120 INCH TELESCOPE COUDE SECONDARY SURFACE REPORT

Summary of Film Removal Techniques Used on the Shane Coude Secondary Mirror

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1.0 Objective:

Assess and remove a persistant film that appears on the surface of the Coude Secondary Mirror soon after recoating.

1.1 Film Description:

The film is patterned and is visible under normal room light under the aluminum coating.

Located about 6" radially from the center, a ring appears about the center that is approximately 2" wide. It has a hazing effect and is visible under the coating. From 6" radially to 12" or 13" radially, an interference color film appears. (Visually, it resembles a gasoline film on water.) Two locations used as fiducials during the process are what must be tape outlines on the surface, around which this film is easily distinguished. One tape outline is located adjacent to "0" orientation marked on the edge, about 7.75" in from the edge and is about 1.5" long. The other tape outline is between edge orientations "168" and "192", is about 7.5" in from the edge and is about 1.25" long.

An added dimension to this film is the formation of particulates on the surface above some areas of the stain or film. These particulates appear as whitetish grains on the surface. Attempting to collect these particles proved futile because they soon disappeared after collection, as if evaporating. These particulates appear some hours after cleaning.

1.2 Coating Removal:

The aluminum coating was stripped and the surface cleaned using the normal, time tested techniques. This included the use of "Green River" acid solution to dissolve the coating, followed by a water rinse, a calcium carbonate sprinkling with potassium hydroxide as a vehicle, followed by a light scrubbing. This is then rinsed with water and repeated if necessary. A final rinse with distilled water finishes the process. Bill Brown stripped the coating, assisted by George on 9/25/97.

1.3 Cleaning Regime:

A cleaning regime was then performed by George and is detailed in the accompanying report "Coude Secondary Cleaning Report." The cleaning appeared to have no effect on the film. Two other techniques were tried that are not mentioned. The first was to use a fresh razor blade to scrape the surface at the tape marks, slicing along the plane of the surface from the clear part of the tape outline across the boundary where the film began and on into the film area. This was observed while looking through a 10X eye loupe, and it had no effect on the film. The 2nd technique was to wash the surface with cerium oxide polishing coumpound and water, using a felt pad and a circular rubbing action. This also had no effect on the film.

1.4 Profilometry of the Surface

Since the attempt to clean the film off the surface failed, polishing the surface was the next course of action. Polishing the surface may effect the surface shape and figure. Measuring the surface shape and figure before any polishing, was performed. Data file "coude/sec oc03a" from the Lick Profilometer describes the surface before any polishing was performed. Since little historical information could be found on the prescription of the optical surface, Curvmon was allowed to determine the various values. As a base reference, a spherometer was used to determine a ball-park radius of curvature to use in the OSD (Optical Surface Description) file, and the aspheric terms were allowed to float, one at a time, to obtain the best fitting coefficients. Thus obtained, the parameters were fixed and the surface scanned on the profilometer. The surface was then fit as if it were a sphere, to determine the departure from sphere. This information was used in designing the lap that would be used in polishing the surface. With a reference base shape and figure established, it was now safe to polish with a fexible lap. (In the event the figure was changed during polishing to remove the film, a target prescription for the mirror had been determined and the surface could be polished back to it.)

1.5 Polishing Regime:

A flexible lap was made on a 13" diameter flat aluminum tool. This consisted of a layer of wet-suit rubber, 1/2" thick, topped with "low smoke foam", 3/8" thick. Squares of polyurethane polishing pad, Rhodes #77, .050" thick were cut, about 1.5" in size and fitted on the surface of the foam in puzzle form, with no spaces between squares. A mixture of #64 Gugolz pitch and bees wax was melted and brushed onto the suface of the polishing pads, and then flashed with a flame to smooth the pitch surface. Plastic sheeting was layed on the mirror surface and the lap was cold pressed on the mirror with 75 pounds overnight. The resultant lap was extremely compliant.

Several polishing cycles were performed, using various compounds and vehicles. All polishing runs used a spindle speed (the rate the mirror was turning) of 1 rpm and a stroke speed (the rate the lap moved across the surface, round trip) of 16 rpm and a weight of 25 pounds on the lap which equates to about .20 psi. polishing pressure. The stroke length was set at 16", and the lap traveled from mid-diameter, 8" in to 8" out, covering center to edge, and overlapping both.

1.5.1 Ultra-Sol 1000 cerium oxide dispersion polishing compound; a pre-mixed slurry with a pH of 8 to 9 and particle size of .5 to1.0 microns. Ran 15 minutes. No

change in film noted.

1.5.2 Rare Earth Polish #85; a pre-mixed slurry with a pH of about 8 and a average particle size of 1.5 microns. Ran for 15 minutes. No change noted. Ran 45 minutes more, checking every 15 minutes. No change noted.

1.5.3 Barnesite # 485 precision polish with vehicle of filtered water. Ran for a total of 1 hour, checking every 15 minutes. No change in film noted.

1.5.4 Barnesite # 485 polish with vehicle of filtered water, with pH adjusted to about 9.0. (Straight water pH = about 7.5) (pH raised by adding baking soda to water and then mixing with polishing powder.) Average particle size is 1.4 to 2.0 microns. Ran for 15 minutes. Initiallly, it looked like film was removed. However, 10-15 seconds after drying surface, film reappeared. Ran for 30 more minutes, checking every 10 minutes. Check consisted of stopping machine and wiping an area dry. Again, 10-15 seconds after surface was dry, film reappeared.

1.5.5 Rare Earth # 85 with water vehicle adjusted to pH of about 9.0. Ran 15 minutes. No change after allowing to dry 15 seconds.

1.5.6 Rare Earth # 85 with water pH adjusted to about 9.5. Ran another 45 minutes, checking every 15 minutes. No change in film after 15 second drying time.

1.6 Total Polishing Time = 4 hours. No change noted in film. Decided to re-measure surface on profilometer to check for figure change. Felt that further polishing would not change film since there was no sign of improvement thus far.

1.7 Profilometry after Polishing Surface:

Profilometry of the mirror was performed on Oct. 13, 1997, and a new flat calibration taken. (The room temperature had changed since the first flat calibration taken on Oct. 3, for data set coude/sec oc03a and using the same flat calibration from a colder room makes an erroneous curvature change.) The profilometry data from coude/sec oc13a looks almost identical to the before polishing data set coude/sec oc03a. There is a difference of curvature of .028" longer, which translates to a difference of sagitta over the 31" diameter of .0000299" = .00076mm or about 2.4 fringes at the 6328 angstrom wavelength. The radius of curvature now is longer, meaning the polishing flattened the curve. From the stroke set-up, this makes sense. However, the aspheric shape is the same as before polishing. I'm confident that this mirror will perform the same as it has in the past.

2.0 Final Assessment:

This mirror, made in the late 1950's or early 1960's, is probably made of Pyrex and was probably polished with the industry standard at that time; red rouge (ferric oxide). It has been stripped and recoated many times. This staining or film has been present on the mirror at least since the early 1970's, perhaps getting worse over time. I believe this mirror has gone through an aging process that is exacerbated by the necessary periodic chemical stripping of the aluminum coating, reheating and recoating process. The fact this type of film exists on other Observatory mirrors, but not all, suggests it is material or blank dependent and probably influenced by the polishing process it experienced during initial manufacture. It is clear with this mirror that there is a kind of leaching process happening in which some glass component is exhibiting itself on the surface. Pyrex is more sensitive to base solutions than acid solutions. Perhaps a process called "dimming" has occurred where alkali ions diffuse from the glass onto a a wetted surface caused by moisture condensation. As these little puddles of concentrated alkaline solutions sit on the surface, they erode the silica gel layer that forms on polished glass surfaces. (The pH of a polishing slurry during formation of the silica gel layer is usually high, around 9.5 or more, which is why polishing slurries are controlled toward the alkaline side.) When they evaporate, alkali and silicon ions are deposited on the surface in the form of a hazy film that is essentially permanent. Or, perhaps the surface , which coincidently or not, is stained in the area that departs greatest from a sphere, has developed a stain due to the repeated bathing of acid and base aqueous solutions. The area that departs from spherical was probably worked differently in polish than the spherical part, which may have made it more susceptible to stain attack. A glass chemist or physicist might be able to describe what has probably happened given the background of the mirror. However, it is my opinion that to remove the film, the existing polished surface must be broken through, down to a pitted surface, i.e. the surface must be reground. At that stage, it might be advisable to acid etch away a thickness of glass before proceeding with fine grinding and re-polishing. Since we cannot predict whether the film will resurface due to the peculiarities of this piece of glass, it might be advisable to use a new blank of Zerodur if the existance of this film warrants regrinding and repolishing. A new mirror could be made using the existing prescription while the present mirror is still in service, then they could be switched. The question to be answered is " Is the film an annoyance or is it hindering performance to the point where it needs replacement?"

Coude Secondary Cleaning Report

1.0 This is an attempt to remove a persistent stain from this Coude secondary mirror that can be distinguished on the surface and its visible through the coating. After the coating was stripped.....

the stain could not be seen under normal conditions. In order to distinguish the stain an intense light has to be used very close to the surface with a very wide viewing angle. Under these conditions, segments of the stain can be seen. There are also visible stain remnants of tape outlines. Collectively speaking, the stain appears to be a circular zone structure, 50 mm wide and about 200 mm from the center of the mirror.

The following chemical compounds were used to attempt to remove the stain:

TABLE 1.

CHEMICAL	TISSUE	SOAK TIME
Windex	Kimwipes	1 Minute
Orvus W/ Acetone	Kimwipes	1 Minute
Ethyl Alcohol	Kimwipes	1 Minute
Xylene	Kimwipes	1 Minute
Methanol	Kimwipes	1 Minute
Acetone	Kimwipes	3X10 seconds
Diatomeceous earth w/ Water	Kimwipes	None

Results:

After all these compounds were applied the stain was still apparent and visible (stains were marked.) It appears that the diatomeceous earth compound slightly sleeked the surface where it was applied.

Opinion:

This stain appears to be etched in the mirror surface and only polishing (or grinding and polishing) will remove it. The mirror has to be tested in the profilometer and then reworked.

GKL 9/25/1997