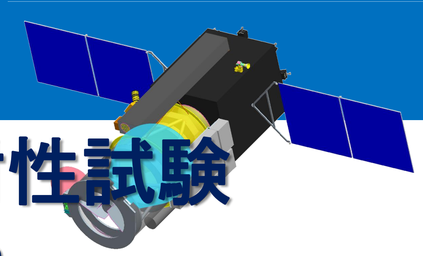

SOLAR-C搭載光学望遠鏡(SUVIT)用のコーティング宇宙環境耐性試験

Space Qualification Tests of Coatings for SOLAR-C Optical Telescope

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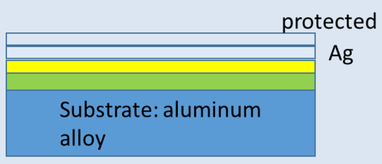
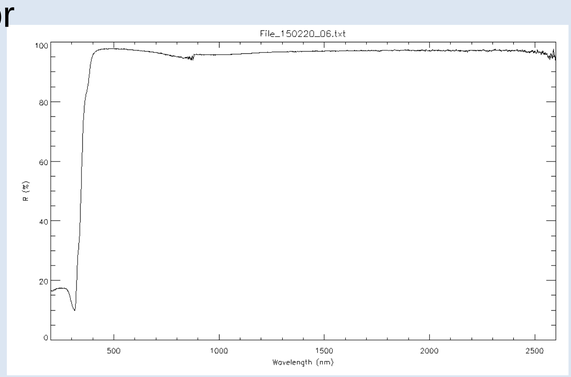
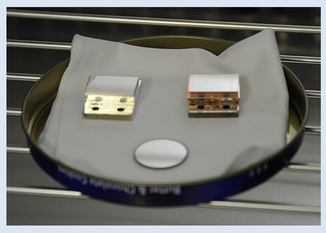
概要：次期太陽観測衛星SOLAR-C搭載の口径1m光学望遠鏡では、超増反射銀コーティング、金属鏡への保護膜付銀コーティング、バンドパスフィルターコーティングなど、開発要素のあるコーティングを多用する。このため、これらのコーティングの宇宙環境耐性試験（紫外線照射、放射線照射、温度サイクル、など）を行い、試験前後の分光透過（反射）率の変化を測定した。コーティング仕様と試験結果を報告する。

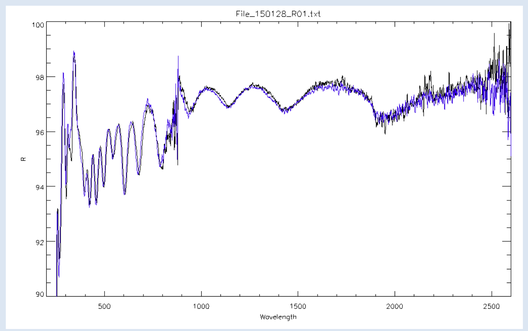
1. Space qualification tests of a Canon protected silver coating for metal mirror and a REOSC highly enhanced silver coating for SOLAR-C primary mirror





Reflectance of the protected silver coating for metal mirror by Canon.





Reflectance of the highly enhanced silver coating for SOLAR-C SUVIT primary mirror by REOSC.

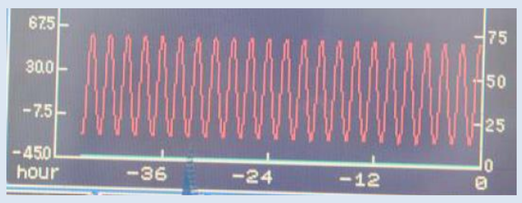
Test samples

Test samples which made of aluminum alloy plates (25x25 mm^2) and of the same surface structure as the actual metal mirrors were deposited with a protected silver coating by Canon. For test samples of highly enhanced silver coating, it was deposited on 1 inch diameter silica plate by REOSC.

Thermal cycling test

The samples were cycled 50 times through temperatures of: -25 degC to 60 degC in a dry air environment. The heating and cooling rates were 3 degC/min and the samples were held for 20 minutes at the high and low temperature ends.

ALMA恒温槽LH41-15P
23℃ → -25℃ (-3℃/min) stay 20min
-25℃ → 65℃ (3℃/min) stay 20min
65℃ → 23℃ (-3℃/min)
50 cycle



Humidity test

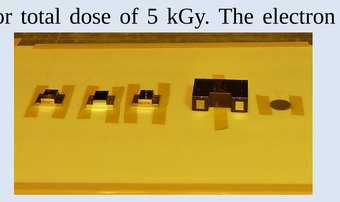
The samples put in a high humid constant temperature reservoir (humidity of 95% and temperature of 40 degC) for 48 hours.

Vacuum test

The samples were exposed in vacuum 10^{-4} Pa for 48 hours without thermal cycling

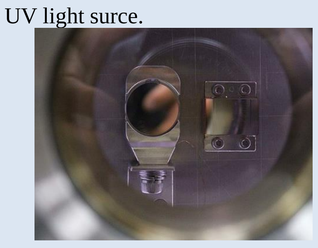
Radiation test

Test samples were exposed in an electron beam of 1 MeV energy for total dose of 5 kGy. The electron beam of this energy stops in a surface layer of the samples



UV irradiation test

The test samples were irradiated for 1867 ESH with 2-3 times solar UV light surce.



ISAS UV Irradiation Chamber

Reflectivity

The optical reflectance of the test samples was measured before and after the tests in the visible and NIR range (200-2600nm) using SHIMAZU UV-3100PC spectrophotometer with an integration sphere configuration to see any change in coating quality. Reflection angle was 12 degs.

Adhesive tape test

The test is performed after the tests mentioned above by applying a Scotch tape and attempting to lift the coating from the surface by lifting the tape to see any removal of surface layers. Note that the test was done without scratching a net structure on the surface of the coating,

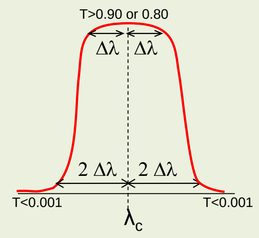
Test Item	Reflectivity	Tape test
Thermal cycling	No change	No removal
Humidity	No change	No removal
Vacuum exposure	No change	No removal
Electron beam radiation	No change	No removal
UV irradiation	No change	No removal

Both the protected silver coating on metal mirrors and the highly enhanced silver coating on silica plate passed the space qualification tests as summarized in the table

2. UV irradiation test of narrow-band blocking filters for SOLAR-C

Specifications in the test fabrication of the narrow-band blocking filters for SOLAR-C

Central wavelength λ_c	524.89 nm	1082.99 nm
Accuracy of the central wavelength λ_c	±0.08 nm (for Φ25.4 mm) Best effort (for Φ50 mm)	±0.16 nm (for Φ25.4 mm) Best effort (for Φ50 mm)
Transmission bandpass 2Δλ	0.56 nm	1.16 nm
Transmission in the bandpass $\lambda_c-\Delta\lambda < \lambda < \lambda_c+\Delta\lambda$	>0.80 (requirement) >0.85 (goal)	>0.90 (requirement) >0.92 (goal)
Transmission out of the bandpass $\lambda<\lambda_c-2\Delta\lambda$, $\lambda_c+2\Delta\lambda<\lambda$ in 480 – 1500 nm	<0.001	<0.001
Size, Quantity	QTY 5 : Φ25.4 mm (CA>Φ20 mm) QTY 1: Φ50 mm (CA>Φ45 mm)	QTY 5 : Φ25.4 mm (CA>Φ20 mm) QTY 1: Φ50 mm (CA>Φ45 mm)

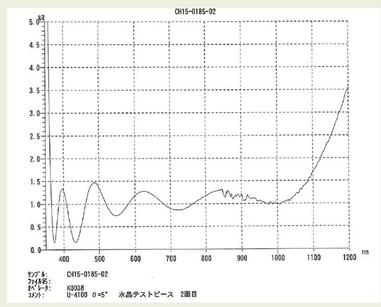


Base material: BK7
Incident beam: ~F/24
Thickness: 2 mm
Environment: 20 – 30 ° C in Space (Vacuum, but the above wavelengths are in air)
Use coating materials verified in space applications
Coating designs to be approved before coating

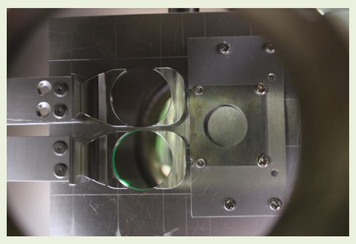
ARコーティング仕様

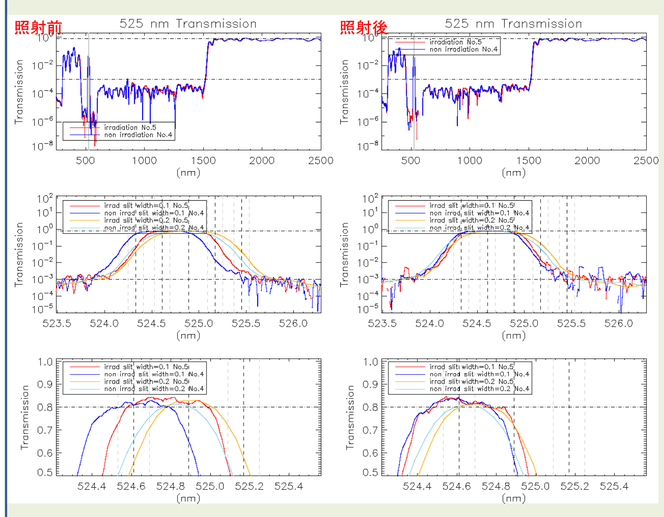
- 波長板 (水晶・サファイア)用ARコーティング
  ただし、評価用は石英基板使用
- 膜材料: Ta_2O_5/SiO_2、最外膜 MgF_2
- 反射率: < 1.8 %　@ 380 – 1100 nm

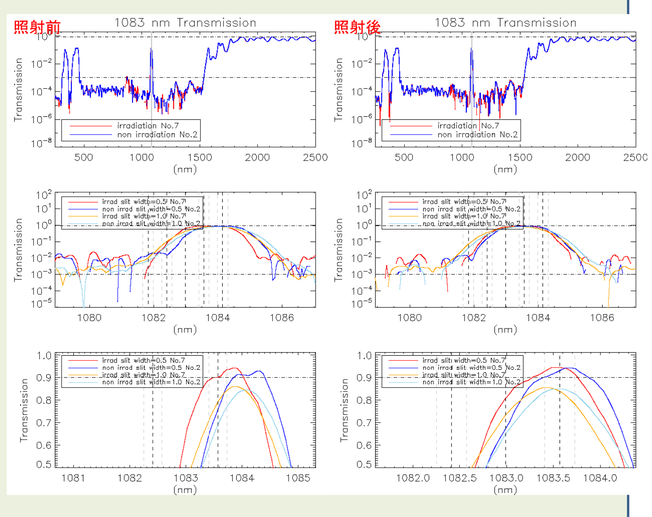
光学技研による反射率測定

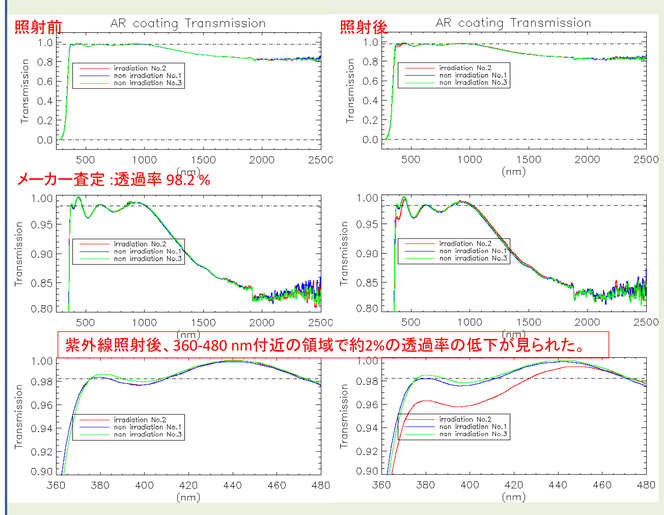


1. 照射強度測定
   Sensor: UV-25
   Pw (240-270 nm) = 0.5481 – 0.1935 = 0.3546 mW/cm^2 (1 solar) NASA TR R-351
2. 照射条件
   UV照射開始: 2016.01.25 18:40
   UV照射終了: 2016.03.08 17:56
   照射強度: 1〜 3 SC
   真空度: 1.5x10^{-4} Pa 以下
   温度: 56〜58° C (@サンプル固定治具)
3. 照射量
   1809.4 ESH

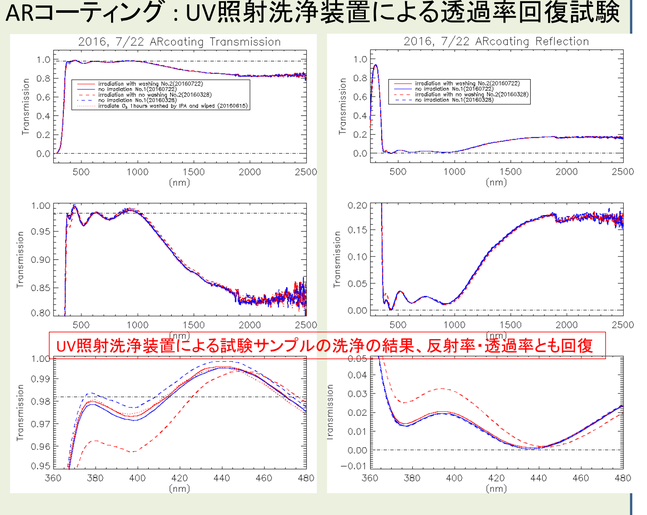








ARコーティング：UV照射洗浄装置による透過率回復試験



Summary

- 525, 1083 nm狭帯域フィルターでは紫外線照射前後で透過率の変化は見られなかった。
  >525, 1083 nmフィルターは紫外線照射前後でメーカー仕様を満たす。
- 波長板用ARコーティングについて、360 – 480 nm 照射前後で透過率の変化が2%見られた。
- ARコーティングの照射後サンプルを洗浄したところ、透過率・反射率とも回復することを確認した。よって、照射後の変化は表面に汚染物質が付着したことが原因と考えられる。ARコーティングそのものの紫外線照射劣化はほとんどないことを確認した。