Per shot Focus & Tilt-X/Y correction technology for improving focus performance of lithography

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1. INTRODUCTION

Although the focus performance in lithography has improved as the focus accuracy of exposure tools has improved, there are two problems that make it difficult to improve focus accuracy of the exposure tools. One problem is false measurement by the optical focus sensor of the exposure tool. Figure 1 shows how a height difference can occur on the focus measurement surface due to differences in the pattern step and film structure between the cell and peripheral such that false measurement occurs because the focus measurement laser is blocked at the pattern step part. The other problem is focus control error due to a physical height gap between the cell and peripheral. In scan exposure, the exposure tool basically measures the height of the wafer surface and exposes according to the measurement results. Figure 2 shows how the exposure tool cannot follow the results and the pattern resolution performance deteriorates when there is a large height gap in the exposure area. These problems are more pronounced in 3D devices compared with 2D devices because 3D device structures are complicated by 3D memory cell arrays that consist of many stacked films and various peripheral structures.

2. SOLUTION

A solution is to apply product and tool control using a new correction technology that corrects focus and tilt-X/Y for per shot. To improve focus error that causes product issues and tool performance, feedback focus and tilt APC are applied for products, and QC frequency and correction parameters are increased for tool control.

3. TECHNICAL EXPERIMENT

First, the focus matrix wafer was measured using a macro inspection tool to obtain luminance data, and then the luminance data were converted into focus and tilt correction values. The correction parameters consist of three linear components: Z-direction focus and X- and Y-direction tilt. Figure 3 shows the results of correction using this technology. This technology leads to a 50% improvement in focus error.

4. CORRECTION METHOD

The correction method in this technology corrects for products by feedback APC and uses manual feedback for tool control. Figure 4 shows that the product correction flow and tool control flow are the same from the exposure processing step to the inspection step. The point of difference between the two flows is in the calculation step. In any case, this APC system uses the existing feedback APC system.

5. PRODUCT VERIFICATION RESULTS

This technology improved the focus error by about 40% in evaluation results for 2D devices. Figure 5 shows the yield defect data for each wafer area. The yield improved drastically at the wafer periphery, where many focus error occurred when correction was not applied. This confirms effectiveness of this technology.

6. USE CASE FOR TOOL CONTROL

This technology can be used for focus control, which is an important item in QC of exposure tools. This technology can measure the entire surface of a wafer in a shorter time than previously. Highly accurate tool control is made possible by correction at high frequency and per shot by shortening the measurement time and increasing the sampling shots.

7. CONCLUSION

This technology can provide a solution for improving the focus performance of 3D devices, and can be expected to provide the same effect in various other products. We intend to evaluate more focus correction parameters in the future in order to further improve the focus performance (Figure 6).

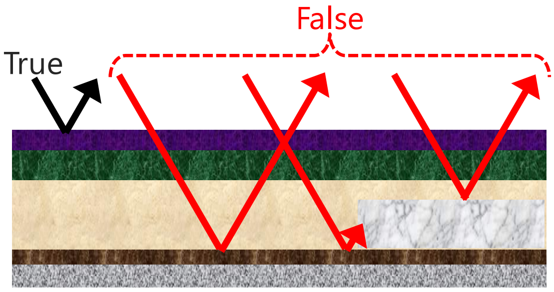

FIG. 1. False measument model

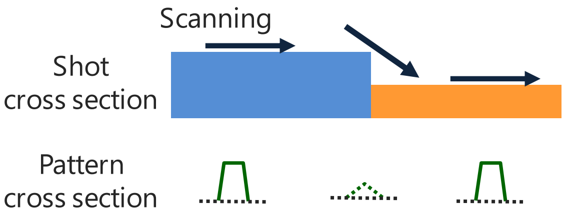

FIG. 2. Control residual error generation model

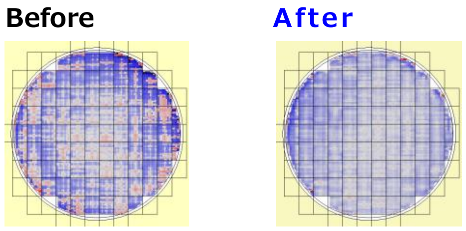

FIG. 3. Technical experiment

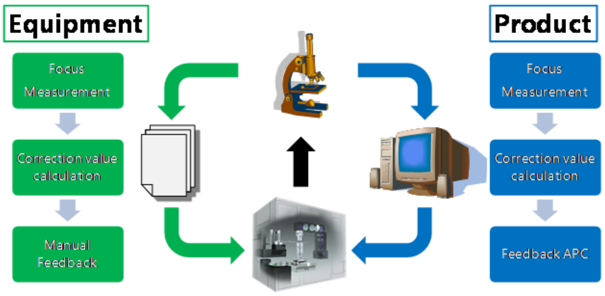

FIG. 4. Correction flow

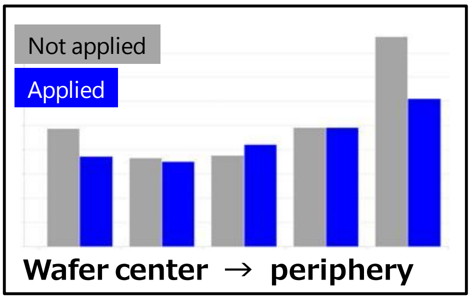

FIG. 5. Product verification result

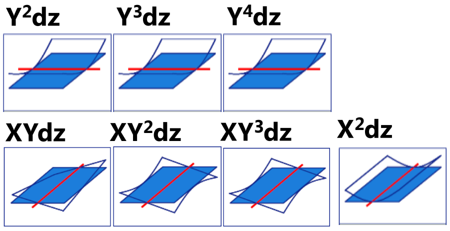

FIG. 6. Extension of the focus parameter