

	EK131: Introduction to Rocket Science	Date: 1-Oct-19
	Epoxy Testing for use at High Temperatures	Rev: 1 Page 1 of 2 Author: Brian Walsh

Objective

Lunar Environment heliospheric X-ray Imager (LEXI) will be deployed into the lunar environment with extreme temperature variations. The X-ray optics are held to the telescope with epoxy to ensure alignment during handling and through vibrations of launch. The performance of the epoxy is tested with extreme thermal environments to evaluate the performance. The temperature range was selected to match that expected on the lunar surface.

Experiment

To test the performance of Arathane 5750 epoxy at high temperatures, the X-ray optics and the optic holder were thermal cycled to monitor the impact on the epoxy. Prior to the experiment, epoxy had already been applied to the optical element in room PHO736 at room temperature and with humidity of approximately 40% in August 2019. Thermal testing occurred by placing the optics holder into a thermal chamber (Associated Environmental Systems Temperature Chamber Model #: FD-508) with the ability to bake the assembly at high temperatures expected on the lunar surface. Table 1 presents the temperatures and profiles in which the optical element and epoxy were tested.

Time into oven (2019)	Time out of oven (2019)	Ramp up time	Soak Temp (C)	Time at Temp	Ramp down time	Temp Band (C)	Visual inspection comments
10SEP 0933	1737	1 hr	40°	6 hr	1 hr	+/- 2°	None
13SEP 0919	1722	1 hr	100°	6 hr	1 hr	+/- 2°	Epoxy yellow/browning
19SEP 0916	1735	1 hr	170°	6 hr	1 hr	+/- 2°	Epoxy black

Table 1 - Temperature measurement profiles.

The temperature profiles of each thermal test are shown in Figure 1. Temperatures were measured with a thermocouple mounted to the outside of the optic holder with Kapton tape and saved with a data logger (88598 4 Ch K SD Logger). The profiles show the ramp up, soak, and ramp down periods measured by the thermocouple. During the ramp time periods, the thermal chamber linearly increases or decreases the temperature to the next target point.

Results

After each thermal test, the optic and epoxy assembly were brought to room temperature and removed from the thermal chamber for inspection. All inspection occurred in a class 10,000 clean room. When moved, the optic assembly was handled with powder-free nitrile gloves and moved slowly to protect the filter.

The first test was a visual inspection of the epoxy joint. After each temperature test the epoxy joint was visually inspected for changes in color, texture, and shape. As part of this, the joint was imaged with a camera from the same angle each time to record the current state. The evolution in color is presented in Figure 2. The color visibly

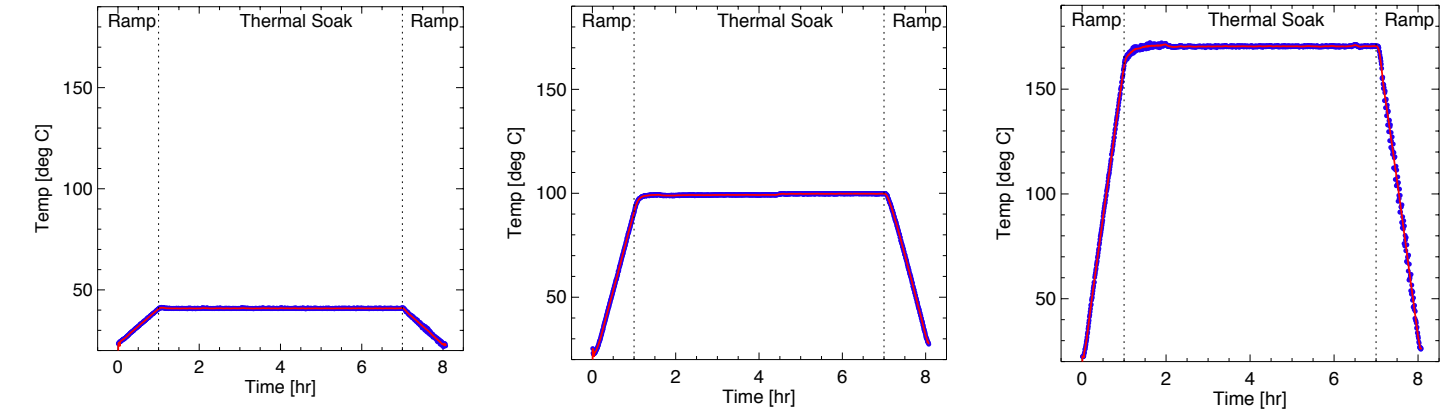


Figure 1. Temperature profiles through which the optic assembly was baked. Left: 40°C, middle: 100°C, Right: 170°C.

darkened with temperature reaching an amber color, particularly at temperatures greater that 100°C. The epoxy does not visibly appear to dry out or change texture or shape with increasing temperature up to the maximum value tested.

The second test was a binary adhesion test. After removal from the thermal chamber and transferred to the clean room, the optic assembly and epoxy was turned upside-down. Does the optic fall out? If no, the epoxy would pass the adhesion test at the given temperature. The epoxy held the optic in after baking at each temperature with no apparent difference to strength with additional baking. No additional force or strain was applied to the optic or epoxy to pull the optics out of the holder. Since no additional force will tug on the optics on launch, this is a reasonable arrangement.

Conclusion

When exposing Arathane 5750 epoxy through thermal soaks up to 170° C, the epoxy will daken with increasing temperature but maintains sufficient adhesion to secure an X-ray optic to the LEXI frame. The optical opacity will decrease with increasing temperature, but it should not impact the performance in X-ray imaging.

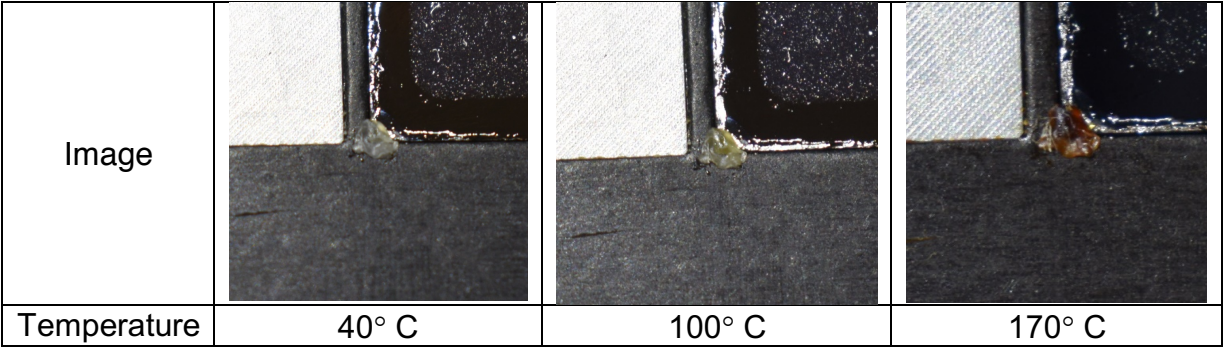


Figure 2. Images of epoxy changing color with bake temperature. The epoxy is placed in the middle of the image and at the corner of the lens.