

## ***06/9401 Active Coating for Position and Attitude Control***

Type of activity: Medium Study (4 months, 25 KEUR)

### **Background and Motivation**

The idea of modulating the action of the Solar Radiation Pressure (SRP) upon the surface of a spacecraft for attitude and orbital control has been around for decades and has already been implemented on several space missions using different engineering schemes.

In principle, the attitude of a spacecraft can be controlled by tuning the position of its center of pressure (CP) with respect to the center of mass (CM) in order to generate the required attitude control torque. This scheme is quite popular for controlling large lightweight structures like solar-sails, where the large surface to mass ratio makes it particularly effective [1] but has also been proposed as a general alternative to reaction-wheel- and thruster-based attitude control system to limit the onset of broadband vibrations, increase reliability and save fuel mass [2].

Commonly proposed implementations of a CP-CM shift involve, for example, changing the sun aspect angle or the position of certain surface areas to trim their contributions to the net torque on the S/C or moving masses inside the S/C to change its inertial properties. These schemes have the clear disadvantage of introducing possible failure points and increasing the overall complexity of the system. Moreover, they have limited control bandwidth and tend to generate harmful vibrations.

Only recently [4] new solutions have been considered utilizing electrochromic materials to change the reflective properties of surfaces and therefore provide a modulation of solar radiation torque without moving parts. Electrochromic materials have found many commercial applications, among them the well known 'smart windows'.

Nevertheless electrochromic materials suffer from a major drawback: a non-negligible amount of power is needed to keep the surface on a fixed reflective state, with a considerable increase in power use depending on the rate of change of the optical properties of the controlled surface. This fact limits the efficiency and bandwidth achievable by any attitude control system based on electrochromic surfaces.

A potential improvement in the performance of active chromatic surfaces for space applications may come from the latest advances in the field of microparticle-based displays, which exploit a bistability property to dramatically reduce power usage [6]. This property can be obtained, for example, by confining microparticles with different optical properties and charges in a colloidal suspension and migrating towards and away from the illuminated surface with the aid of an external electric field.

While considerable progress is being made towards commercial applications of active display technology (e.g. portable electronic papers), nothing has been done to address the feasibility of the same technology for space applications and the necessary design modification to improve their performance as control actuators.

## Research and Study Objectives

The objectives of the study are:

1. To carry out a review about the state of the art of active chromatic devices (electrochromic, electrophoretic, cholesteric, others), with an emphasis on European research. The review should give solid references for mechanical and thermal properties, power consumption, range of obtainable optical variation, control bandwidth, technological readiness, cost.
2. To address reliability and lifetime issues of active coatings in the space environment including:
  1. Radiation hardness of materials used in active chromatic surface (e.g. semiconductor polymers, electrophoretic material).
  2. Temperature sensitivity of the devices.
  3. Degradation over time.
3. To propose, in collaboration with ACT, design variations of the most promising active chromatic devices, in order to optimise their performance as space actuators.

## References

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- [5] M. Granmar and A. Cho, "Electronic Paper: A Revolution About to Unfold?", Science, Vol 308, pp785-786, 2005.
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