7735-145

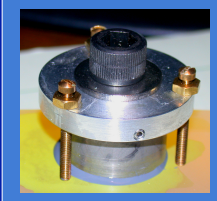
Experimental Investigation of Adhesive Bond Strength Between Metal and Optical Glass

Lee H. Laiterman, Matthew V. Radovan, Gerald F. Cabak
UCO/Lick Observatory, University of California Santa Cruz

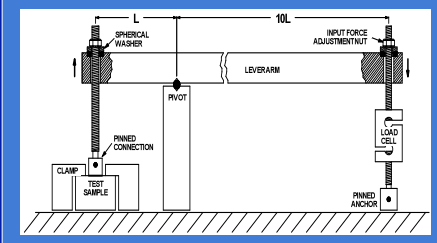
ABSTRACT

Within the general astronomical community as well as at the University of California Observatories, there has been a long history of using epoxy to mount optics within instruments such as spectrometers and telescopes. The Ken & Gloria Levy Spectrometer, part of the Automated Planet Finder (APF) telescope located at Mt. Hamilton's Lick Observatory, relies on epoxy-bonded joints to attach the instrument's large cross-dispersing prism and echelle grating to its Invar space-frame structure. Design constraints dictated that these large optics each be attached at only three points, and that the bond areas be as small as possible while maintaining an adequate strength factor of safety. Previous UCO instruments, such as the Keck Telescopes' primary mirror segments and the ESI Spectrometer, used Hysol's 9313 epoxy product for this purpose. Concerns over long-term reliability of such joints led us to re-examine this issue. We empirically investigated the roles played by epoxy selection and techniques such as surface preparation and the use of a primer, in creating a robust metal-to-glass bond. Bond strength data was generated, leading us to select a previously unused epoxy, and to implement particular techniques to ensure bond quality. Most notably, we found that bond strength data as typically reported on adhesive manufacturers' datasheets was not a reliable indicator of long-term bond reliability between metal and optical glass.

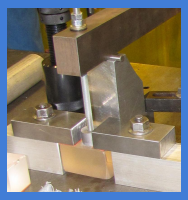
Test Apparatus



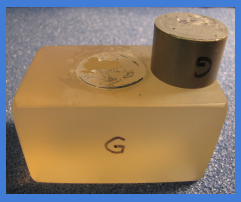
Gluing jig used to control test sample bond thickness.



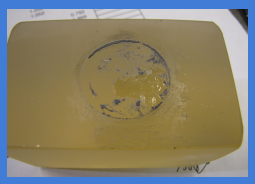
Schematic and photo of testing apparatus.



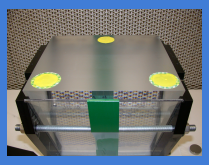
Results



Destructively tested bond showing mixture of adhesive failure, cohesive failure, and adherend fracture.

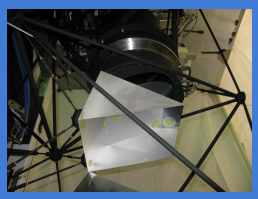


Implemented Bonding Procedure



Cross-dispersion prism in handling fixture with primer applied.

Bonded puck showing epoxy fillet and its removal.



Bonded cross-dispersion prism mounted within the instrument structure.

CONCLUSIONS

- We developed a gluing procedure with which we were able to repeatedly create 20-23,000 kPa (2,900-3,300 psi) metal-to-glass bonds whose failure mechanism was almost fully cohesive, and therefore close to optimal.

- Fillets created by excess epoxy at the junction of metal and glass should be avoided because they increase stress. This may seem counter-intuitive, but here the adhesive itself is the source of stress since its CTE is significantly higher than the substrates it bonds. Combined with the relatively large dimensions of a fillet, this can generate damaging stress on the glass substrate, especially when operating temperature differs significantly from that experienced during bonding.

- Adhesive datasheets typically report bond strength based on a standardized test, ASTM D1002, whose test conditions deviate far from those needed to make these measurements, and so are not meaningful. Relevant metal-to-glass adhesive bond data is difficult to find, necessitating the need to perform your own tests. It is particularly important to increase test loading at a rate slow enough to capture micro-creeping events, which are indicative of incipient bond failure.

University of California Observatories- Santa Cruz
For more information contact Lee Laiterman: lee@ucolick.org

References:
[1] Sheinis, A.I., Nelson, J.E., Radovan, M.V., "Large prism mounting to minimize rotation in Cassegrain instruments", *Proc. SPIE 3355, 1998*
[2] Iraninejad, Bijan and Lubliner, Jacob and Mast, Terry and Nelson, Jerry "Mirror Deformations Due to Thermal Expansion of Inserts Bonded to Glass", *Keck Observatory Report No. 160,* January 1987