



4ITM07 Postmortem

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LSC Meeting - March 2006



4ITM07 removed from H1 June 2005

Found in analysis of H1 (LIGO-T050074-01)

For ITM07:

Coating absorption

13 ppm

(If all power is absorbed there)

Absorption in substrate

42 ppm/cm

(If all power is absorbed there)

Typical numbers for reference:

Typical Absorption in HR Coating

1 ppm

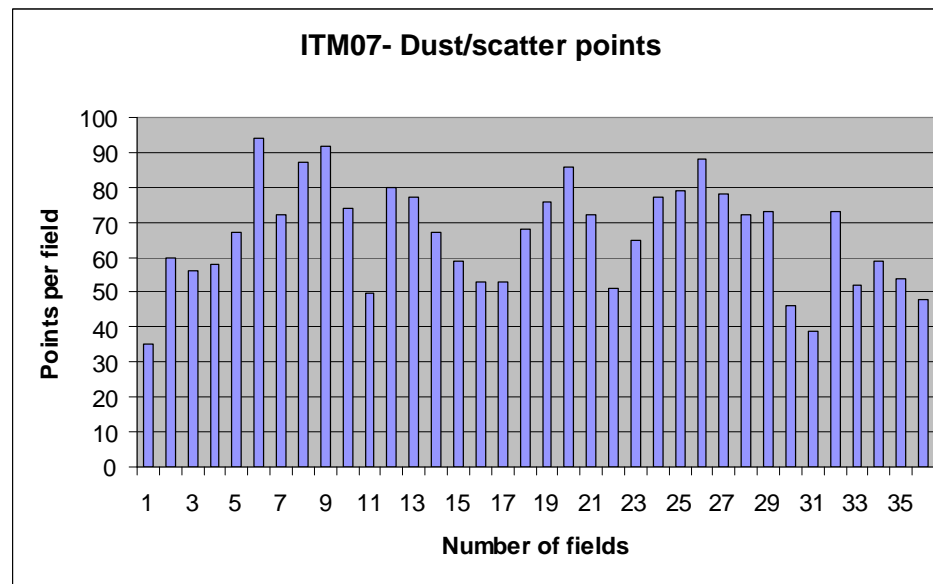
Typical Absorption in Fused Silica

4 ppm/cm



Point Defects / Dust on 4ITM07 - Ref.: T050117-00

- Dark Field Microscope at Caltech
- 4mm field of view – 36 readings across the optic
- The point defects ranged from < 5 micrometers to 19 micrometers in dia., most falling into the < 5 micrometers category.
- Magnification 5x.



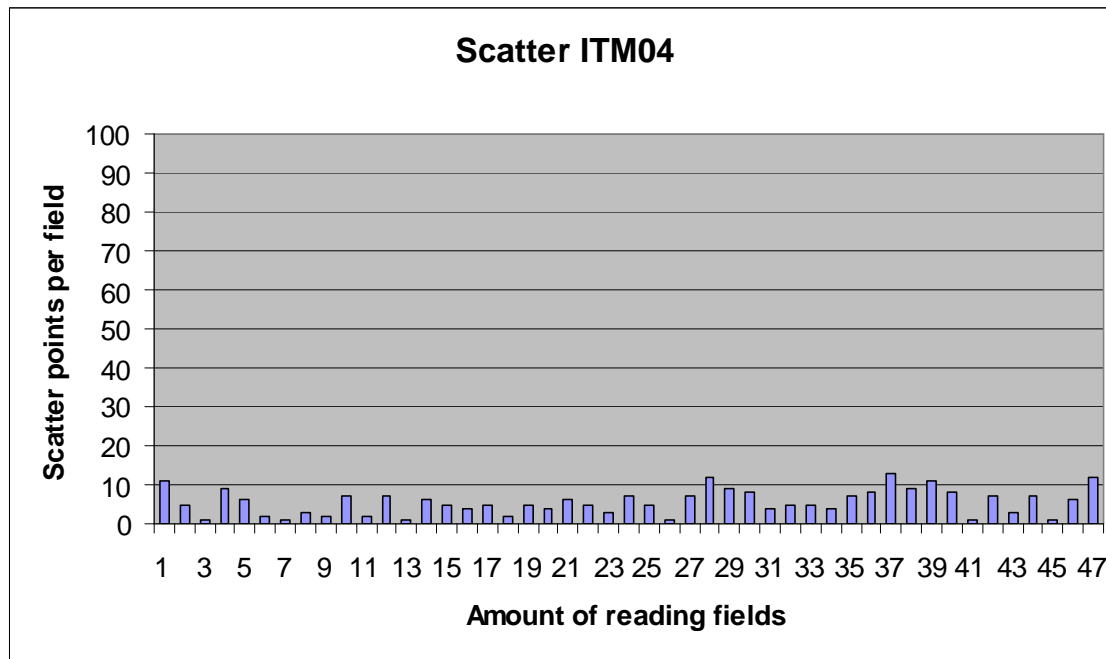
LIGO-G060040-00



Comparison with ITM04 just cleaned

ITM07, points per field of view: 35 minimum; maximum 94 (36 readings)

ITM04, points per field of view: 1 minimum; 13 maximum (47 readings)





FTIR Analysis

Ref.: T060029-00-D

- **Method**

The analytical swabs consisted of dichloromethane (pre-tested). The areas sampled were $\frac{1}{2}$ 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 2ITM04	Aliphatic hydrocarbon, trace Ester	~0.01
2ITM04 HR edge 2	Diallyl Phthalate	~0.02
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.



Report

- 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.



Particle Contamination

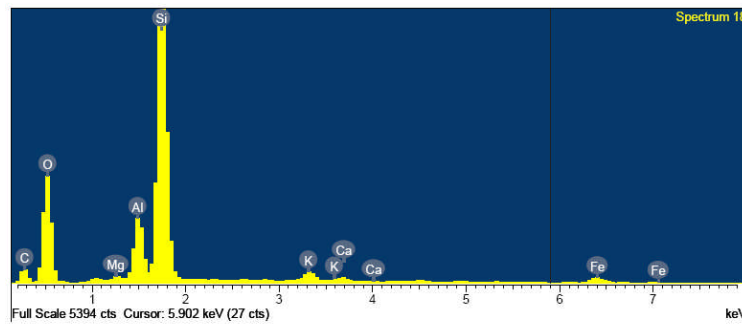
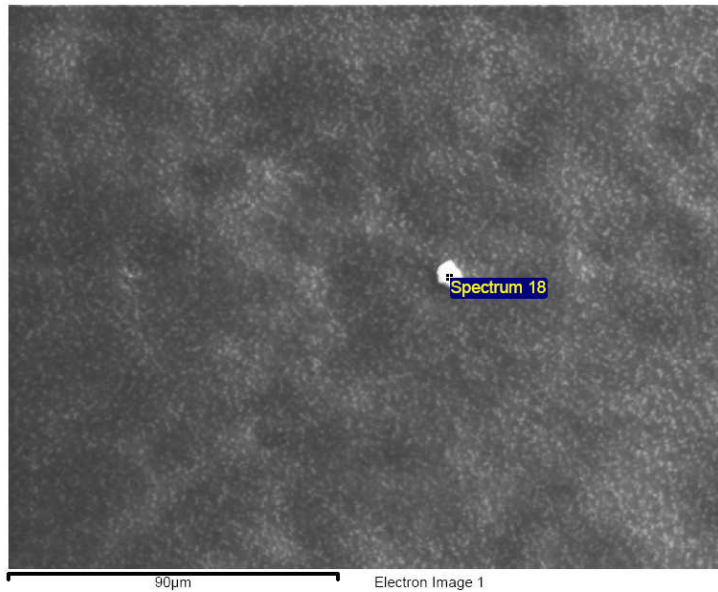
Ref.:LIGO-T060061-00-D

Evans Analytical Labs. provided 12 mm dia.“stubs” covered with carbon tape. The tape was pressed on the mirror’s surface twice and sent to the lab.

They used an Energy-Dispersive Spectrometer (EDS) for element identification which is a solid state device that discriminates among X-ray energies.

Particle Contamination

1 of 30



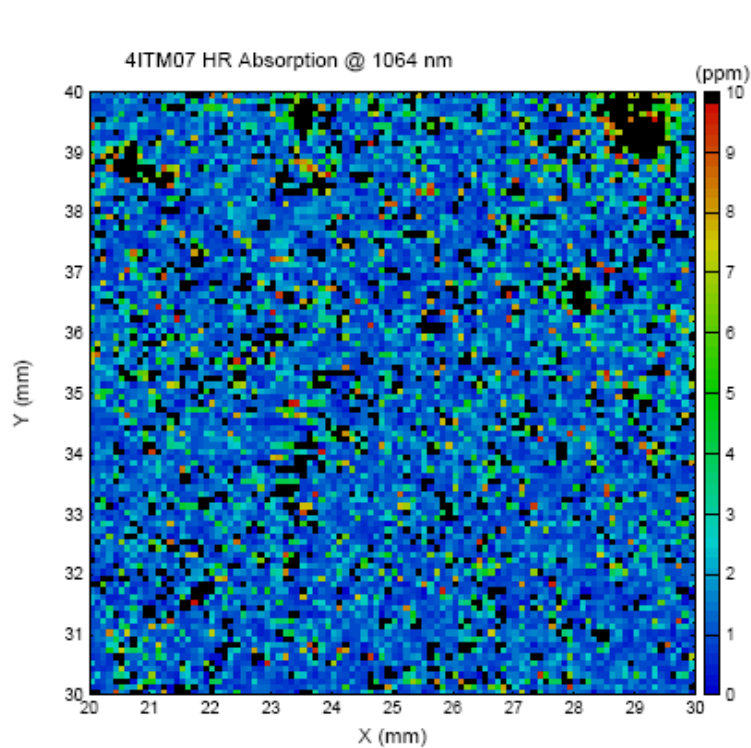


Particle Contamination

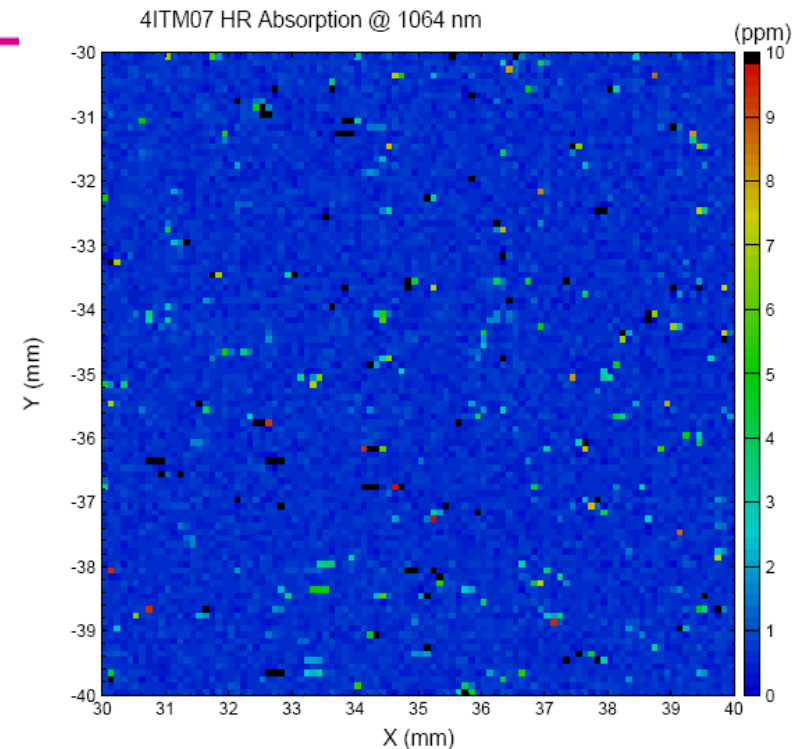
From Bill Kells analysis:

“I assume that in stamping the HR surface all particulates "stuck". The HR surface was stamped twice. Disregard all "foil shard" images. Glancing through the images, I conclude a fair mean "blob" size is $\sim 10 \times 10$ micrometers. Then taking the actual number of "blobs" in the scanned area (0.85 cm^2) to be 50 gives a total HR surface obscuration of $\sim 30 \text{ ppm}$. **Taking $\sim 10\%$ as "foil shards, and guessing $1/2$ the remainder to be the "culprit" absorbing population would result in a mean HR absorption of 13 ppm** (I believe that all this really serves to indicate is how very sensitive we are to sparse contamination of some highly absorptive species !).”

Absorption Scan at Caltech



Before Cleaning (mean 11.87)



After Cleaning (mean 1.023)

The calibration was done with a 19ppm 1" dia. mirror. With this calibration, one contamination cavity mirror was also checked, its absorption is about 0.4 ppm, which is basically consistent with our contamination measurement, ~0.5ppm.



Conclusion and Recommendations

- The 4K ITM incident appears to be an anomalous occurrence.
- Absorbing contaminant is easily cleaned off the optic
- Cannot yet say if there is or is not an absorbing film in the background.
- Must establish a way to monitor the vacuum quality of the chambers (Calibrated RGA and/or quartz micro-balance monitor).

RGA scanning is currently available on each isolatable volume. They do not run during “science runs”. Set for 100 AMU lines usable at high vacuum. Setup and calibration preparations require great care so not to contaminate vacuum and requires close scrutinizing by qualified personnel. ✓ Done

- Repeat cavity measurements to confirm that the high absorption was caused by the ITM's. ✓ Done
- Repeat scatter measurements (B.Kells) now and on an ongoing basis. ✓ Done