Using moiré fringe for nanoprecision alignment in photolithgroaphy application

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1. Introduction

In the semiconductor development process, wafer alignment is the great significance of the technology. During the wafer bonding [1] [2] or photolithography process, poor alignment causes the wafer to have defective products or even circuit discontinuities. Thus, the alignment of the wafers before photolithography is important.

The Moiré fringes can be used for nano-level detection, which can be directly detected by the optical system through the magnification characteristics of the fringes without additional assistances. J. Zhu et al. designed a set of alignment marks, and a dual line grating which is composed of different periods side by side will have twice sensitivity of Moiré fringes [3].

2. Methodology

The moiré fringe can be used to amplify the misalignment and to analyze the deviation of x, y, and θ_z. The intensity distribution of the moiré fringes being caused by the grating can be analyzed by the optical software. We choose the period of two gratings as p_1 = 4 μm and p_2 = 4.2 μm and the grating size is 350 μm × 350 μm. The selection of this period is proper that the manufacturing accuracy is about 0.1 μm. However, it has at least more than four Moiré fringes which can be detected. It is also easy to analyze as doing phase acquisition.

We apply a low-pass filter to take out the high-frequency terms with using approach of Fast Fourier Transform (FFT) to analyze the frequency terms of the images with gray value. After using FFT to convert the time domain image to the frequency domain, we get the periodic vector expressed in brightness and position. The overlay is complex but the periodic structure does exist. In order to clearly find out the frequency of the main overlay fringes, all the information showed in the frequency domain is processed by logarithm and absolute value. After measuring the positions of peaks and valleys, we can calculate the practical displacement of two wafers.

3. Results and Discussions

In Fig. 1, we calculate the relationship of the practical x offset and the displacement though image processing from the moiré fringes.

Fig.1. Grating model and Moiré fringe misalignment schematic diagram.

In Fig.2, For a case with 0.1 μm misalignment, the left half and right half of the misalignments according to the calculation and imaging processing from the moiré fringes are 0.0976 μm and 0.1016 μm respectively. In general, the practical displacement average error is 0.19%.

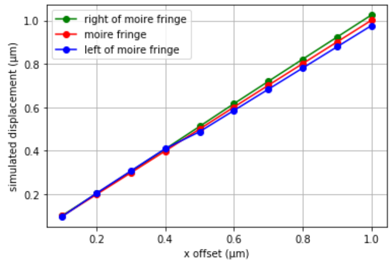

Fig.2. Direction of offset x.

During the adjustment of z axis deflection alignment, the change of the in-plane deflection angle can be directly seen in the spatial phase change. This small angle change is easier to be observe. It is the relationship between the in-plane deflection angle and the corresponding θ_f Moiré fringe deflection angle. It can be viewed from Fig. 3 that when p_2 = 4.2 μm, the δ_t deflection within ±0.025 rad will cause the deflection of the fringes. The phenomenon leads linearity to exceed approximately ±50 degrees.

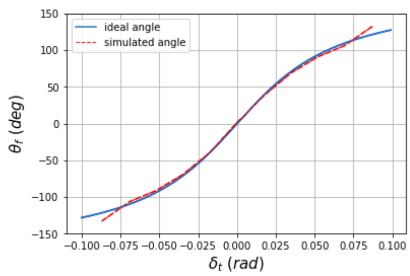

Fig.3. Z axis deflection alignment.

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