Mech. Adv. Technol. Vol. 5, No. 3, 2021, pp. 294–301

DOI: 10.20535/2521-1943.2021.5.3.249629

UDC 658.012

Reducing the Specular Properties of Metalized Teflon Coverings on Canadian Mobile Servicing Station on the International Space

J.I. Kleiman[1]

Received: 18 December 2021 / Accepted: 28 December 2021

Abstract. *A surface modification process was developed for the metalized Teflon coverings used for thermal protection of electronic equipment on the International Space Station. The developed modification process of Teflon surfaces reduced substantially the specularity of Ag-Inconel back-coated Teflon FEP thermal control films by changing the morphological appearance of their surfaces by ion-beam texturing in a controlled manner from a metallic-like and shiny to complete milky-white appearance without significantly affecting the thermal optical properties.*

The treated Ag-Inconel coated Teflon thermal control films were applied to camera boxes and placed on the outside of the International Space Station. A number of space hardware units covered with the back-metallized- textured Teflon FEP that were exposed to the open space environment between June 2002 and June 2006 were delivered back to Earth at the end of 2006. Remarkable performance was demonstrated by the treated Teflon FEP, with the solar absorptance (α) and total emittance (ε) values and the α/ε ratio remaining very close to the original values as measured before the flights.

In an attempt to protect further the textured surfaces of Teflon from possible erosion by atomic oxygen and VUV in LEO environment, an additional novel surface modification process was developed that created an $Si_xO_yC_zF_n$ type of structure on the treated surface. The textured Teflon samples before and after surface treatments were tested in a space simulator facility under a combined atomic oxygen/vacuum ultraviolet exposure. A number of advanced characterization techniques were used to evaluate the properties of the modified films.

Keywords: *the specular properties, metalized teflon, servicing station.*

1. Introduction

The International Space Station (ISS) has a considerable amount of electronic equipment positioned on the outside of the station. This equipment has a range of allowable temperatures that must be maintaine d to meet survival and operational requirements during all mission phases. Effective thermal control over such equipment is extremely important for normal operation of the station. In general, temperatures are regulated with passive and/or active thermal management technologies and design methods [1, 2]. Among passive thermal management methods paints and single and multilayer films, with engineered absorptance and emittance properties are used [3–5].

✉ *J. I. Kleiman*
jkleiman@itlinc.com

[1] *Integrity Testing Laboratory Inc.,Ontario, Canada*

For extreme thermal environments present in the low Earth orbit space, the use of radiative paints on electronic boxes to control heat absorption appeared to be unacceptable. The silver/Inconel back-coated Teflon film is used widely on different satellites and on the International Space Station (ISS) as a passive thermal control system; given its low solar absorptance to thermal emittance ratio and as-manufactured high specular reflectance, and relative ease of manufacture and processing [6]. However, in its use on the ISS, the high specular reflectance gave rise to the problem of excessive glare which blinded the optical equipment installed on the Mobile Servicing System (MSS), designed and manufactured in Canada and used to locate targets attached or in close vicinity to the equipment covered with the back-metallized Teflon FEP films. Canada's Mobile Servicing System (MSS) is composed of three robots that can work together or independently and that include the Special Purpose Dexterous Manipulator (SPDM), known as “Dextre” [8], the Mobile Base System (MBS) and the

ISSN 2521-1943 Mechanics and Advanced Technologies

Remote Manipulator System (SSRMS), known as "Canadarm2". MSS is a sophisticated robotics complex that plays a critical role in the assembly, maintenance, and resupply of the ISS. Four color cameras that are installed one on each side of the Canadarm elbow with the other two on each of the two "hands" of the Canadarm had to be protected from the specular reflections caused by the silver/Inconel back coated Teflon FEP film coverings.

The solution to the excessive glare problem was to alter the surface of the Teflon film so that the specular reflection from the film would be reduced substantially to an acceptable level, maintaining at the same time the low absorptivity properties of the Teflon, with no significant change to the total reflectance and the α/ε ratio [6].

2. Experimental

To solve the problem of excessive glare a surface modification process was developed for the back-metallized-Teflon film that allowed to texture the front surface of the film and provide to it a matt finish. All materials used in the present work were prepared from Teflon FEP purchased from Sheldahl [4]. FEP is a visibly transparent polymer produced by DuPont with the general structure shown below (eq. 1).

$$-(F_2C-CF_2)_n-\underset{\displaystyle F}{\overset{\displaystyle CF_2}{\overset{|}{\underset{|}{C}}}}- \qquad \text{(eq. 1)}$$

The strength of the C-F bond relative to typical C-H bond strengths gives FEP an advantage over organics in resisting attack by atomic oxygen. The material consists of an approximately 5-mil-thick layer of FEP with approximately 800 angstroms of vapor deposited silver on one side and another 400 angstroms of vapor-deposited Inconel applied over the silver.

An ion-beam vacuum system that was used for preparation of the textured material (Fig. 1) contained a linear ion-beam source and a large 58 cm diameter rotating drum to which the samples were mounted, providing a large surface area of 150×50 cm^2 for the ion beam exposure of the samples.

A typical drum speed of 2 rpm was used in the experiments. A number of different neutral and noble gases including Argon, Xenon and Krypton were tried and high purity krypton gas was selected and used for texturing the films. The chamber vacuum pressure of $3\cdot10^{-2}$ Pa was maintained during the experiments at the above conditions. Typical etching rates of 0.015 μm/min were achieved with the drum being rotated during the treatment.

Scanning electron microscopy (SEM) study of all samples was performed on a JEOL JSM-T300 model microscope. The surfaces of the polymer samples were coated with a thin layer of carbon to prevent charging.

The solar emissivity (or total emittance) (ε) of the samples was measured in accordance with the ASTM specification E-408 [9] using an infrared reflectometer manufactured by Gier Dunkle Instruments, Model DB100. The total and the diffuse optical reflectance as well as the solar absorptivity of the samples (α) were measured using a spectrophotometer (Beckman Instruments, Model DK-2a) equipped with an integrating sphere. The solar absorptivity in UV, visible, and the near-infrared (IR) ranges of the spectrum, covering the range 200–2450 nm was measured in accordance with the ASTM-E903 specification [10].

Fig. 1. General view of the ion-beam vacuum system with a linear ion-beam source that was used in the experiments (left) and the schematic of the configuration inside the chamber (right) showing the rotating drum to which the samples were mounted, the slits and the ion-beam direction

3. Results

3.1. Texturing Process

The developed surface texturing process is based on ion-beam bombardment of the surface with noble gases. As a result of such treatment, the specularity of the front surfaces of the back-metallized-Teflon FEP thermal control films can be reduced dramatically, with the surface morphology changing from metallic-like and shiny to complete milky-white appearance.

Ion beam texturing is a well-known phenomenon [11]. Most ion sputtered fluorpolymer surfaces develop cone or spire-like features. The applications of ion beam textured polymers for adhesion improvement, biomedical applications, electrical properties changes, wettability properties changes, etc., were studied and described [12–14]. It was shown that depending on the ion beam power density and target temperature the etch rates of PTFE range from 3 to 1700 µm/h [14].

An optimization of the process parameters allowed achieving a strong texturing effect. In preliminary experiments it was established that, all conditions being the same, krypton ions had a stronger texturing effect on the FEP films. The values of diffuse reflectance for krypton-treated samples were much higher than for samples treated with argon ions [7]. Fig. 2 shows the total and diffuse reflectance of a 127 µm thick Ag-Inconel coated on back Teflon after it was treated with Argon (Fig. 2 *a*) and Krypton (Fig. 2 *b*) ions. As can be seen from Fig. 2, most of the light was reflected as diffused, with the diffused reflectance almost equaling the total reflectance in the sample treated with Krypton ions.

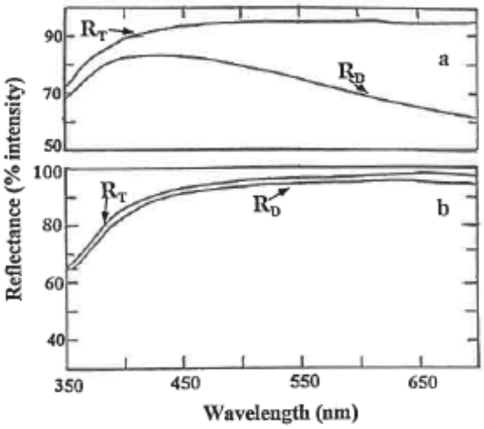

Fig. 2. Total (R_T) and diffuse (R_D) reflectance measurements for two Ag-Inconel coated on back Teflon FEP samples after an exposure to Argon (*a*) and Krypton (*b*) gas ion-beams

The surface of the treated film attains rough morphology with well-developed cone or spire-like features. Images in Fig. 3 show the appearance of the surface of an Ag-Inconel back-coated Teflon FEP sample treated with Krypton ions in planar (*a*) and cross-sectional (*b*) views after a forty-hour exposure at optimized conditions.

As a result of the treatment, the front surface of the Ag-Inconel coated on back Teflon FEP changed from a metallic-like and shiny to complete milky-white. To demonstrate the effect of texturing on the general appearance of the surface after the treatment, coins were placed in front of a sample in pristine condition and after the texturing treatment. Fig. 4 shows these two samples with the left image of the pristine untreated sample and the right image of the sample after the texturing process.

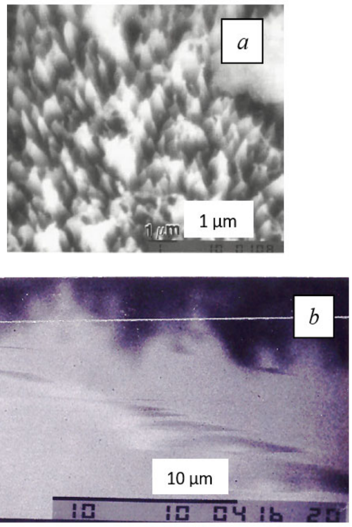

Fig. 3. Planar (*a*) and cross-sectional (*b*) scanning electron microscopy images of a Krypton ion-beam textured Teflon FEP after 40 hours of exposure. Magnification ~3,500x

Fig. 4. Optical images of Ag/Teflon samples before (left) and after (right) treatment with the texturing process

While the surface morphology of the treated sample underwent strong changes, the thermal optical properties of the surfaces practically remained unchanged (table I). As can be seen from table I, all thermal optical parameters underwent very little changes, providing the α/ε ratio of 0.09 as compared to 0.10 of the original material.

Table I. Summary of property changes in the textured Ag/Teflon FEP sample

Parameters	Teflon Original	Textured Teflon
Solar Absorptance (α)	0.08	0.07
Total Emittance (ε)	0.79	0.81
α/ε	0.10	0.09
Appearance	Shiny, grey-metallic	Mat, milky-white
Total Reflectance (R_T)	0.95	0.93–0.95
Diffuse Reflectance (R_D)	0	0.92–0.93

3.2. Protection of the Textured Teflon FEP from LEO Environment

Early studies of Teflon FEP flown on different missions, including the LDEF mission flown in 1984–1989 [6], the Hubble telescope [15, 16], the Solar Max mission flown in 1983–1989 [17] had shown that the samples of Teflon FEP placed at different location on the external surfaces of the space structures experienced various degrees of erosion from atomic oxygen. In examination of LDEF flown samples, the SEM images show featureless surfaces with occasional particles of contamination on trailing-edge specimens. The LDEF specimens exposed to atomic oxygen showed the characteristic roughening of the surfaces seen on hardware previously returned from the Solar Max mission and materials experiments on Space Shuttle flights. The textured surface features point generally in the direction of the impinging atomic oxygen. This effect can be seen clearly in the transition region of blankets where a short distance provides about a 90° range of angles [6]. Such angular dependence of the erosion pattern on the atomic oxygen impingement direction was also found in other materials flown on LDEF. Fig. 5 presents a result obtained from one of the carbon fiber composite material tubes flown by UTIAS Team on LDEF [18]. A total of 108 epoxy matrix composite samples containing carbon, boron, and aramid fiber reinforcements were flown on the Long Duration Exposure Facility (LDEF) satellite in ITIAS experiment. For the first 371 days after deployment, strain and temperature data were recorded every 16 hours. Results were obtained on time to outgas, dimensional changes, coefficients of thermal expansion, atomic oxygen erosion, and damage due to micrometeoroid/debris impacts [18]. The angular dependence of the erosion of the carbon fibers in the upper surface of the composite tube sample on the location on the tube and the impinging atomic oxygen flux is clearly visible in Fig. 5. The orientation and degree of texturing changes with change of AO impingement angle.

3.3. Surface Modification of Control and Textured Samples by a Modified Silylation Process

The properties of metallized Teflon FEP (Tetrafluoroethylene-hexafluoropropylene copolymer (trade name Teflon® - FEP)) that is commonly used for space applications as a top layer in multilayer insulation or as a second surface mirror on radiator panels because of its good thermo-optical properties and resistivity exposed to different space environmental condition. were extensively studied [15–17 and references therein]. Thus, for instance, it was concluded that the observed mass loss of the Ag/Inconel Teflon FEP on Hubble Space Telescope (HST) resulted from the influence of AO erosion and energetic electromagnetic radiation, probably also accelerated by the thermal environment [15–16].

Since the developed textured Teflon FEP was used in the LEO environment, where the atomic oxygen erosion plays a dominant role, to protect the textured samples from the influence of the AO, they were originally coated with a layer of SiOx type of coating using a conventional vacuum coating process. During the thermal cycling testing of such samples, it was noticed that the surfaces of cycled samples attained a yellowish discoloration and that the α/ε ratio increased from a 0.10 value to 0.21 value. It was therefore decided to investigate the possibility of replacing the SiOx coating with a novel process that allowed to introduce substantial amounts of silicon into the subsurface region of the textured Teflon thus protecting it from the atomic oxygen effects in the LEO orbit [19, 20]. The thermal optical properties of textured samples after the SiOx deposition and af-

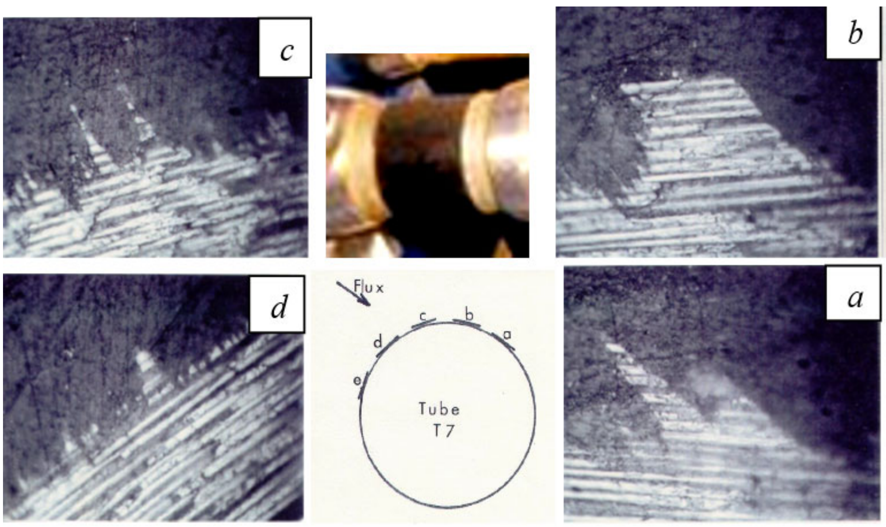

Fig. 5. Angular dependence of the erosion on the location on the tube and the impinging flux. The upper middle image is showing the carbon fiber-epoxy composite tube. The lower middle image shows schematically the location of the areas where the four images, marked as *a–d*, were taken from on the tube with respect to the impinging atomic oxygen flux

ter the new surface modification process were checked together with these for samples that were textured but did not undergo any other surface treatment, and a control, untextured but modified sample using the new surface modification technique. Table II summarizes these measurements compared, for reference, to data taken from [Ref. 7]. As can be seen from table II, a slight increase in the α/ε ratio, due to an increase in solar absorptance, was observed for samples after texturing and further surface treatment, which may lead to higher surface temperatures [12].

No visible changes in color and morphology or any measurable mass losses occurred in the textured Teflon samples before and after the surface treatment when they were thermally cycled or tested in an atomic oxygen space simulator facility [19].

Table II. Summary of Optical Thermal Properties of Teflon FEP Films After Thermal Cycling

Thermal Optical Parameters	**Ref. 7**	**Ref. 19**			
	Text. + SiO_x coated	**Textured**		**Untextured**	
		Untreated	**Surf. Mod.**	**Control**	**Surf. Mod.**
α	0.17	0.12	0.16	0.10	0.07
ε	0.81	0.81	0.82	0.80	0.81
α/ε	0.21	0.15	0.20	0.13	0.09

3.3. Application of the Textured Teflon FEP

The developed textured Teflon FEP was applied to outside walls of cameras and lights on the International Space Station using an acrylic adhesive (3M 966). The camera/light covered with the textured back-metallized-Teflon was launched with the Mobile Base Structure (MBS) on STS-111 in June 2002. The equipment was removed from MBS on June 2006 (which occurred between shuttle missions) and brought inside the ISS. Then it was stored inside the ISS until it was brought down on STS-115 (September 2006) and delivered back to MDA Company around November 2006 [21]. Remarkable performance was demonstrated by the treated back-metallized-Teflon, with the solar absorptance and total emittance values and the α/ε ratio remaining very close to the original values as measured before the flights. The Ag/Teflon surfaces, immediately after return, had the same, complete milky-white appearance.

An interesting phenomenon was observed with the change in appearance of the Teflon FEP on the camera enclosure after a prolonged, 8 months storage in the clean room. The surface of the Teflon FEP changed its color from milky-white to brownish (Fig. 7).

A similar phenomenon of Teflon discoloration was observed in one of LDEF experiments that underwent 5.8 years of exposure to the LEO space environment [22]. It was noticed in the Thermal Control Surfaces Experiment (TCSE) samples on LDEF that the front thermal cover consisting of Sheldahl's 50 µm (2 mil) thick Ag/FEP thermal control material glued with Y966 acrylic adhesive that in exposed to the space environment areas the material underwent a clear delineation and attained a diffuse whitish appearance with brown discoloration [22].

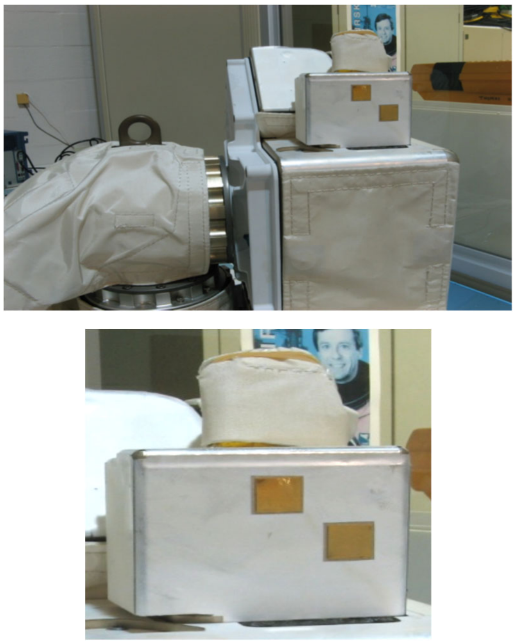

Fig. 6. Visual appearance of the camera CLPA S/N 206 (TVC S/N 209) (stored in a clean room at MDA) after delivery in November of 2006

The discoloration effects observed on the textured Teflon in this work upon return of the camera/light equipment and after a prolonged storage, were explained by oxidation processes occurring in the epoxy used to attach the Ag/Inconel back-coated-Teflon FEP to the hardware and or in the silver layer deposited on the back of the Teflon that could be initiated by the atmospheric oxygen [21]. To evaluate the changes in the thermal optical properties such discoloration can cause, the solar absorptance of the discolored and unaffected regions was measured. Table III presents the data on solar absorptance values, as measured in different regions of the Teflon FEP surfaces after the prolonged storage.

Data from Ref. 22 is also included in the table for comparison. As can be seen from table III, the solar absorptance values of the Ag-Inconel coated Teflon FEP are much higher especially in regions with heavier discoloration. In table III, the results identified in the second column as samples #1 through #4 were collected from the surfaces marked with the same numbers in Fig. 6.

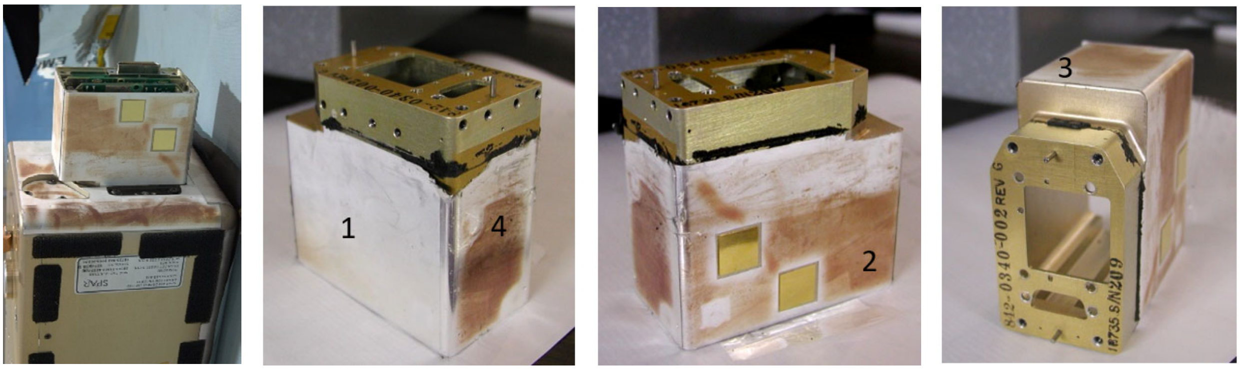

Fig. 7. Visual appearance of the camera CLPA S/N 206 (TVC S/N 209) (stored in a clean room at MDA) after an eight months storage

Table III. Comparative evaluation of the solar absorptance data for MDA and LDEF flown samples

Sample		Solar Absorptance, α: After storage (MDA) or LEO flight Ref.7)	Solar Absorptance, α: Original
MDA [Present work]	1	0.180	0.09 (0.17 with SiOx)
	2	0.444	
	3	0.248	
	4	0.316	
Ref. [22]	Low discoloration	0.10	0.08
	Strong discoloration	0.49	

4. Conclusions

A novel surface texturing process was developed for treatment of polymer films with specular optical characteristics. Large areas of back metallized Teflon FEP films were successfully textured in a continuous ion beam process using selected noble gases as the ion source. Surfaces with highly-developed morphology having milky mat appearance were produced, dramatically increasing the diffuse reflectance of the Teflon FEP films without substantially changing their thermal optical properties.

A number of space bound components used on the International Space Station were covered with these textured films. The camera/light units covered with the textured Ag/Teflon were successfully exposed to space on the ISS for a prolonged time while retaining their highly diffuse properties and the required thermal optical properties. The textured films retained their milky-white appearance after a four-year exposure to the LEO environment on the ISS.

Discoloration effects were observed on the textured Teflon surfaces after they were stored for a prolonged time, upon return of the camera/light equipment. These effects could be associated with oxidation processes occurring in the epoxy used to attach the Silver-Teflon to the hardware and or of the silver layer deposited on the back of the Teflon that could be initiated by the atmospheric oxygen.

References

[1] D.G. Gilmore, *Spacecraft Thermal Control Handbook*, 2nd Ed., The Aerospace Corporation Press: El Segundo, California, 2002.

[2] M. N. De Parolis, and W. Pinter-Krainer, Current and Future Techniques for Spacecraft Thermal Control 1. Design Drivers and Current Technologies, 1 Aug 1996, Web: 5 Sep 2014.

[3] *Thermal control coatings for satellites* [Online]. Available: https://www.map-coatings.com/en/page/thermal-control-coatings-for-satellites.php

[4] *The Red Book*, Sheldahl, The Multek Brand, [Online]. Available: http://www.sheldahl.com/sites/default/files/Documents/ShieldingMaterials/RedBook.pdf

[5] Multilayer Insulation Films [Online]. Available: https://www.dunmore.com/products/multi-layer-films.html?gclid=Cj0KCQiA_c-OBhDFARIsAIFg3exOL2054LTG02pi7UKxlT-mEj_xihZyCOugHndym9dHvZNFc85PfHQEaAkqyEALw_wcB
[6] H. Garry Pippin, Analysis of Silverized Teflon Thermal Control Material Flown on the Long Duration Exposure Facility, NASA Contractor Report 4663, July 1995.
[7] J. I. Kleiman *et al*., "Development of High Diffuse Reflectance Surfaces on Teflon", in *Proc. of the Third International Space Conference on Protection of Materials and Structures from the LEO Space Environment*, ICPMSE-3, Toronto, 25–26 April, 1996, eds., Kluwer Academic Publishers, pp.167–178, 1999. https://doi.org/10.1007/978-94-011-4768-2_14
[8] (James) Elliott Coleshill *et al*., "Improving maintenance operations on the International Space Station", *Acta Astronautica* 64 (9–10), pp. 869–874, 2009. DOI:10.1016/j.actaastro.2008.11.011
[9] Annual Book of ASTM Standards, E408, 15.03.
[10] Annual Book of ASTM Standards, E903, 12.02.
[11] B.A. Banks, Topography: Texturing Effects, in @Handbook of Ion beam Processing Technology@, Ed. J.J. Cuomo, S.M. Rossnagel, and H.R. Kaufman, Noyes Publications, (1994) Ch.17, 338–361.
[12] M.J. Mirtich and J.S. Sovey, "Optical and electrical properties of ion-beam-textured Kapton and Teflon", *J. Vac. Sci. Techn*. 15(2), pp. 697–701, 1978. https://doi.org/10.1116/1.569674
[13] Z.W. Kowalski, *J. Mat.Sci.*, 29, 3542, 1994. https://doi.org/10.1007/BF00352061
[14] J.S. Sovey, "Ion beam sputtering of fluoropolymers", *J.Vac.Sci.Techn*., 16(2), pp. 813–816, 1979.
[15] M. Moser, C. Semprimoschnig, van Eesbeek, M., Pippan, R.: 2005, Comparison of results from post-flight investigations on FEP retrieved from the Hubble Space Telescope solar arrays and LDEF. In: *Spacecraft Structures, Materials and Mechanical Testing 2005*, SP-581, ESA, Noordwijk, ADS.
[16] Kim K. de Groh and Morgana Martin, "Thermal Contributions to the Degradation of Ground Laboratory and Space-Irradiated Teflon®", *Journal of spacecraft and rockets*, Vol. 41, No. 3, pp. 366–372, 2004. https://doi.org/10.2514/1.10723
[17] C.G. Rapley, J. Sylwester, K.J.H. Phillips, New Results from the Solar Maximum Mission/Bent Crystal Spectrometer, Solar Phys (2017) 292:50; DOI 10.1007/s11207-017-1070-y
[18] R.C. Tennyson *et al*., "Space Environmental Effects on Polymer Matrix Composites –The UTIAS/LDEF Experiment", in *Proc. of the Materials in a Space Environment Symposium*, Toulouse, September 1991, pp. 93–110.
[19] J.I. Kleiman and Y. Gudimenko, "Reduced Glare, High Diffuse Reflectance Teflon Surfaces for Improved Performance of Video Cameras on Canadian MSS for SS Alpha", in *Proc. of the 7th International Symposium on "Materials in Space Environment"*, Toulouse, France, 16–20 June, 1997 (SP-399, Aug. 1997), pp. 419–424.
[20] J.I. Kleiman and Y. Gudimenko, High Diffuse Reflectance Teflon Surfaces for Improved Performance of Video Cameras on Canadian MSS for SS Alpha, The 4th IUMRS International conference in Asia, IUMRS-ICA-97, Makuhari, Japan, 1997.
[21] J.I. Kleiman, Z. Iskanderova and J. Antoniazzi, "Long Term Flight Performance of High Diffuse Reflectance Ag/Teflon Coverings Flown on Canadian Mobile Servicing Station, MSS, Proceedings of 11th International Symposium on Materials in a Space Environment (ISMSE), 15–18 September 2009, Aix-en-Provence, France.
[22] J.M. Zwiener *et al*., "Unusual Materials Effects Observed on the Thermal Control Surfaces Experiment" (S0069), in Proceedings of Symposium "LDEF-69 Months in Space", Kissimmee, Fla, June 2–8, 1991, NASA Conference Publication 3134, Part 3, pp. 919–934, 1991.

Снижение зеркальных свойств металлизированных тефлоновых покрытий на канадской мобильной сервисной станции на международной космической станции

Д. Клейман

Аннотация. *Был разработан процесс модификации поверхности металлизированных тефлоновых покрытий, используемых для тепловой защиты электронного оборудования на Международной космической станции [1]. Разработанный процесс модификации тефлоновых поверхностей существенно снизил зеркальность тефлоновых терморегулирующих пленок, покрытых Ag-Inconel, за счет изменения морфологического вида их поверхностей с помощью ионно-лучевого текстурирования контролируемым образом от металлического и блестящего до полностью молочно-белого. без существенного влияния на теплооптические свойства.*

Ряд единиц космического оборудования, покрытых текстурированным серебристо-тефлоновым покрытием, были подвергнуты воздействию открытого космоса в период с июня 2002 года по июнь 2006 года и доставлены обратно на Землю в конце 2006 года. Замечательные характеристики были продемонстрированы обработанным Ag / тефлоном с Значения солнечного поглощения и полного излучения, а также отношение α/ε остаются очень близкими к исходным значениям, измеренным до полетов [2].

В попытке дополнительно защитить текстурированные поверхности тефлона от возможной эрозии атомарным кислородом и ВУФ в среде LEO был разработан дополнительный новый процесс модификации поверхности, который создал структуру типа $Si_xO_yC_zF_n$ на обработанной поверхности. Текстурированные образцы тефлона до и после обработки поверхности были испытаны на космическом имитаторе в условиях комбинированного воздействия атомарного кислорода и вакуумного ультрафиолета. Для оценки свойств модифицированных пленок был использован ряд передовых методов характеризации [3].

Ключевые слова: *зеркальные свойства, металлизированных тефлоновых, сервисной станции.*

Зниження дзеркальних властивостей металізованих тефлонових покриттів на канадській мобільній станції обслуговування на міжнародній космічній станції

Джейкоб Клейман

Анотація. *Розроблено процес модифікації поверхні металізованих тефлонових покриттів, які використовуються для теплового захисту електронного обладнання на Міжнародній космічній станції [1]. Розроблений процес модифікації тефлонових поверхонь суттєво зменшив дзеркальність тефлонових термоконтрольних плівок із покриттям Ag-Inconel за рахунок зміни морфологічного вигляду їх поверхонь шляхом текстурування іонним пучком контрольованим способом від металевого і блискучого до повністю молочно-білого вигляду. без істотного впливу на тепло-оптичні властивості.*

Декілька космічних апаратних засобів, покритих текстурованим срібло-тефлоном, були піддані впливу відкритого космосу в період з червня 2002 року по червень 2006 року і доставлені назад на Землю в кінці 2006 року. Чудову продуктивність продемонстрував оброблений Ag / тефлон з значення сонячного поглинання та загального випромінювання, а також співвідношення α/ε залишаються дуже близькими до вихідних значень, виміряних перед польотами [2].

У спробі додатково захистити текстуровані поверхні тефлону від можливої ерозії атомарним киснем і VUV в середовищі LEO був розроблений додатковий новий процес модифікації поверхні, який створив структуру типу $Si_xO_yC_zF_n$ на обробленій поверхні. Текстуровані зразки тефлону до та після обробки поверхні були випробувані на симуляторі космічного простору під комбінованим впливом атомного кисню/вакуумного ультрафіолетового випромінювання. Для оцінки властивостей модифікованих плівок було використано ряд передових методів визначення характеристик [3].

Ключові слова: *дзеркальні властивості, металізованих тефлонових, станції обслуговування.*