Development of reflective 193-nm DUV microscope system for the defect inspection on the large size optical surfaces

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1. Introduction

Recently, the size of optical elements extensively applied in space/astronomy, accelerators, and high-power lasers is increasing to a one meter level. However, current inspection systems do not have an ability to inspect the large size optical elements such as one meter size, which become a bottleneck that hinders the development of large-scale optical elements. Currently, the inspection systems for the macroscopic observation of overall optical surface cover the optical elements with the size of a few hundreds of mm, whereas its spatial resolution do not approach the sub-μm range [1]. In the case of the inspection systems for the microscopic observation of localized optical area, the spatial resolution reaches a few hundreds of nm range, but they are limited to the optical size with a few tens of mm [2]. Therefore, the development of a surface inspection system capable of observing large size optical surfaces of one-meter scale with the spatial resolution of a few hundreds of nm range is required.

In this study, a 193 nm deep ultraviolet (DUV) microscope system was developed to inspect the defects on the large size optical surfaces with one-meter scale. Using a 193 nm ArF laser, the DUV imaging is directly performed without the pretreatment of the sample at room temperature and atmospheric pressure. In addition, we removed the limitations on the selection of materials and its thickness of optical sample, by implementing the reflective DUV microscope. As a result, the reflective DUV imaging was firstly demonstrated and the spatial resolution which is closed to the diffraction limit of wavelength were achieved.

2. Experimental configuration

Figure 1 shows the overall experimental setup of a reflective 193 nm DUV microscope. It consists of a light source (193 nm excimer laser), a light control unit, a microscope body tube, and a 4-axis stage. The light control unit consists of beam attenuator, iris diaphragm, beam guide, fiber coupler and optical fiber. The microscope body tube consists of a beam expander, beam splitter, reflective objective lens, and UV CCD camera, which is combined with a z-axis stage for the adjustment of the focus of imaging. The 4-axis stages consist of long traveling x and y axes and rotational (r) axis for the movement of the large size optics and the z-axis for the movement of microscope body tube.

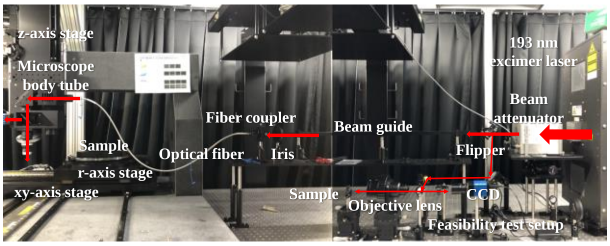

Fig.1 Full experimental configuration of reflective 193 nm DUV microscope system

3. Results and discussion

To investigate the spatial resolution of the reflective DUV microscope system, two kinds of samples with line grating patterns having a line width of 225 nm and a period of 450 nm and alphabet patterns having a line width of 400 nm were prepared. Each patterns were analyzed by the image of scanning electron microscope (SEM), and the spatial resolution was verified by comparing the DUV microscope image with the SEM image. As a result, the spatial resolution at the pattern/blank boundary position within alphabet patterns was estimated to be 240 nm using the knife-edge method. For the case of line grating patterns, the line width of 225 nm was clearly classified by analyzing the full-width at half maximum of the intensity profile in the DUV microscope imaging results.

4. Conclusion

A reflective 193-nm DUV microscope system was developed for the inspection of various defects formed on the optical surfaces with the large size of one-meter scale by providing a high spatial resolution with about 200 nm scale. It is not limited by the sample materials and its thicknesses unlike the transmittive DUV microscope. It is expected that this system would be extended to nano/bio imaging as well as the inspection of the large size optical surfaces.

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References

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