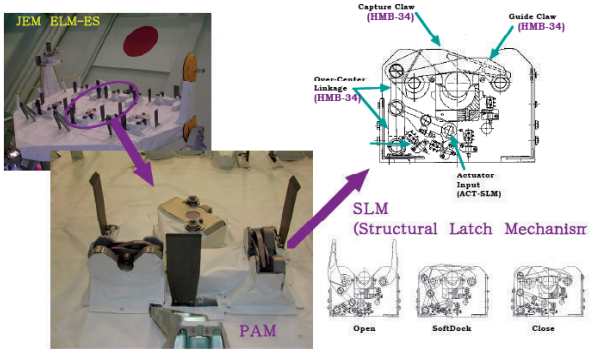


Fig.1 SLM on JEM ELM-ES

2. MoS2 Bonded Film

HMB-34 MoS2 bonded film has been selected for the JEM ELM-ES PAM from in-house research and development conducted by IHI Aerospace. HMB-34 is kind of MoS2 with organic binder which are coated onto Ti-6Al-4V, CRES and Aluminum Alloys on JEM ELM-ES PAM.

Fig.1 describes the JEM ELM-ES and where the mechanisms are installed.

Structural Latch Mechanism (SLM) is one of the critical component on ELM-ES which has to withstand the launch and re-entry load and need to release / latch on orbit.

3. Post Exposure Evaluation

Evaluation has been conducted upon space exposure test article and also comparison has been conducted to evaluate the space exposed effects to the MoS2 bonded film with Ti-6Al-4V bas material. Test Article which are evaluated as 3 year exposre are described in Fig. 2

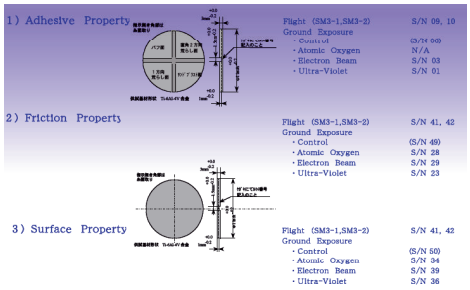


Fig.2 Test Article of MoS2 Bonded Film

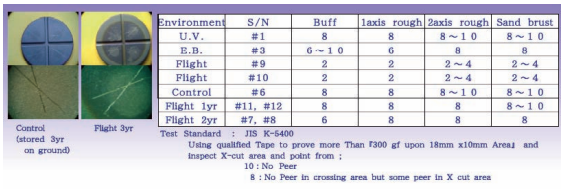
3.1 Adhesive Property

Adhesive property were evaluated according to JIS-K-5400 and the measured result is described in Tab. 1as,

(1) There were clear degradation upon adhesive property after 3 year exposure to Space environment.

(2) Compare to ground exposure test result, there seems no difference to adhesive property under single U.V. nor E.B. environment.

Table 1 Adhesive Property Result



Environment	S/N	Buff	1axis rough	2axis rough	Sand brust
U.V.	#1	8	8	8～10	8～10
E.B.	#3	6～10	6	8	8
Flight	#9	2	2	2～4	2～4
Flight	#10	2	2	2～4	2～4
Control	#6	8	8	8～10	8～10
Flight 1yr	#11, #12	8	8	8	8～10
Flight 2yr	#7, #8	6	8	8	8

Test Standard : JIS K-5400
Using qualified Tape to prove more Than f300 gf upon 18mm x10mm Area and inspect X-cut area and point from ;
10 : No Peer
8 : No Peer in crossing area but some peer in X cut area

3.2 Friction Property

Friction property was evaluated according to ball on disk test as described in Fig.3 as,

(1) LEO Exposed Environment

Due to decrease of initial friction and increase of on-orbit exposure duration has decreased the friction of MoS2 Bonded Film.

(2) Atomic Oxygen Exposure

Decrease of initial friction were similar to on-orbit exposure , but no difference due to exposure duration.

(3) Ultra-Violet Exposure

Decrease of initial friction were similar to on-orbit exposure , but no difference due to exposure duration and friction itself was not stable.

(4) Electron Beam Exposure

No difference of the friction property were measured

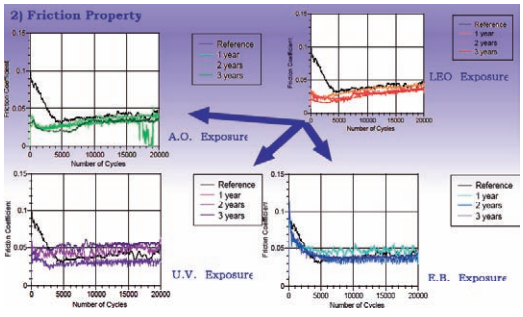


Fig.3 Friction Property Measurement

3. 3 Surface Property

SEM, XPS and EDS evaluation were conducted to each test article and Si02 were measured as contamination to MoS2 Bonded Film surface of space exposure samples as decribed in Fig.4 to Fig.6.

(1) Surface of 3 year space exposure seems to have same contamination of Si (SiO2).

(2) Cu and Fe were measured from A.O. exposure which seems to come from the A.O. generator.

(3) SiO2 has been identified as Si on MoS2 Bonded Film exposed to space environment according to the measurement of Si4+ peak near 104 eV. (1) Si has been increasing on the surface of MoS2 Bonded Film. This means the surface has been contaminated by Si (SiO2).

(4) Si has been increasing on the surface of MoS2 Bonded Film. This means the surface has been contaminated by Si (SiO2).

(5) Si contamination seems to be only on very surface of Bonded Film compare XPS to EDS result.

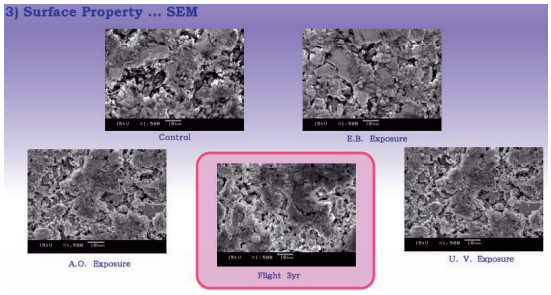


Fig.4 SEM

	C	O	S	Mo	Sb	Si	Cr	Fe	Ni	Cu
LEO	16.5	57.3	0.1	0.4	-	25.8	-	-	-	-
AO	24.2	50.5	1.7	4.5	0.2	1.6	0.9	7.6	1.3	7.6
UV	68.4	18.6	5.6	3.3	0.2	3.9	-	-	-	-
EB	72.7	17.2	5.5	4.0	0.2	0.4	-	-	-	-
Ref.	64.7	18.6	9.7	6.3	0.4	0.3	-	-	-	-

Fig.5 XPS

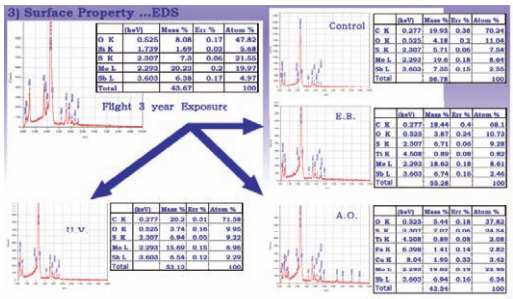


Fig.6 EDS

4. Coclusion

As from 3 years of exposure experiment with 1 and 2 year exposure as reference of degradation of MoS2 Bonded Film, following are the conclusion we have got.

(1) Adhesive property, friction property and surface property evaluation were conducted to all test articles including 1 year, 2 year and 3 year exposure to space environment and same effect were measured.

(2) According to 3 year exposure to ISS exposed environment,

a) Initial friction of space exposed HMB-34 MoS2 Bonded Film has been decreased compare to ground initial condition (Control) and not have changed during 1 to 3 year exposure.

b) Overall friction has decreased and Life time of HMB-34 Bonded Film seems to increase.

c) This property change might have some relation with the SiO2 contamination which is also proved not to change MoS2 Bonded Film lubrication property.

(3) This space exposure has proved that the HMB-34 Bonded Film have enough performance for JEM exposed mechanisms such as ELM-ES PAM SLM for 10 year life operation under ISS space exposed environment.

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