View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by NASA Technical Reports Server

Effect of charging electron exposure on 1064nm transmission through bare sapphire optics and SiO_2 over HfO_2 AR-coated sapphire optics.

Brian P. Ottens[1+], Joseph Connelly[1], Stephen Brown[1], James Roeder[2], Lonny Kauder[1], John Cavanaugh[1]

Abstract

Experiments measuring the effect of electron exposure on 1064nm transmission for optical sapphire were conducted. Detailed before and after inspections did not identify any resulting Litchenburg patterns. Pre- and post-exposure 1064nm transmission measurements are compared.

Keywords: Space-based laser altimeter, sapphire optics, 1064nm optics, SiO_2 and HfO_2 AR coating, LOLA, MLA, radiation belt effects, space charging

Introduction

Once launched, the Lunar Orbiter Laser Altimeter (LOLA), an instrument on NASA's Lunar Reconnaissance Orbiter (LRO), will provide a precise global lunar topographic map using laser altimetry[1]. During lunar transit, LOLA will encounter charging environments, energetic enough to charge surfaces and substrates, and that charging (or a resulting discharge) could potentially effect the performance of the instrument.

The specific potential performance effect is damage to the function of the optic, possibly through a chemical reaction, loss of material, or Lichtenburg pattern. For LOLA, these phenomena would effect optical performance through a transmission loss at 1064nm.

The samples used were (A) ISP, Inc sapphire with Quality Thin Films SiO_2 over HfO_2 AR coating and (B) Meller Optics sapphire with no AR coating. Both were approximately 5.25" diam. Sample A was 0.488" thick and sample B was 0.457" thick. Sample A was selected because of its similarity to the LOLA coating supplier, and sample B was selected because of its similarity to the LOLA sapphire supplier. The samples were not held in identical brackets and sample A was part of a multi-lens assembly, so the samples cannot be compared side-by-side. However, a third assembly, identical to the assembly used in sample A was available and not exposed to charging electrons, so it was used as a control sample.

Configuration

To measure pre- and post-exposure transmission, an integrating sphere, 1064 +/-5nm FWHM filter, power meter, and right-angle bracket were configured as in figure 1. Intensity measurements were recorded for each sample (including control sample).

[1] Applied Engineering and Technology Directorate, NASA Goddard Space Flight Center, Greenbelt, MD 20771
[2] The Aerospace Corporation Mail, Los Angeles, CA 90009
[+]Presenting Author. phone: (301)286-3091, (fax 301)286-1763, Brian.Ottens@nasa.gov

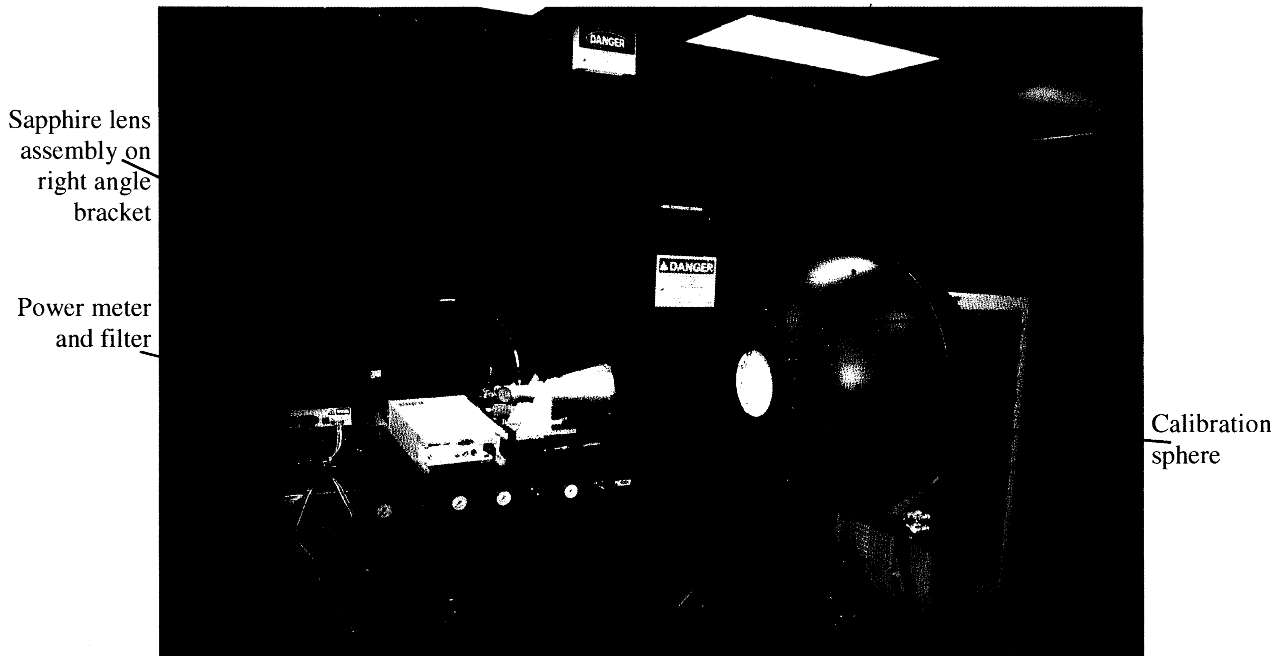

Figure 1 – Setup for the Transmission Measurement

A pre-exposure inspection was also conducted to identify the state of the samples under test. It revealed no significant anomalies.

After pre-exposure inspections and measurements, sample A was exposed to 10 keV electrons in the NASA Goddard Contamination and Coatings Branch Electrostatic Chamber and sample B was exposed to 1 MeV electrons at the NASA Goddard Radiation Effects Facility. Dosing for sample A was 1 nA/sq cm for 2 hours and dosing for sample B was 8×10^6 e-/sq cm-sec for 5 hours. One inch diameter x 0.5" thick, bare-sapphire witness samples were placed in the chamber but blocked from the electron beam to bound possible effects of contamination. The witness sample was measured using an automatic transmission spectrometer.

A photograph of sample A inside the chamber is shown in figure 2 and a photograph of sample B inside the chamber is shown in figure 3.

To monitor possible discharge events, a current monitor was placed between the metal housing and ground. For sample A, it was implemented via an off-the-shelf current probe, amplifier, and oscilloscope. Events were triggered at 30A on the oscilloscope. For sample B, it was connected to an integrator and logged approx every 200msec through LABView

Results

Approximately 4 major spikes in the current monitor were seen for during sample B exposure. A plot of current vs. time for that exposure is given in figure 4. No events >30A were seen during sample A exposure, therefore no graphics of scope triggers are presented.

Once exposure was complete, a post-exposure inspection was immediately conducted. This eliminated any possible transportation damage from being attributed to electron exposure. It revealed no identifiable changes in the surface or bulk of the material for either sample.

Optical measurements were then conducted for all samples, with results given in table 1. Total measurement uncertainty for exposed samples is estimated at 2% and 1% for the witness samples. Transmission effects were within or very close to those bounds.

Conclusion and Acknowledgements

Four major and 1 minor discharge events are believed to have occurred during 1 MeV exposure and no discharge events were seen during 10 keV exposure. Transmission loss and Lichtenburg patterns, if any, due to electron exposure are believed to be very slight.

The authors would like to thank Jay Smith, Henning Leidecker, Luis Ramos-Izquierdo, and Ed Wollack at NASA Goddard for their guidance and support.

References

[1] Haris Riris et al. The lunar orbiter laser altimeter (LOLA) on NASA's lunar reconnaissance orbiter (LRO) mission. Proc. SPIE Int. Soc. Opt. Eng. 6555-6563, 65550I (2007).

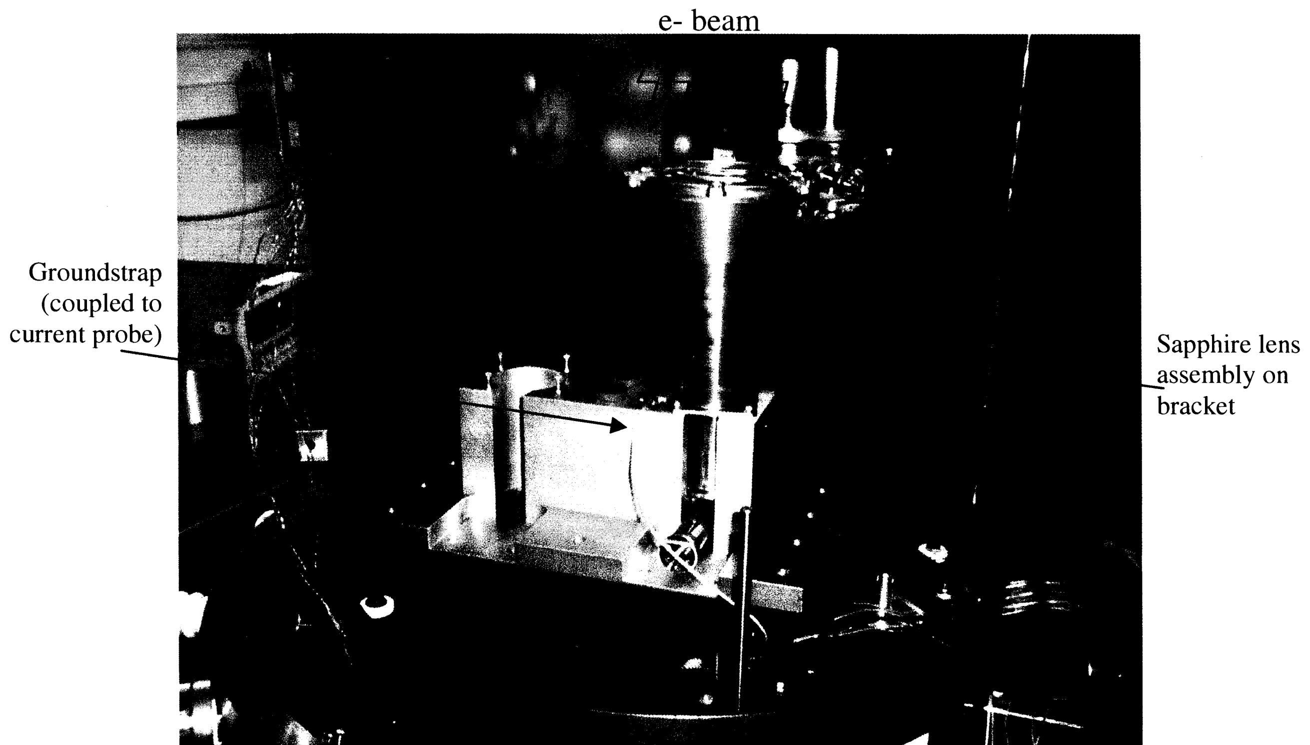

Figure 2 – Sample A prior to 10 keV exposure

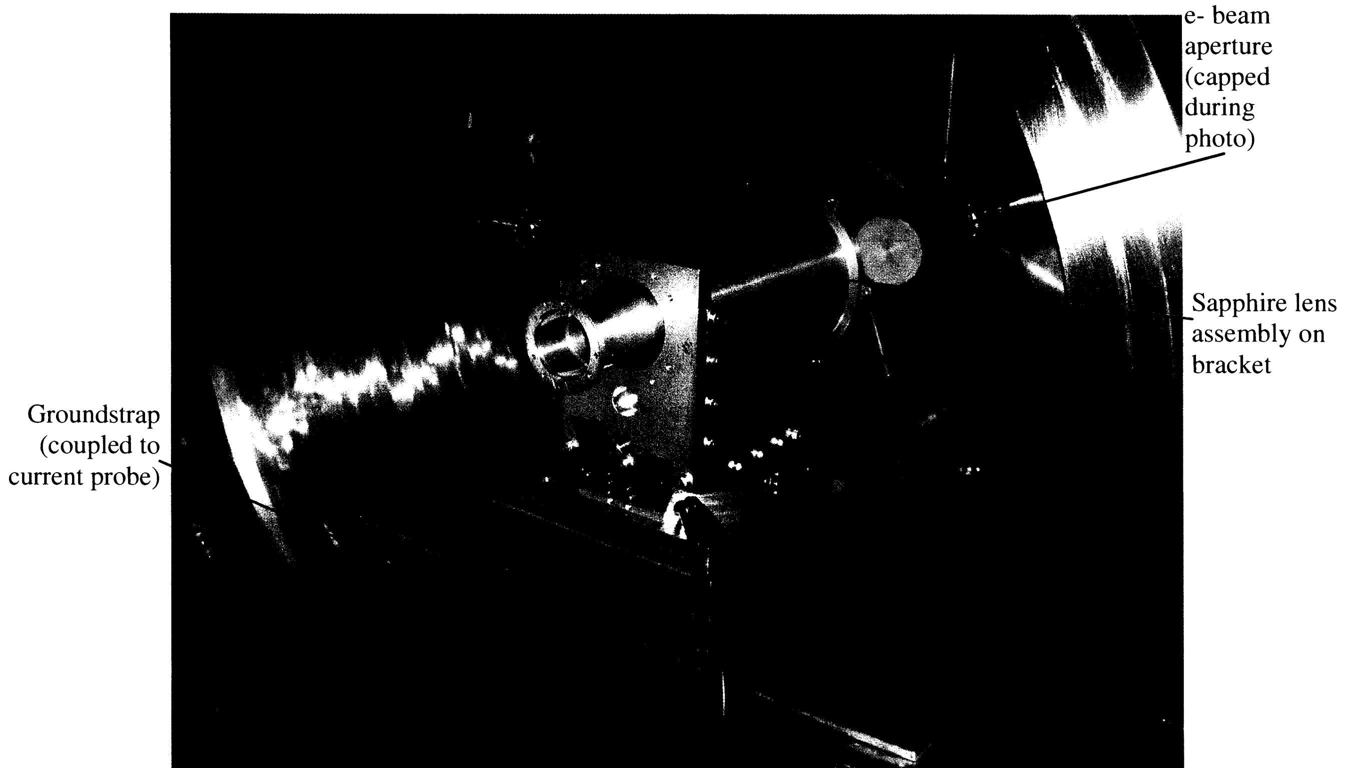

Figure 3 – Sample B prior to 1 MeV exposure

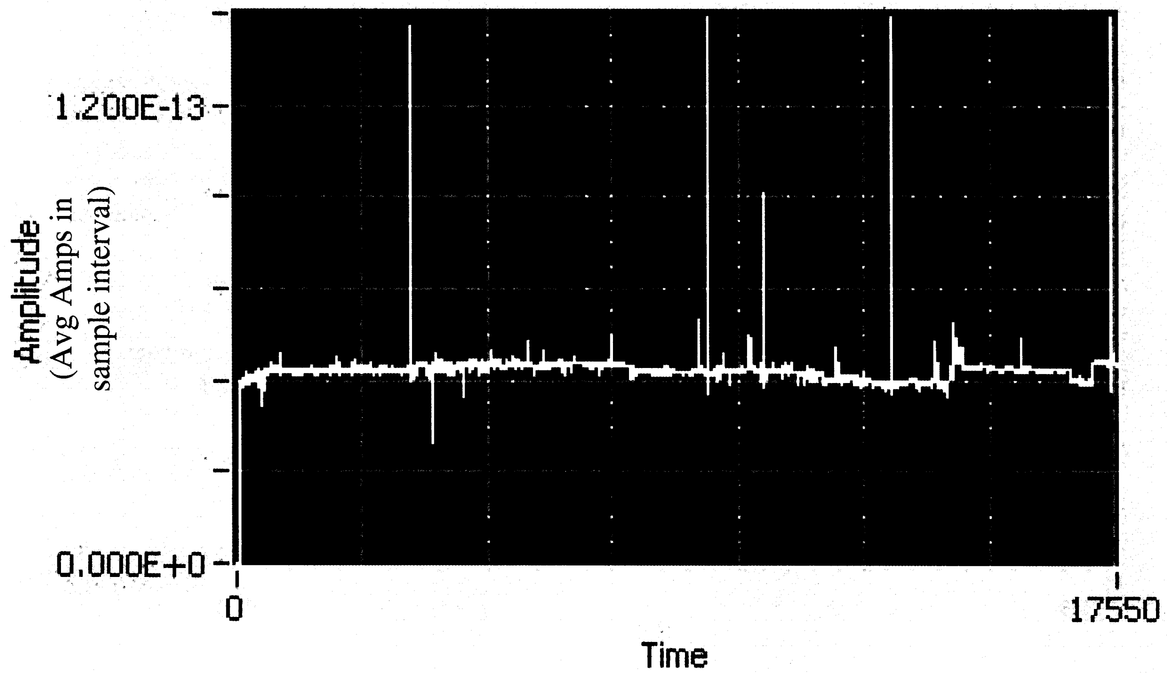

Figure 4 – Current monitor for sample B

Sample	Pre-exposure	Post-exposure	Delta	Units
Ratio of sample A to control sample	1.03	1.01	-0.02 (2%)	nW / nW of 1064 at power meter
Sample B	84.0	83.6	-0.4 (-0.5%)	nW of 1064nm at power meter
Witness sample for sample A	85.6	86.3	0.7	% transmission at 1064nm
Witness sample for sample B	86.3	86.0	-0.3	% transmission at 1064nm

Table 1 – 1064nm Transmission Data