Thales SESO Silver coatings for Space programs

Patrick Robert[1], Christian Du Jeu[1], Cédric Cammarata[1] , Mailys Thorigny[1], Karine Mathieu[2], Matthieu Tatat[2], Vincent Costes[2], Fabrice Champandard[3], Aurélien Suau[3], Guillaume Briche[3], Jean-François Blanc[3]

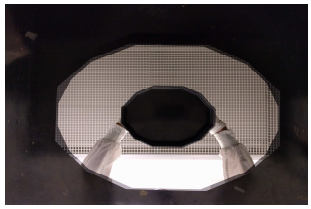
[1] Thales-SESO, 530 rue Frédéric Joliot 13290 Aix-les-Milles, France - [2] CNES, 18 avenue Edouard Belin, 31400 Toulouse, France - [3]Thales Alenia Space, 5 Allée des Gabians, 06150 Cannes, France

PURPOSE

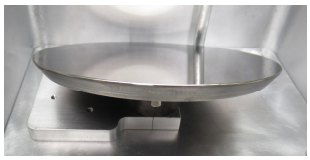
Thales SESO has already produced more than 166 total space mirrors from which 105 are flying successfully some for decades. Most of them (more than 90%) are coated with Thales SESO protected silver coatings.

DESIGN CONSTRAINTS

- Space applications ➔ high resistance to radiation and ATOX
- High reflectivity
  - Different wavelength ranges from 400 nm to more than 14 µm, with reflectance above 96% from 450 nm up.
  - Incident angles ranging from 0° to 63 °
- High uniformity
  - For mirror size up to 1.7 m diameter
  - Uniformity lower than 10% on layer thickness inducing variation in reflectance less than 0.5% over corresponding range



Silver coated scan SiC mirror



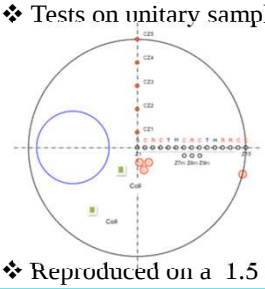
Silver coated scan Ni plated beryllium mirror

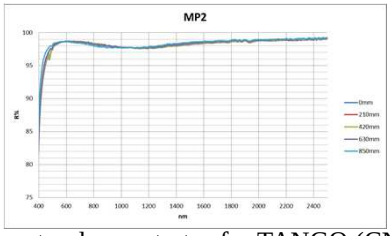
RESISTANCE TO HARSH ENVIRONMENT

- Flight conditions
  - Radiation resistance : > 70 Mrad
  - ATOX resistance : > 2.4 10^{21} at/cm²
  - Insensitive to vacuum conditions (no WFE change of the coated mirror)
  - Sun resistance up to 99 Solar Constants
- Ground, AIT and storage conditions
  - Cleanable coating, high adhesion
  - High resistance to thermal and humidity environment
    - Temperature down to liquid N2 and up to 70°C
    - Humidity 95%, 24 H, 50°C

HIGH UNIFORMITY

- Tests on unitary samples distributed over the radius of the chamber





- Reproduced on a 1.5 m diameter demonstrator for TANGO (CNES program)

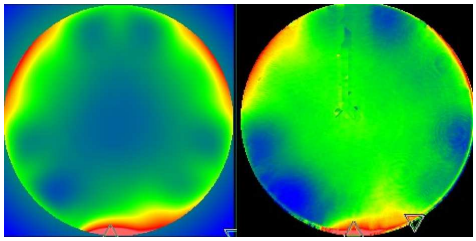
TANGO zerodur M1 silver coated mirror during testing at TAS

ENHANCED DURABILITY – COMPATIBILITY WITH GLUED ASSEMBLIES

- Part of the last improvement as supported by CNES and TAS was related to enhanced adhesion resistance
  - Adhesion was demonstrated at sample level (distributed over the complete radius of the chamber)
  - It was confirmed with more than 40 testing on windows coated on a radius of the chamber
- The preparation/coating process was also improved to allow coating assemblies including
  - Glass to glass bonding
  - Mechanical parts to glass bonding
  - This allows reducing overall mirror assembly manufacturing timeline
- Thales SESO protected silver coatings have been qualified on different substrates such as
  - Zerodur, fused silica, SiC, Nickel plated Beryllium or aluminum, …

ACCURATE WFE PREDICTION

- WFE impact of the coating is simulated by finite element modeling.
- Last improvement allowed to reduce by 30% the coating induced WFE change
- Measurement on lightweighted mockup is in line with updated prevision which allow a good anticipation in the polishing process
- After coating, the WFE remains stable when going to vacuum



Simulated WFE map Measured WFE map

CONCLUSION : HIGH DURABILITY, HIGH EFFICIENCY PROTECTED SILVER COATINGS FOR SPACE

- **Thales SESO has a long proven knowledge in protected silver coatings for space**
- **Thanks to CNES and TAS support Thales SESO still has improved the performances of this type of coating**
  - **Highest durability (mainly adhesion improvement)**
  - **Lower impact on WFE, inducing lower prediction residual error**
  - **Compatibility with glued assemblies (glass to glass and mechanics to glass)**
- **Such coatings can be applied on many different substrates and for size up to 1700 mm diameter with minimum uniformity variation (< 0.5 % on reflectance)**