Development of Optical glass window for SR monitor by using a metal O-ring sealing

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Abstract

A metal O-ring sealed optical glass window for SR monitor has been designed and constructed at the B factory KEK. An optical material of fused-silica glass for refractive-optical components is used as the optical grass flat. To seal an optical glass flat, it is sandwiched by two metal O-rings from the both sides. We tightened up the metal O-ring with 60% of full stroke for the sealing of the vacuum. The transmitted wavefront error is measured with an interferometer (Fizeau type). The result of remaining wavefront error is less than $\lambda/20$. No sign of warp due to mechanical stress was detected in effective diameter of 60mm.

1. Introduction

So called SR monitor in that mainly aided to measure the beam size and the profile based on optical method is one of most fundamental monitor in the storage ring [1]. Many apparatuses are adopted in the SR monitor such as imaging system to make an image of the beam, the SR interferometer to measure the beam size, and the streak camera to measure a longitudinal beam profile, etc. In this monitor, the visible SR beam is usually extracted from the storage ring by a mirror. A vacuum tight glass window, which has a good optical quality, is necessary for the extraction of visible SR beam from the vacuum duct of accelerator. A glass window made by the brazing is commonly used for view port. The remaining wavefront error of a transmitted light for such a brazed window is usually greater than $\lambda/8$ due to thermal warp. The surface flatness is also worse than $\lambda/8$. For the purposes of precise optical measurement in the SR monitor such as interferometry [2], error in the transmitted wavefront must be less than $\lambda/10$. By this reason, we cannot use the hermetic-sealed glass window for the extraction of visible SR beam. To reduce the remaining wavefront error less than $\lambda/10$, we developed a metal O-ring sealed optical window at the B factory KEK. In this paper, a design, preparation of glass flat and performances are described.

2. Design of Window

The basic design of the glass window using a metal O-ring sealing is shown in Fig. 1. In our design of the glass window, an optical glass flat is sandwiched by tow metal O-ring from both sides. The metal O-ring locates on vacuum-side flange serves as a function of vacuum sealing and locates on the air-side flange serves to take a balance of tighten up force.

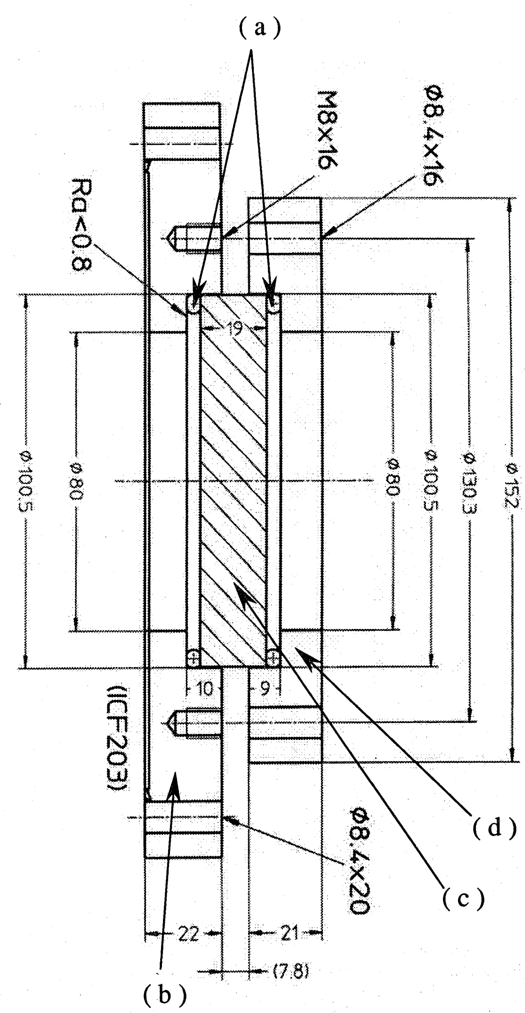


Fig.1 General design of the glass window. In this figure, (a): metal O-ring, (b): vacuum-side conflat flange, (c): optical glass flat, (d): air-side flange.

By this structure, the optical glass flat is tightened up with equal forces from both side, and we can seal the vacuum with minimum torque. Since we designed to attach the ordinal conflat flange (ICF203) structure in the backside of vacuum-side flange, we can easily attach this glass window to the SR extraction port in the accelerator. The physical aperture is 80mm.

3. Preparation of optical glass flat

We used a fused-silica glass material for refractive-optical components such as lens. The diameter of the optical flat is 100mm and thickness 19mm. The slope error of surface of the optical flat is polished better than $\lambda/10$. The surface quality is better than scratch and dig 60/40. The parallel degree of both sides is better than 2". As a result of performance test with an interferometer (Fizeaumeter), we obtained an error in the transmitted wavefront less than $\lambda/20$. The both sides of the glass flat is coated with a single layer of MgF_2 as a anti-reflection coating. The surface HV hardness of this coating is greater than 65, and it is tight enough for metal O-ring sealing.

2. Performance of vacuum sealing

We used the Helicoflex-delta (le Carbone k.k) as a metal O-ring. We tightened up the flanges until to detect the no sign of leakage. To test the vacuum sealing performance of the glass window, we use a He leak detector. As a result, we tightened up with 60% of full stroke (0.9mm for each metal-ring) for the sealing of the metal-O ring. A photograph of assembled glass window is shown in Fig. 2.

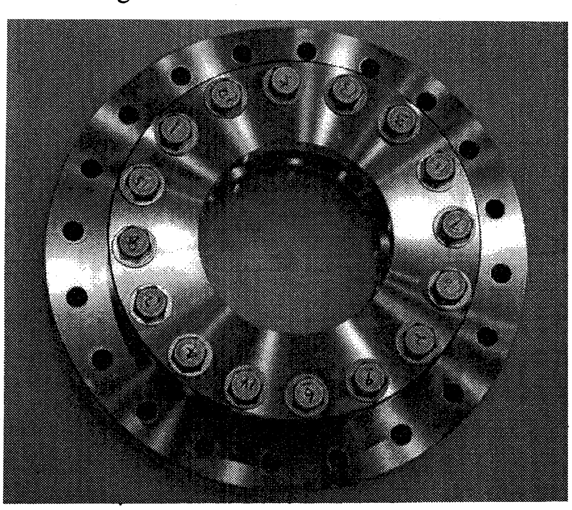


Fig.2 A photograph of assembled glass window.

3. Optical performance test

The optical performance for transmitted wavefront of the glass window has tested by using an interferometer (Fizeaumeter) [3]. The set up of measurement is shown in Fig. 3. This test is performed in the effective aperture of 60mm in diameter.

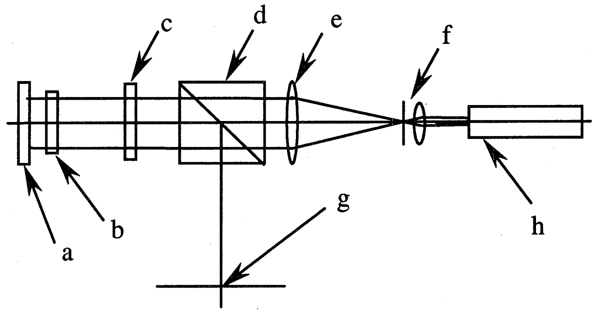
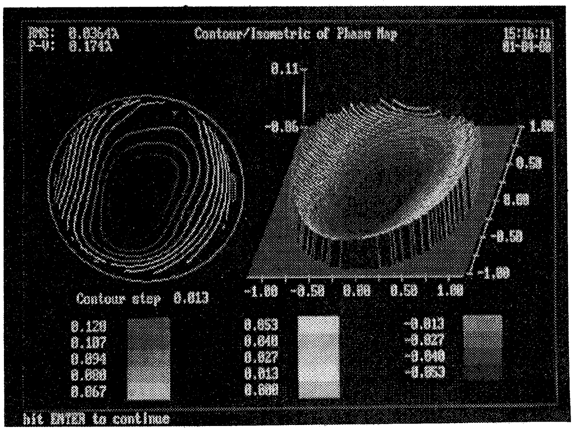


Fig.3 Measurement set up for the transmitted wavefront error by the glass window; (a) reflector, (b) testing window, (c) half mirror for reference, (d) beam splitter, (e) beam collimator, (f) spatial filter, (g) observation screen, (d) He-Ne laser. The components from (c) to (h) make the set up of Fiszaumeter.

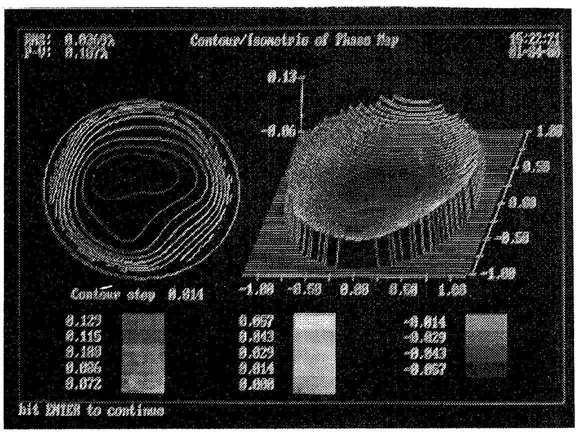
A transmitted wavefront error of the glass window has measured by using a flat mirror by following procedure.

1. Measure a reflected wavefront from the flat mirror with the glass window,
2. Measure a reflected wavefront from the same flat mirror without the glass window.
3. Subtract both wavefront.

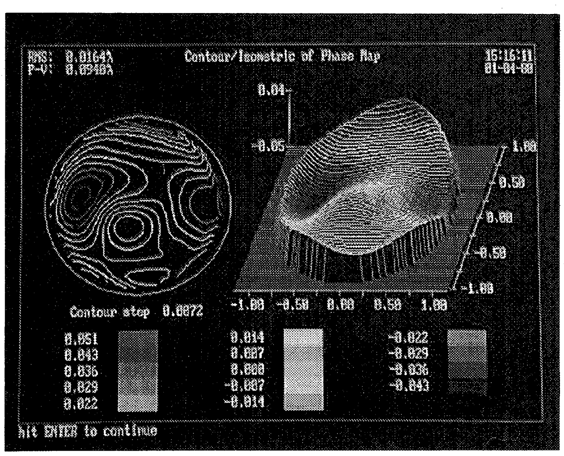
The results of reflected wavefront from the flat mirror with the glass window, reflected wavefront from the same flat mirror without the glass window, and subtracted wavefront error are shown in Fig.4 with a counter map and a 3-dimensional phase map. From figure 4, the peak to valley of wavefront error of subtracted wavefront is 0.095λ, and rms. wavefront error is 0.016λ. Since the probe light is passing through the glass window two times, the transmitted wavefront is given by a half of the subtracted wavefront. Then the transmitted wavefront error is less than $\lambda/20$. The quantity of remaining wavefront error after the metal O-ring sealing is almost same as the original wavefront in the optical glass flat. We made five sets of the optical glass windows for the SR monitors of B factory, the remaining wavefront errors in 5sets were less than $\lambda/20$. We can also detect the remaining warp in the glass due to the mechanical stress through a change of contrast of the interferograms. As a result, no sign of warp was detected inside of measured aria for all five sets of the optical glass windows.



(a)



(b)



(c)

Fig.4 A result of transmitted wavefront error. (a): reflected wavefront from the flat mirror without the glass window, (b): reflected wavefront from the same flat mirror with the glass window, (c): subtraction of (a) and (b). Each wavefront is shown with a counter map (left) and a 3 dimensional phase map (right).

5. Conclusions

A metal O-ring sealed optical glass window for SR monitor has been designed and constructed for The SR monitor of the B factory KEK. In our design of the glass window, an optical glass flat is sandwiched by tow metal O-ring from both sides. An optical material of fused-silica glass for refractive-optical components is used as the optical grass flat. The optical glass flat is typically tightened up with 60% of full stroke for metal O-ring, and no vacuum leakage is detected. The effective diameter of glass window is 60mm. The transmitted wavefront error is measured with an interferometer (Fizeau type). The result of remaining wavefront error is better than λ/. No sign of warp due to mechanical stress was detected. Four sets of optical windows are used for the extraction of visible SR beam in the HER and the LER in last 3 years, and no accident was happed.

REFERENCES

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