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Analytical Chemistry and Materials Development Group 3531

Thermal and Propulsion Section 3530

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Subject: LIGO Mirror: Molecular Contamination Analysis

Purpose

Mirror surfaces were sampled using solvent wipes. This was to determine the level and identity of molecular contamination on the surface. A reference mirror (ITM 04) and the ITM 07 mirror were analyzed.

Method

The analytical swabs consisted of dichloromethane (pre-tested) with specially extracted fiber free lens tissue. The areas sampled were ½ of the 25cm diameter mirror or 245 square centimeters. The swab was slowly passed over the surface 3 times. The low volatility residue (LVR) was analyzed using Diffuse Reflectance/ Fourier Transform Infrared (DRIFT/FTIR) spectroscopy. FTIR provides chemical functional group information for quantitative analysis and qualitative identification of materials. The analysis followed the ACL-120 procedure that complies with Mil-STD-1246C Notice 3 and is sensitive to the most stringent level (A/100).

Results

Only minor, trace levels of hydrocarbon oil and plasticizer (diallyl phthalate) were removed. The levels may be bounded to a monolayer thickness or less on the mirror surfaces.

Sample Location	Chemical Functional Group	Amount micro-grams/cm^2
Reference mirror ITM 04	Aliphatic hydrocarbon, Trace Ester	~0.01
Mirror ITM 07	Aliphatic hydrocarbon, Diallyl Phthalate	0.02

Note: This is dially phthalate or a mixture of similar ester based plasticizers that are used in many plastics. Aliphatic hydrocarbons are common oil with a distribution of branched and straight chain alkanes. A 1.0 microgram per square centimeter level is a 10-nanometer (nm) average film thickness for a residue with a density of 1.0. A rule of thumb is a monolayer is ~1 nm.

Discussion

The mirror surfaces were relatively clean in terms of molecular contamination. Approximately a monolayer level of oily contamination is typical for surfaces stored in a clean room. The optical attenuation effect of this level of contamination in the 1-micron wavelength region should be negligible.

There was visible dust removed by the swabs that is not quantitatively detected by this method (unless it dissolves in the solvent). The optical attenuation by visible levels of dust may be significant. This is best characterized by direct optical measurements or by particle size counting to estimate the surface obscuration by the dust.