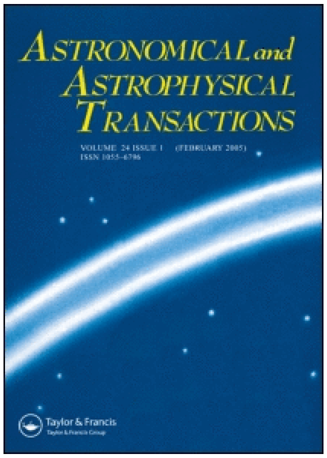

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SUV T-170: The mirror roughness

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SUV T-170: THE MIRROR ROUGHNESS

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The ion-etching technique is planned to be used for the figuring of the mirrors of the SUV telescope. In order to evaluate the effect of this technique on the roughness of the surface of the mirrors, we carried out two series of non-contact measurements. The first run of measurements was performed on six samples: the first two samples were standard polished and the last four were worked by increasing the duration of the ion-etching. These measurements showed the presence of peculiar structures that affected the ion-etched surfaces. The second run was performed on a single sample divided into four quadrants, three of which were worked with increasing duration of the ion-etching. The new surfaces have probably suffered bad handling in the shipping or in the manipulation during the polishing work, since they are full of more or less deep scratches and of randomly distributed bumps. We observed that even in the regions free from bumps and scratches, the ion-etching technique produces surfaces which are rougher than the standard polished ones.

KEY WORDS Ion – etching, mirror roughness, light scattering

1 THE SAMPLES AND THE TECHNIQUE OF MEASUREMENT

Table 1 and 2 contain the sample specimens. All samples were standard polished before the ion etching. We have measured the rms of the surfaces of the samples with the *Micromap PROMAP-512* optical profiler located in the Optical and Beamlines Laboratory of the Trieste Syncrotron Society. The device was employed at two magnifications, 40× and 5.172×. At 40× the Optical lateral resolution on the sample surface is 0.55 μm, while at 5× it is 2.8 μm. The areas examined in each measurement are 80.5 × 77.1 μm at 40×, and 643 × 616 μm at 5× respectively. Several tens of different zones were examined. For a complete analysis see Monai and Morossi (1995).

2 THE RESULTS OF THE FIRST RUN OF MEASUREMENTS

In Table 3 we report the average values of the rms roughness (the root mean square of the surface profile) and the Ra (the mean deviation from the mean profile) for

Table 1. Etching rate 0.12 μm/hour

Samples	*Ion etch. hours*	*Depth (μm)*
1	0	
2	0	
3	5	0.6
4	30	3.6
5	30	3.6
6	60	7.2

Table 2. Sample 1 quadrants (etching rate 0.41 μm/hour)

Quadrant	*Ion etch. time (h)*	*Depth (μm)*
a	0	
b	5	2.05
c	25	10.25
d	50	20.50

the standard polished samples at 40× and 5×. Figure 1 shows a plot of the surface of sample 1 observed at 5×.

With regard to the samples polished with the ion-etching method, the observations of the surfaces revealed the presence of particular structures, formed by hundreds of little craters with walls with height ranging from 2 to 4 nm, and with a very smooth bottom. These features are clearly seen in Figure 2a in which we plot a portion of the surface of sample 3. Two examples of cross-cut of samples 1 and 3 are shown in Figure 2b. The average roughness values are reported in Table 4.

Table 3. Standard polished samples

Sample	*rms (nm)*	*Ra*
1 (40×)	0.53	0.40
1 (5×)	0.62	0.49
2 (40×)	0.634	0.49

Table 4. Old ion-etched samples

Sample	*rms (nm)*		*Ra*	
	40×	5×	40×	5×
3	1.18	1.12	1.02	0.87
4	0.97	1.10	0.77	0.78
5	1.57		1.10	
6	1.47		1.11	

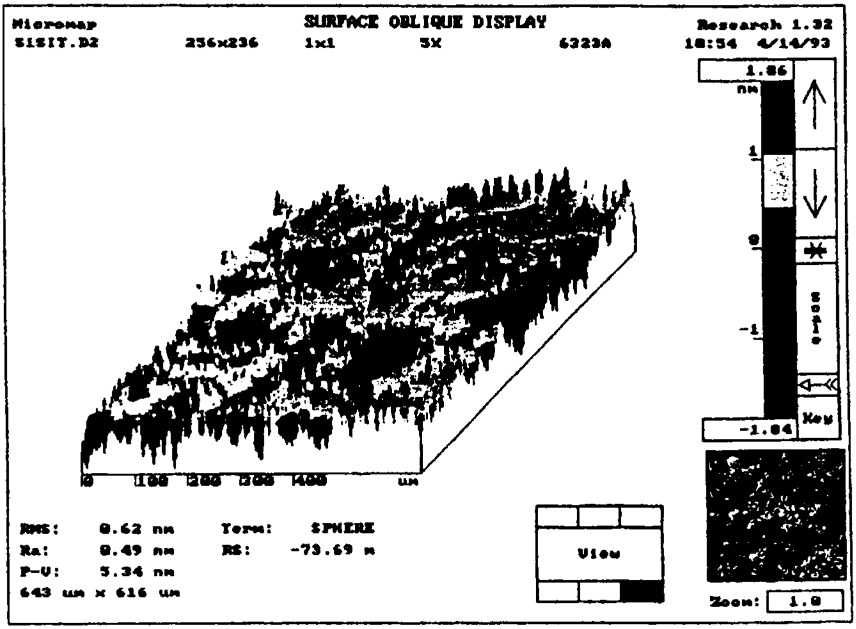

Figure 1 Oblique plot of the standard polished surface of sample 1 at 5×. The height scale is reported on the right-hand side.

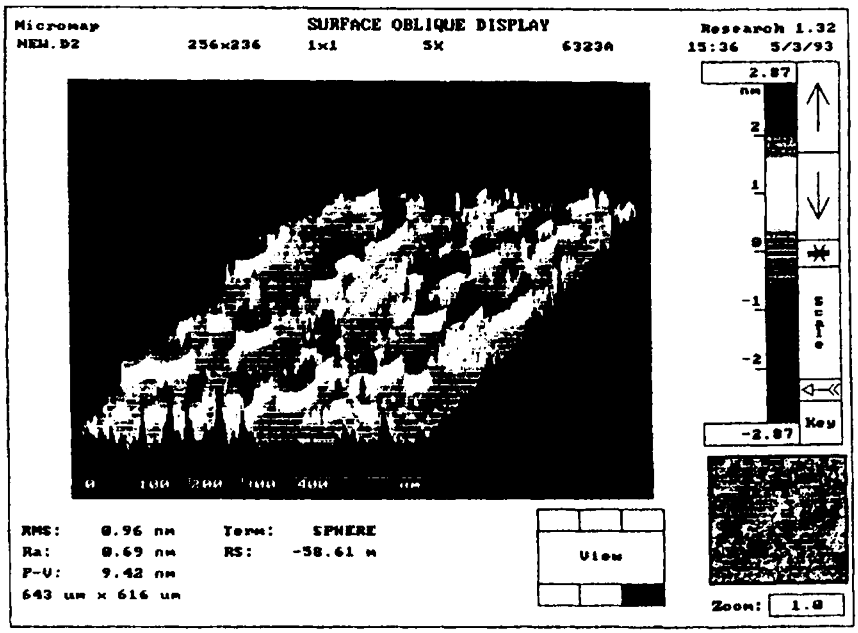

Figure 2a Oblique plot of the ion etched surface of sample 3 at 5×. The height scale is reported on the right-hand side.

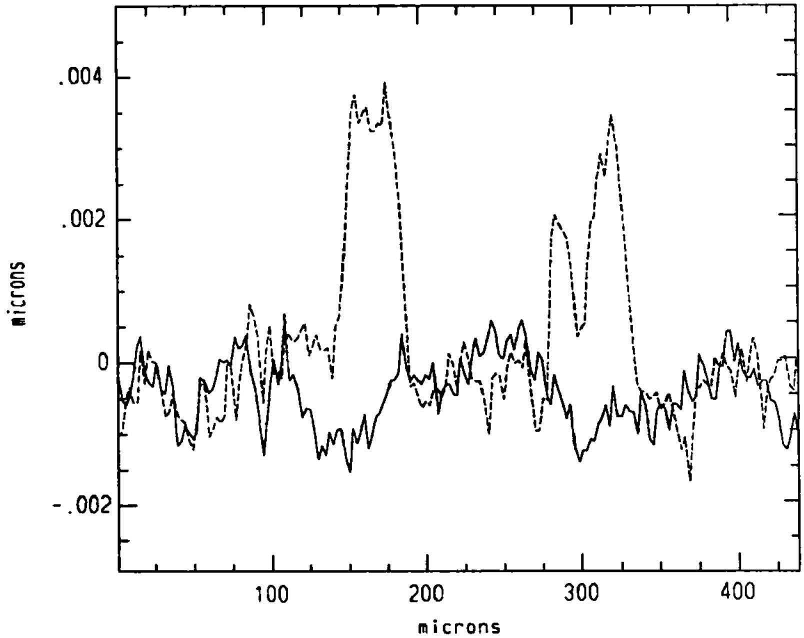

Figure 2b Cross – cuts of the surfaces of samples 1 and 3 at 5×.

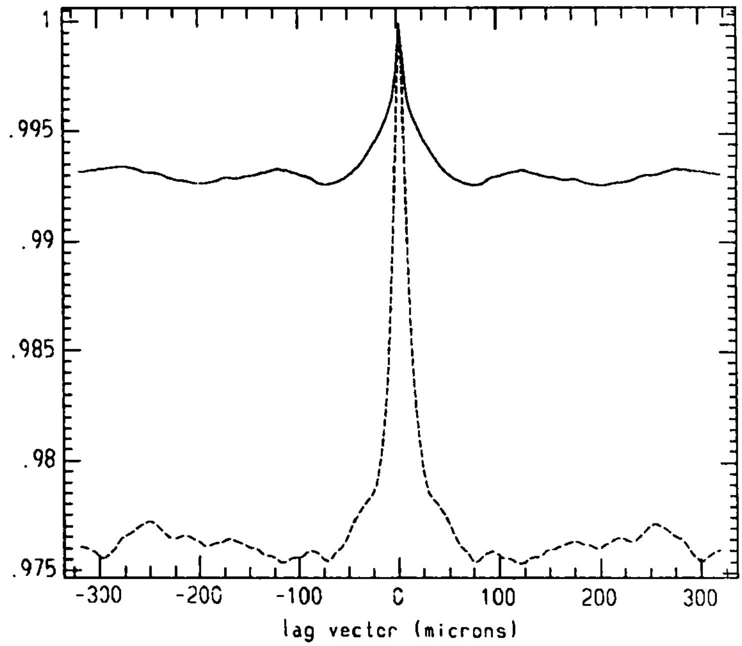

Figure 3 The MTF degradation function at $\lambda = 91.2$ nm for the surface of sample 1, compared with the same curve for sample 3.

Table 5. Fraction of scattered light at 5×

Samples	*av. rms*	*300 nm*	*120 nm*	*91.2 nm*
1	0.62	0.001	0.004	0.007
3	1.12	0.002	0.014	0.024
4	1.10	0.002	0.014	0.023

Table 5 reports the fraction of light scattered outside the theoretical PSF, calculated as Strehl factors (Church and Takacs, 1993) with value derived from the rms's at 5× for samples 1, 3 and 4, for three wavelengths: 300, 120 and 91.2 nm respectively.

In Figure 3 we plot the MTF degradation function at $\lambda = 91.2$ nm for the surface of sample 3, compared with the same curve for the old sample 1. We stress the fact that the value for the standard polished surface is very good for this wavelength.

3 THE RESULTS OF THE SECOND RUN OF MEASUREMENTS

The re-polished sample 1 was analysed with the same device specifications which we used for the previous runs at 5×.

The average rms data for each quadrant are reported in Table 6. By comparing the previous results obtained for the same sample (Table 3), the standard surface results rougher (mean rms 0.81 against 0.62 nm). This difference could be explained with the improvement in the statistics at 5.172×, (eight areas instead of only one) and/or with the bad handling of the sample during the travel to and from the Crimea. In fact, we now detect many more scratches than we previously did. The Strehl factors for each quadrants are reported in the last three columns of Table 6. We can conclude that if we take into account a possible improvement of the sample handling, the standard polishing technique meets the requirements of excellence with regard to the residual roughness of SUV mirrors.

The images of the surfaces reconstructed by the interferometer show that the ion-etched zones are full of more or less deep scratches and of randomly distributed

Table 6. New ion-etched sample

Quadrants	*rms*	*fraction of scatt. light*		
	nm	*300 nm*	*120 nm*	*91.2 nm*
a	0.81	0.002	0.008	0.012
b	7.77	0.101	0.485	0.684
c	14.54	0.310	0.902	0.983
d	14.63	0.313	0.905	0.983

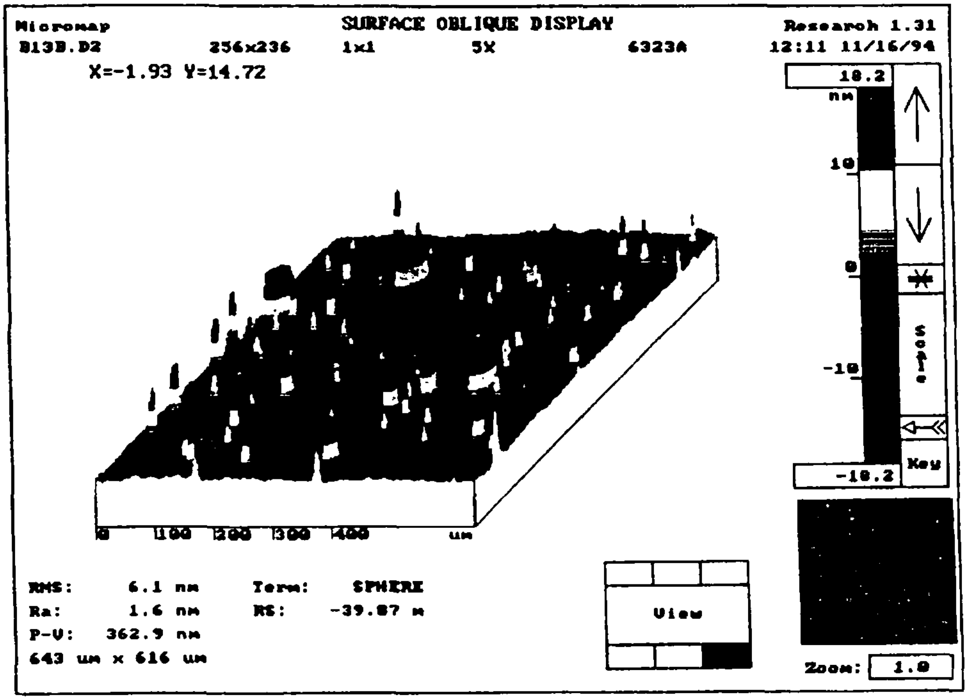

Figure 4 Oblique plot of the ion etched surface of quadrant b at 5×. The height scale is reported on the right-hand side.

bumps (Figure 4). The scratches are sometimes present also in the quadrant a, even if less numerous, and are probably related to bad handling of the sample. Their depths range from 11 to 360 nm. The bumps are present only in the ion-etched areas and have a base diameter ranging from a few tens of microns to more than one hundred, and their heights are between 250 and 600 nm.

The annular structures we observed in the old ion-etched samples have disappeared, but the surface is still rougher than in the standard polished quadrant (the absence of such crater-like structures is probably due to the different etching rate).

The rms values are now one order of magnitude greater than those reported in Table 4 and they also vary significantly in the same quadrant. The percentage of scattered light has became unacceptably high, since it ranges from 10% at 300 nm for the quadrant *b*, to more than 98% at 91.2 nm for quadrants *c* and *d*.

We must stress the fact that the new surfaces have probably suffered bad handling in the shipping or in the manipulation during the polishing work. On the other hand, the bumps are present only in the ion etched areas and in some way must be related to their processing.

If the bumps are not directly produced by the ion bombardment but by another unknown factor, the true ion-etched surface must therefore lie in the space between these bumps. We have analysed several restricted areas of 64 × 64 pixels, chosen

Table 7. Mean rms values for 64 x 64 pixels windows

Quadrants	*rms*	*fraction of scatt. light*		
	nm	*300 nm*	*120 nm*	*91.2 nm*
a	0.43	0.001	0.002	0.004
b	0.75	0.001	0.006	0.016
c	1.38	0.003	0.021	0.036
d	0.81	0.001	0.007	0.012

where the surfaces are free from bumps and scratches. The mean results for each quadrant are reported in Table 7. We must stress that even in these regions the ion-etching technique produces surfaces which are rougher than the standard polished ones.

This leads to the conservative conclusion that:
if the ion-etching is used for the figuring, in order to get a smooth surface a final standard polishing run is needed.

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References

Monai, S. and Morossi, C. (1995) *SUV Project Report Series*, Report No. 1.95.
Church, E. L. and Takacs, P. Z. (1993) *Appl. Optics* **32**, 3344.