Spectroscopic BPR and Initial Bench Test Result

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Abstract – we introduce a new measurement module, Spectroscopic BPR, which can detect wafer reflectance at the pupil plane in both large AOI range (for example: 0~60°) and large wavelength range (for example, 260~900nm) with high AOI resolution and high wavelength resolution. The measurement information provided by this module is much more than the aggregate of traditional White Light Reflector (WLR) and Optical-Probe Beam Profiler Reflectometer (BPR). It is an excellent candidate to meet the performance challenge of very thick layer measurement, such as N7 (greater than 128 pair) VANAD layers. A UV two-dimensional BPR breadboard system has been modified to prove the Spectroscopic BPR concept, and the 1st Spectroscopic BPR data collected from a thick VANAD wafer is shown here.

I. Introduction

In all optical film and CD metrology tools provided by major vendors, there are two types of measurement modules: one is based on wavelength resolved technology, such as spectroscopy ellisposomter or reflector whose signals are acquired from wide wavelength range but with limited number of AOIs (angle of incident); the other is based on angular resolved technology, such as Archer600 SCOL3 module whose signals are acquired from wide AOI ranges but limited number of wavelengths.

To take advantage of both wavelength resolved technology and angular resolved technology, a new type of technology whose signals are acquired from both wide wavelength range and wide AOI range is desired. Rudolph Research Corporation has patenWe call this ecology as Spectroscopic BPR. Spectroscopic BPR idea was first patented by Rudolph Research Corporation [1]. In their proposed design, a slit following by a dispersion component were added before the two dimensional pupil detector. One of major drawback of this design is low light efficiency. The slit cuts off most of the power of illumination light. Here, we have proposed to use a cylindrical lens or cylindrical mirror, or spatial light modulator (SLM) to convert an illumination beam to a narrow line shape, which can conserve almost all of the illumination light power[2].

II. Spectroscopic BPR Concept

Figure 1 shows the concept of Spectroscopic BPR module with cylindrical lens. The cylindrical lens in the illumination path converts the beam shape of a white light source into a narrow line on the wafer. In the collection path, a dispersion component disperse the line shape beam in 2D rectangular shape on 2D detector. The signal at each pixel represents the reflectance at specific wavelength and AOI. The white light source provide the large wavelength range, while the high NA objective lens provides large AOI range (0~60°) at pupil plane, where the 2D detector is located.

For UV Spectroscopic BPR system, a cylindrical mirror or equivalent, such as the deformable mirror array, can be used to change the illumination beam shape to a narrow line on the wafer. The desperation element can be a prism, or grating.

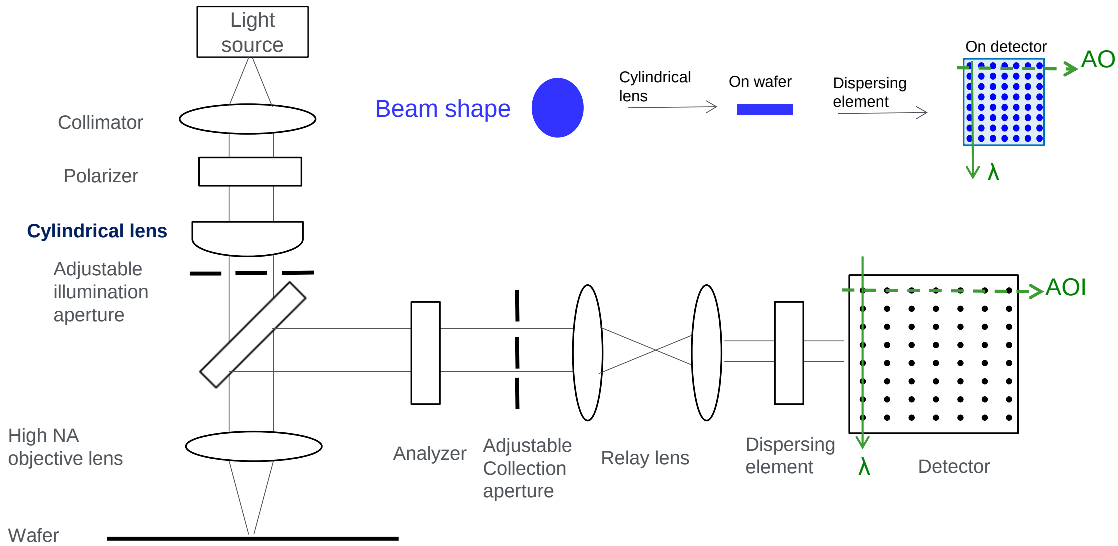

Fig. 1. Spectroscopic BPR with cylindrical lens

III. Spectroscopic BPR Bench Test

We have proposed to replace one of spherical mirror in the illumination path of UV 2D-BPR breadboard measurement path (Figure 2) to a same radius cylindral mirror. Due to the long lead time of the cylindral mirror to match the spherical mirror radiu, we started the bench test by adding a slit and a transmission grating in front the pupil CCD. Figure 3 shows the calibrated wavelengths at specific narrow band filter.

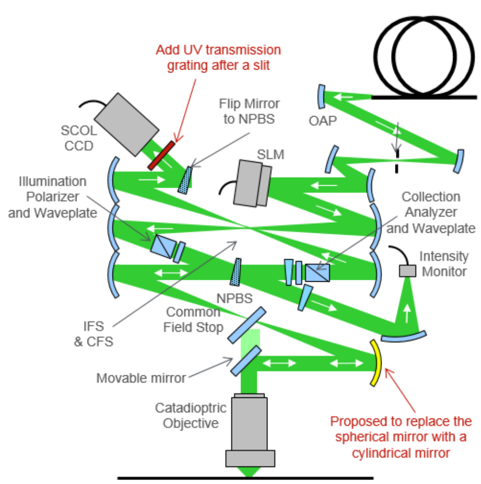

Fig. 1. UV-2DBPR bench test layout

Figure 4.a and Figure 4.b show the measured and simulated VNAND wafer reflectivity respectively. Please note that only the reflectivity in the wavelength range 364~720nm and AOI range 20~60 ° are shown here. This is due to lack of an order sorting filter in front of the pupil CCD to block higher order wavelength diffraction. Only the 1st order wavelength diffraction signal is shown here.

IV. Conclusion

With carefully optical design and components selection, spectroscopic BPR can achieve large wavelength range and AOI range with fine wavelength resolution (~0.6nm per pixel) and fine AOI resolution (~0.004NA). This shall be a good candidate for next generation techno in critical dimension (CD), film thickness and overlay measurement.

Acknowledgment

The Authors would like to thank Gia Ta for supporting UV-2DBPR breadboard alignment, and ChiaJung Chung for providing the VNAND wafer.

Bibliography

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[2] Jiyou Fu, Noam Sapiens, Patent application, " Method and apparatus for measuring a property of a substrate"

[3]