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Analysis of surface X-ray scattering from synthetic quartz mirror

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Introduction

It is important to evaluate the nm-scale structure of large-area engineering surfaces, especially when these are prepared for optical applications [1]. Surface X-ray scattering is an extremely promising method for this purpose [2,3]. The present report describes the quantitative determination of the surface morphologies for synthetic quartz mirror with different finishes.

Experimental

Measured samples are synthetic quartz mirror (25mmx25mmx5mm) with optically flat surfaces of different quality, "20-2" (certified flatness λ/20, λ=632.8nm), "10-5" (λ/10), "4-5" (λ/4) and "1-3" (λ), which are commercially available from SIGMA KOKI Co., Ltd. X-ray scattering measurements were carried out with 16.0 keV X-rays. The beam size was 0.05×1.0mm.

Results and Discussion

Fig. 1 shows experimental results of specular and non-specular scattering for samples, "20-2" and "1-3". The maximum reflectivity below the critical angle, around 1.9 mrad, was 93.6 % and 81.8 %, respectively. No oscillating structures were observed in the whole specular reflectivity curve, indicating that significant surface layers do not exist. Non-specular scattering, as shown in the inset, exhibits Yoneda peaks at around 1.8 mrad and 15.7 mrad. Those features of the data were more or less common for all the samples.

During previous studies [3], it was found that the intensity ratio of the specular and non-specular scattering is strongly correlated to the surface morphology. In the present case, the intensity at Yoneda peak (1.8 mrad) is 20.5%, 14.2%, 15.2%, and 11.8% to the specular scattering at 8.75 mrad, for "1-3", "4-5", "10-5" and "20-2", respectively. One can see that the order agrees well with that of flatness as certified by the laser-light method.

The data were analyzed based on the self-affine surface model [2], of which the height-to-height correlation function for the distance ρ is given as $C(\rho) = \sigma^2 \exp[-(\rho/\xi)^{2h}]$, where σ, ξ and *h* are the surface roughness, the correlation length in horizontal directions, and Hurst parameter, respectively. In the present study, simultaneous fitting has been attempted for specular and non-specular (rocking and detector scans) data. The results are summarized in Table 1. The rms roughness σ was different, but quite close for the four samples, around 1.3 nm. This is not so surprising considering that their specular reflectivity did not show such big differences even in the higher-angle region (7~14 mrad). On the other hand, ξ and *h* are quite different. One can see that density factor also exhibits differences. It has been found that "20-2" is quite normal and has a moderate surface, while "1-3" has an extraordinarily jagged surface. The authors would like to thank Prof. S. Kishimoto for his assistance during the experiment.

Table 1 Summary of the curve fitting.

	Hurst Parameter	Correlation Length [nm]	Roughness [nm]	Density Factor
1-3	0.135	132	1.36	1.025
4-5	0.215	190	1.27	1.013
10-5	0.235	263	1.30	1.048
20-2	0.203	320	1.28	1.006

References

[1] M.Wormington, I.Pape, T.P.A.Hase, B.K.Tanner and D.K.Bowen, Phil. Mag. Lett., **74,** 211 (1996).
[2] K.Stoev and K.Sakurai, Spectrochim. Acta, **B54**, 41 (1999).
[3] H.Eba and K.Sakurai, Photon Factory Activity Report 1999 #17, 51 (2000).

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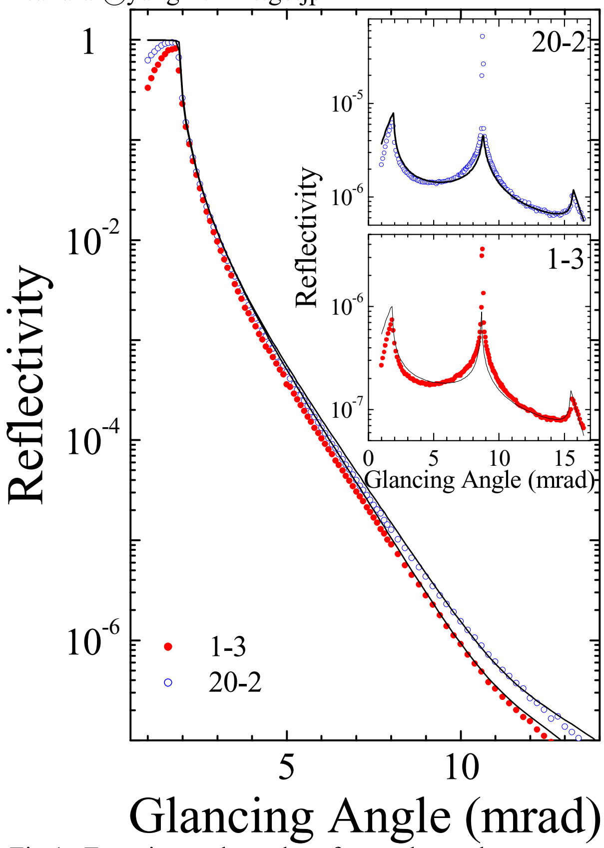

Fig.1 Experimental results of specular and non-specular (inset, rocking scan at 17.5 mrad fixed scattering angle) reflections for the samples, 20-2 and 1-3. Fitted curves are shown as solid lines. For the rocking scan, the calculation only considers the non-specular portion, while the experimental data include specular reflection.