Effective in-line Monitoring Structures for Critical Dimension Measurement in Photolithography

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Abstract

In-line monitoring structures for critical dimension measurement in HBT photolithography have been designed and implemented to reduce the measurement deviation between the CD artifact and real device. The standard CD artifact features and real device CD may not be well correlated or have non-linear deviations. A novel CD structure was designed to match the product device topology and features as closely as possible. This improved the accuracy of measurement from 0.03µm to 0.01µm.

Introduction

Critical dimension (CD) control of each photolithography layer plays a very important role in creating a reliable and high yielding manufacturing process. In semiconductor industries, controlling and measuring CD are one of the key steps for successful production. They are irreplaceable requirements for precision and measurement accuracy. However, measuring the CD with the standard artifact becomes less and less meaningful because the in-line data from standard CD artifact is not the actual CD of the device. This means the standard CD artifact features and real device CD may not be well correlated or have non-linear deviations.

Results and Discussions

The standard TQS CD artifact used for in-line measurements is a pair of chevrons (two L Bars, see Figure 1). Regardless the real device CDs are 0.7µm, 1.0µm, 3.0µm, 5.0µm, etc., the drawn CD of the standard artifact is 2µm for most of photolithography layers. In this study, we found the standard CD artifact and real device CD was not perfect linear. Non-linearity CD measurement can result in difference between the real device and the measured CD artifact. To eliminate this measurement deviation, it is necessary to measure the device in the circuit die, which provides the true CD. However the charging effects of CD scanning electron microscopy (CD SEM) on the photoresist may damage the device which could affect quality of that die and leads to reliability issue. It is also an inefficient way to measure the actual CD and costs time.

Figure 1. The Standard CD artifact.

The work has been done, includes seeking a more effective approach of CD monitoring without changing PCM and circuit die layout. A novel CD structure was designed and implemented to eliminate the deviations from standard CD artifact. The new CD structure was built on the same topography as real device instead of on flat surface to improve the measurement accuracy (see Figure 2). Since it has identical upstream layers as real device, the CD deviation between the new CD structure and real device is minimized. The CD from the new structures can be used to control the process directly with accuracy. This improved the accuracy of measurement from 0.03µm to 0.01µm (see Figure 3).

Figure 2. The new CD structures (match the product device topology and features).

The standard artifact is placed in the Process Control Monitors (PCM) area and is widely used to check CD. Unfortunately it does not provide the CD uniformity information within the printfield. The new CD structures, which are placed in center and 4 corners of a printfield, help to detect the CD uniformity issue, and provide the opportunity to monitor the stepper performance such as focus and tilt issues etc. at the same time. This will be described in more detail in the paper.

Conclusions

The new CD measurement structures are an effective way to replace the standard CD artifact in the practice even if they are not perfect but leave room for further development.

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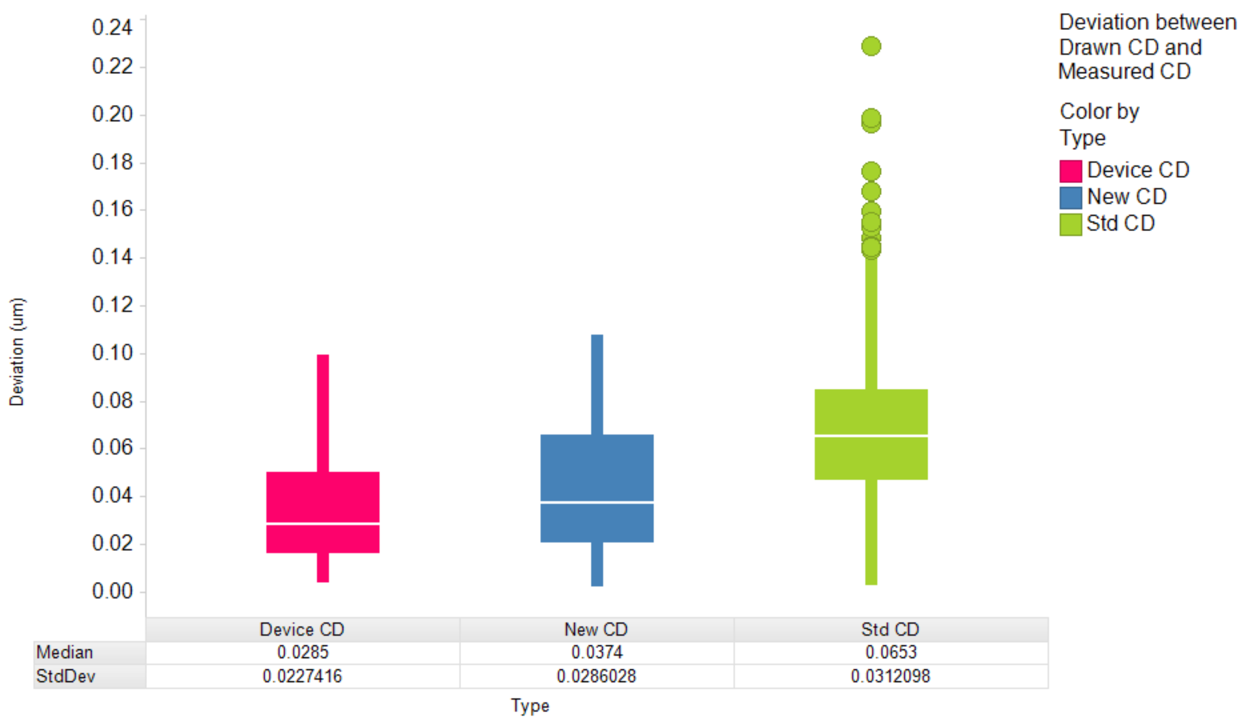

	Device CD	New CD	Std CD
Median	0.0285	0.0374	0.0653
StdDev	0.0227416	0.0286028	0.0312098

Figure 3. The difference between the Device CD, New CD and the standard CD.