DEVELOPMENT OF A HIGH TEMPERATURE BLACK COATING FOR SPACE APPLICATION

Guillaume Sierra(1), Stéphane Solé(2), Dinis Sacramento(3), Sophie Perraud(4), Pascale Nabarra(5), Stéphanie Remaury(6)

(1) MAP, ZI - 2 Rue Clément Ader, 09100 Pamiers, France, g.sierra@map-coatings.com
(2) MAP, ZI - 2 Rue Clément Ader, 09100 Pamiers, France, s.sole@map-coatings.com
(3) MAP, ZI - 2 Rue Clément Ader, 09100 Pamiers, France, d.sacramento@map-coatings.com
(4) CNES, Centre National d’Etudes Spatiales - 18, avenue Edouard Belin - 31401 TOULOUSE Cedex 9, France, Sophie.Perraud@cnes.fr
(5) CNES, Centre National d’Etudes Spatiales - 18, avenue Edouard Belin - 31401 TOULOUSE Cedex 9, France, Pascale.Nabarra@cnes.fr
(6) CNES, Centre National d’Etudes Spatiales - 18, avenue Edouard Belin - 31401 TOULOUSE Cedex 9, France, Stephanie.Remaury@cnes.fr

ABSTRACT

In the last years, several missions close to the sun have highlighted the low number of thermal control coatings that can withstand temperatures of around 400 °C and a large flow of charged particles. Based upon this observation, CNES and MAP have therefore decided to develop a coating that can withstand this extreme environment while remaining compatible with “paint” technology.

These coatings have to withstand high temperatures, the adhesion has to be compliant on the following specific metallic substrates used for high temperatures uses: TA6V, INOX 304L or INCONEL 600 for instance. Moreover to these specificities, the following ones common for all the coatings dedicated to space application have to be validated: compliance versus ECSS-Q-ST-70-02C, resistance under thermal vacuum cycling tests, adhesion versus ISO 2409 standard, high solar absorptivity (αs) and infrared emissivity (ε). In order to avoid any electrostatic risk, it has been decided to develop an antistatic coating which is defined by an electrical surface resistance Rs < 1 MΩ/□.

Regarding the requirements, it has been decided to select a silicon polymer for this coating. Indeed, silicon has the better behaviour under high temperature compared to other polymers such as polyurethane, epoxide or others standards organic materials.

The initial properties of the coating were the following:

- αs = 0.96 +/- 0.02 and ε = 0.89 +/- 0.03
- Rs = 9.1 kΩ/□ and ρ = 14.4 kΩ/□
- TIS 4.51%  
- TML = 0.13 %, RML = 0.05 % and CVCM = 0.00 %

At the initial state, the adhesion of the coating was defined as 0 or 1 class depending upon the substrates.

All the thermal cycling tests performed under vacuum in the temperature range of -170°C to 400°C were compliant and did not show any change in the thermo-optical properties nor electrical surface resistance nor adhesion.

Cumulative damp heat test + thermal cycling tests were also performed and were compliant to the requirements.

GEO simulated environmental tests were carried out at ONERA laboratory. A three years GEO exposure was simulated; this exposition is composed of the following: 1133 equivalent solar hours (ESH) of UV + 1.1015 electrons/cm² of energy 400 keV + 2.1015 protons/cm² of energy 240 keV + 2.1015 protons/cm² of energy 45 keV. After an exposition of three years simulated GEO the solar absorptivity of the coating was increased of 0.01 whereas infrared emissivity was not changed.

ESD tests were also carried out at ONERA with monoenergy or multienergy irradiation. The electrical surface potential is measured during the irradiation and relaxation phase. The results are listed hereunder:

<table>
<thead>
<tr>
<th>Test</th>
<th>Mono energy flux</th>
<th>Multi energy flux</th>
</tr>
</thead>
<tbody>
<tr>
<td>T (°C)</td>
<td>-150</td>
<td>-80</td>
</tr>
<tr>
<td>Surface potential (V)</td>
<td>1 - 2</td>
<td>&lt; 3</td>
</tr>
</tbody>
</table>

For the temperatures used during this test and for the used fluxes, the electrical surface potential is under 1000 V which gives a complete compliance versus ESD risk.

Finally, a new high temperature coating called MAP® HT 1607 has been successfully developed.