NASA TECH BRIEF

Optical Contamination During Thermal Testing in Vacuum

Comparative tests on in-vacuum optics degradation were conducted for vacuum systems served by either an oil-type or an ion-type pumping operation. Within large vacuum systems the contaminants usually consist of backstreaming hydrocarbons originating from mechanical roughing pumps and oil-diffusion pumps; in ion-pumped systems they can originate from saturated ion pumps where trapped gases are liberated by continued pumping.

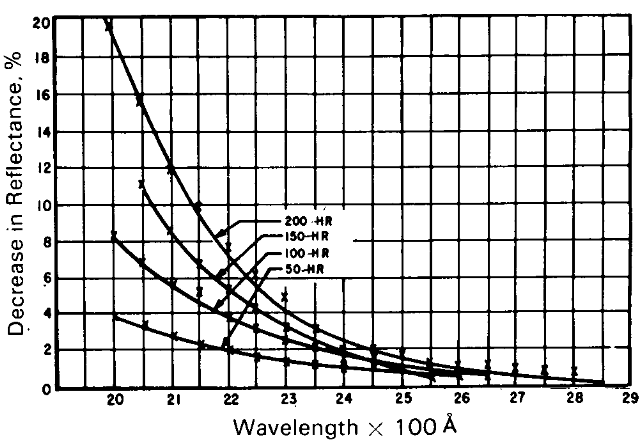

Figure 1. Decrease in Reflectance in an Oil System by UV Exposure

The results showed that degradation occurs only during ultraviolet irradiation (wavelengths shorter than 0.3μ) in vacuum systems with oil-type pumping systems and that it increases with exposure time (Fig. 1). It does not occur with oil-free (ion) systems. The electron microscope showed that the contaminant formed a homogeneous layer covered with larger particles ranging in size from ≤ 0.5 to 50μ.

In the oil-vacuum system (Fig. 2), a Welch mechanical roughing pump in conjunction with a Roots blower lowered the pressure to about 1.3 N/m^2 (10μ-Hg). It was lowered further, to about 13.33×10^{-5} N/m^2 (10^{-7} torr), by an oil-diffusion pump with two traps: an optical one, and one cooled by liquid nitrogen.

The ion system (Fig. 2) included three sorption roughing pumps cooled by liquid nitrogen, ion pumps, and a titanium-sublimation pump that was not used during the contamination tests. Samples in both vacuums were exposed to radiation. High-pressure mercury-arc lamps and high-pressure xenon or infrared lamps were used as the radiation sources.

Optical degradation was measured using six mirrors: two in each of the oil and ion systems, and two for controls. With a scanning spectroreflectometer, changes in reflectance were determined by comparing reflected energies of exposed and control mirrors. With the oil system, changes in reflectance were generally determined every 50 hr during $\leq$200-hr irradiation in vacuum; wavelength coverage was from 0.2 to 2.8μ. Identical treatment in the ion system showed no measurable effect ($<0.5\%$).

It is shown that even a carefully operated, typical oil system can effect contamination, and that a typical ion system with sorption-roughing pumps does not cause optical degradation. Optical damage is apparent only from wavelengths shorter than 0.3μ, and increases at shorter wavelengths, at least down to 0.2μ. Damage is not measurable in the infrared region up to 2.8μ.

Ultraviolet radiation is necessary for degradation, but not contaminant condensation, to occur on the surface and be converted to a degrader by subsequent ultraviolet radiation. Mirrors in an oil system were

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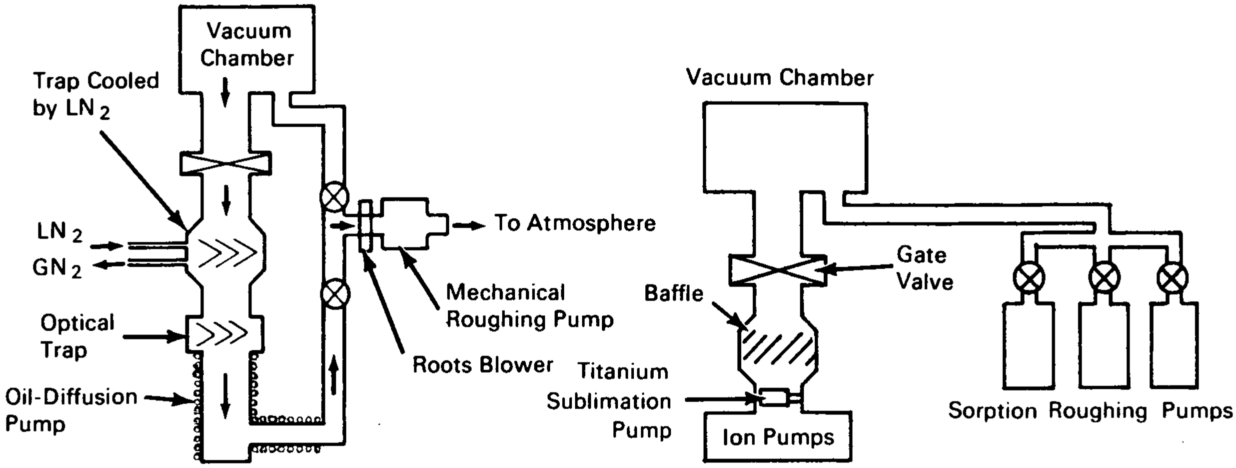

Figure 2. Diagrams of Oil and Ion Vacuum Systems

first exposed to 50-hr infrared irradiation without detectable change in reflectance. When the same mirrors were then subjected to 50-hr ultraviolet irradiation in an ion system, their reflectance was reduced by 6.5%.

Note:

Requests for further information may be directed to:

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No patent action is contemplated by NASA.

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