Flatness correction of polished quartz glass substrates

Frauke Rüggeberg, Thomas Leutbecher , Steffen Kirchner , Hartmut Sauerbrei, Kurt Walter, Frank Lenzen, Lutz Aschke

Schott Lithotec AG, Jerusalemer Str. 13, D-98617 Meiningen, Germany; e-mail : Frauke.Rueggeberg@schott.com, tel.: +49/3693/522-152 (fax:-151)

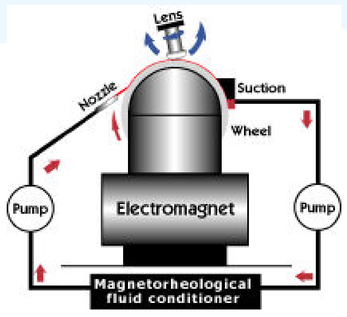
To achieve a substrate flatness as it is postulated in Semi P 37 – 1102 the surface has to be improved by a flatness correction. To fulfil the requirements of a flatness of 50 nm two different flatness correction methods are compared, first results are presented and discussed.

— MRF – Magnetorheological Finishing and IBF – Ion Beam Figuring —

The quartz glass substrates used for evaluating the flatness correction methods were prepared in the regular substrate production by Schott Lithotec in Meiningen. Both correction methods were tested on the one hand with prepolished and on the other hand with completely polished substrates. The flatness measurements were analyzed with a 5 mm edge exclusion.

MRF – Magnetorheological Finishing

The principle of MRF is based on computer controlled polishing. With an electromagnetic field a special MR fluid is pulled to a wheel and can then polish accurate on small spots. For calculating the residence time to get a final flatness of 50 nm the topography of the substrate has to be measured before the correction and a target topography has to be simulated. The position of the sample is varied in x- and y- direction by a computer. The process time took one hour with two iteration steps.

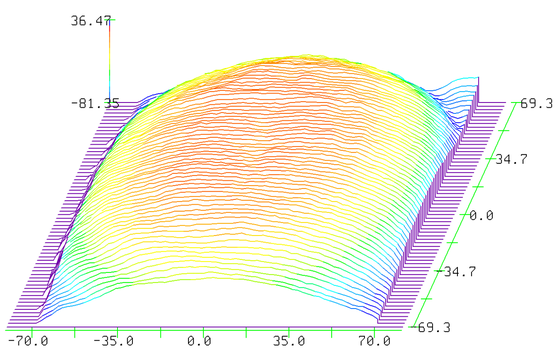


Principle of MRF
(the correction was done at QED Technologies, USA)

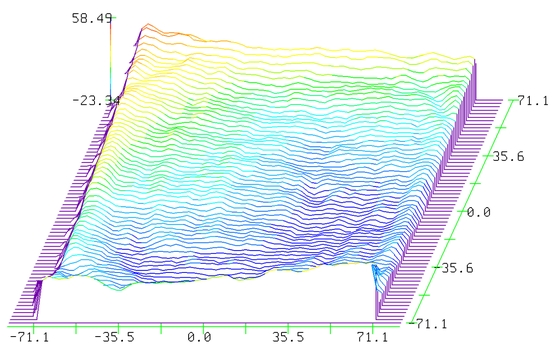
Evaluation with

Prepolished substrates | Finished substrates

Before processing the substrate the flatness was measured 224 nm for the prepolished substrate and 230 nm for the completely polished substrate.

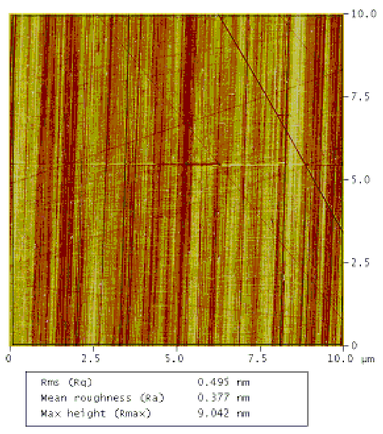


Flatness of 117 nm after processing with MRF

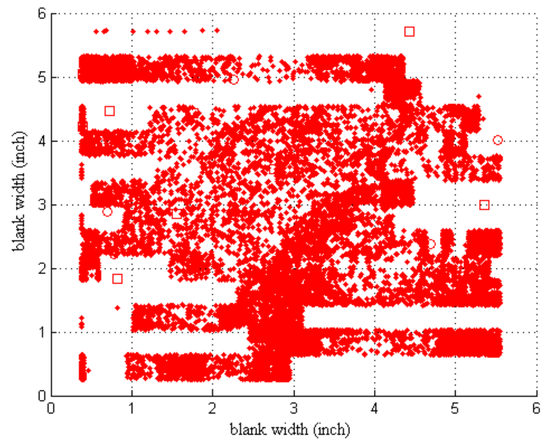


Flatness of 82 nm after processing with MRF

The flatness of the prepolished substrate could be improved by MRF to 117 nm and the flatness of the completely finished substrate to 82 nm. But none of these results fulfils the requirements so far.

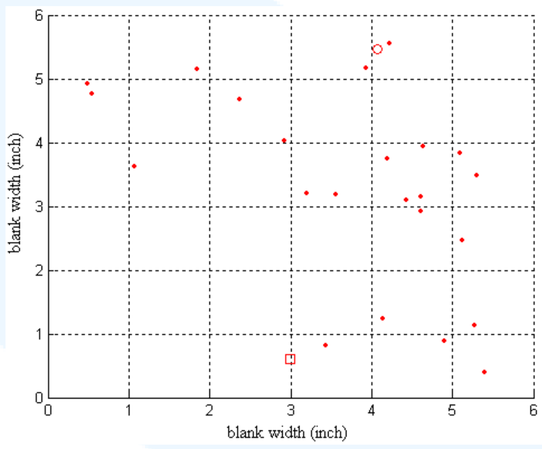


Surface structure of a substrate after processing with MRF



Defect map of a substrate after processing with MRF

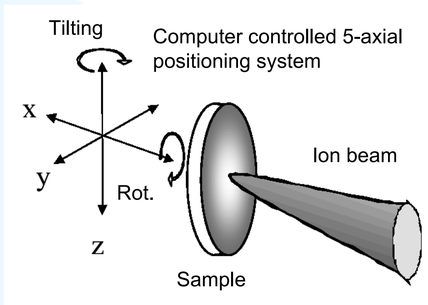
By processing the surface of the substrates with a slurry wheel the roughness of the completely polished substrate is destroyed. It does not matter after which state of processing the flatness is improved by MRF because the surface is structured in the same way. The defect level had a sharp rise so that the laser scanner could not resolve every defect. With an additional finishing polishing step the roughness and the number of defects could be decreased to the same level as after a regular polishing process.



Defect map after an additional polishing step

IBF – Ion Beam Figuring

Ion beam figuring flattens surfaces by scanning the surface line by line. The duration on a spot depends on the thickness of the material that has to removed. For calculating the residence time of the ion beam for every spot of the substrate to gain a flatness of 50 nm the topography of the substrate has to be measured before the correction and a target topography has to be simulated. The sample can be rotated, tilted and moved in x-, y- and z-direction. The duration of one run took two and a half hours.

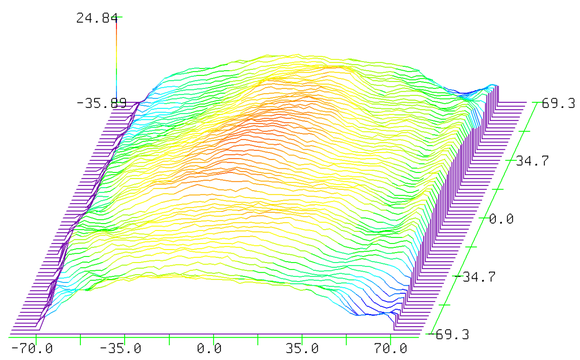


Principle of IBF
(the correction was done at IOM e. V. Leipzig, Germany)

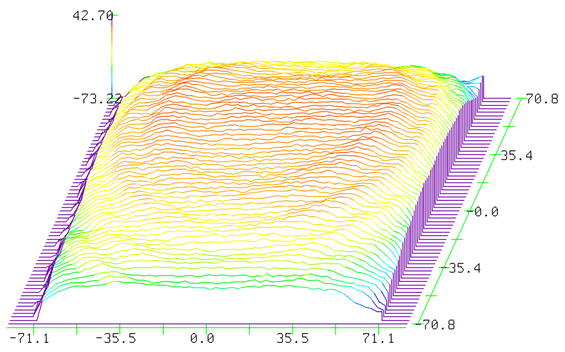
Evaluation with

Prepolished substrates | Finished substrates

The flatness measured of the substrates before IBF was 202 nm for the prepolished substrate and 205 nm for the completely polished substrate.

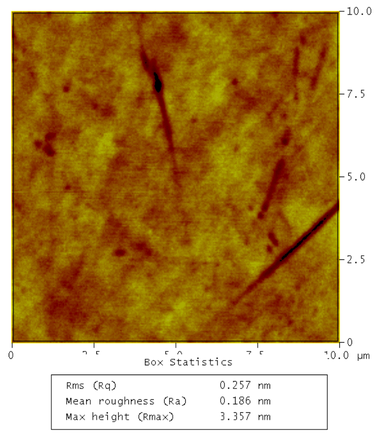


Flatness of 60 nm after processing with IBF

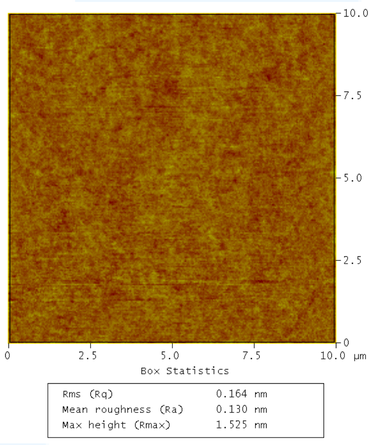


Flatness of 115 nm after processing with IBF

With IBF the flatness of both substrates could be improved. With processing the prepolished substrate a flatness of 60 nm could be reached. A flatness of 115 nm could be achieved by processing the completely polished substrate. With IBF a required flatness of 50 nm can nearly be achieved.



Roughness and decorated defects of a prepolished substrate after processing with IBF



Roughness of a completely finished substrate after processing with IBF

In both cases the roughness could be improved compared to the initial state. The polishing structure the substrate had after the prepolishing process can not be removed with IBF. The surface is getting smoother but scratches on the surface before doing the correction were decorated. That means that no more defects are generated but existing defects are getting broader. In case of the completely polished substrate the roughness could be improved so that it nearly fulfils the requirement of 0,15 nm in a area of 10 x 10 µm².

Conclusions

One advantage of MRF is that just prepolished substrates can be used because the surface is structured in the same way independent of the polishing state of the substrate. The duration to get the required flatness is acceptable. The additional polishing step to reduce the defects and to get a roughness like after a regular polishing process is the disadvantage of MRF. The advantage of IBF is that the flatness and roughness are nearly achieved within the processing. There is no need of an additional polishing step after processing a substrate with IBF. But the therefore used substrates have to be completely polished because existing defects are getting decorated. The process takes long time with two and a half hours.

Acknowledgement

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