CHARACTERIZATION OF SEALED THERMO-OPTICAL WHITE COATINGS ON ACTUAL FLIGHT PARTS INVOLVING NON-TACTILE DIGITAL MICROSCOPY

OUTLINE:

The joint ESA and JAXA mission BepiColombo is the first European mission to Mercury and is to be launched in mid-fall of 2018. The extreme and very aggressive environment requires thermal protection to maintain full functional performance of the spacecraft especially on heat exposed surfaces. Thermal coatings are the best lightweight and least complex solution for thermal control and heat reflective purposes.

MISSION REQUIREMENTS:

With a minimum solar distance of 0.3 AU the BepiColombo satellite will be exposed to extreme high temperatures and high irradiation. In its orbit around Mercury it will face the challenge of different types and direction of illumination and harsh radiation environment comprising:

- High UV, proton and electron irradiation and high temperatures
- Thermo-mechanical requirements: adhesion, no cracking
- Sufficient electrical surface conductivity to avoid discharge

THERMO-OPTICAL COATING V14 (Nanovation NV14):

CeraNovis has developed V14, a thermo-optical ceramic coating with low α (0.20) and high ε (0.88). The water-based non-toxic coating is used on various sun exposed Titanium surfaces of the satellite:

- Solar Array yoke sunshield box and edge protections/heat shields
- Sunshield and sunshield skirt
- Thruster cones
- Deployable Thermal Covers (DTCs)
- HGA main reflector and subreflector

V14 PROPERTIES:

The slurry based ceramic composition uses a potassium water glass as binder. The coating is applied by a usual spraying process and cured in a standard oven at 500°C in ambient atmosphere. BOL is α ≤ 0.2 and ε ≤ 0.8. The coating withstands 100 thermal cycles between -195°C and 500°C, thermal shock tests in liquid nitrogen, tape tests before and after cycling and HT UV tests. After long-term HT UV tests of 25,000 ESH at 420°C the ECL properties are well within the requirements with α ≤ 0.4 and ε ≤ 0.87 for the required temperature range.

CONTAMINATION:

In clean and contamination-free environment, V14 is stable under high vacuum and high UV load. But in the presence of contamination sources (such as decomposing silicones etc.), V14, due to its porous structure, might capture the volatile specimen which might carbonize under UV-thermal vacuum leading to a significant increase in α/ε-value.

CLEANING AND SEALING:

To protect the V14 surface, a patented glass-like thin sealing (in combination with an ozone cleaning step) has been developed which protects and cleans the V14 surface against potential contamination. This treatment renders the surface virtually unsusceptible against entrapment of organic species. ESA/ESTEC has performed a qualification campaign under VUV contamination atmosphere for sealed samples and it has been validated.

CeraNovis performed upscaling activities to apply the sealing on actual flight parts starting from sample level.

With such a sealing, the increase of a upon UV irradiation in thermal vacuum, is significantly reduced keeping the surface basically white and radiation-reflective. The flight part covered with the sealed V14 is thus cooler compared to an unsealed surface.

CONTROL / CHARACTERIZATION VIA DIGITAL MICROSCOPY:

The sealing is also applied via a sophisticated spraying method but control of overall presence, homogeneity, cracks and principal layer thickness on the actual part is essential. Visualization with small process/dummy witness samples is not sufficient. Thus a technique yielding non-tactile control of the V14 coating and its sealing via digital microscopy on actual coated real flight parts was developed. For this task, a digital microscope with a 3D-mobile jointed arm equipped with an attached objective lens is used.

RESULTS / SUMMARY:

The sealed flight parts were directly examined via the jointed arm without the need to touch the surface. The sealing could be very well differentiated from an unsealed surface. No cracks or visible flaws could be found within the sealed structure.

As conclusion it can be stated that sealing is a very good method to protect a thermo-optical coating against external contamination. The efficacy and homogeneity of the sealed surface can be verified directly, non-tactile and destruction-free with a digital microscope equipped with a mobile device. This device allows to directly examine the surface of larger objects without the need to use witness/dummy samples.

The described technique is generally suitable to verify coated surfaces of any spacecraft.