Inspection Flow of Yield Impacting Systematic Defects – Chimin Chen

ChengHua ang/ Hsiang-Chou Liao/Tuung Luoh/ Ling-Wu Yang/ Tahone Yang/ Kuang-Chao Chen/ Chih-Yuan Lu
Donghua Liu*/ Jeff Fan*/ Rong Lv*
chiminchen@ mxic.com.tw, chenghuayang, jimliao@mxic.com.tw - chrisluoh@mxic.com.tw -
lwyang@mxic.com.tw - thyang@mxic.com.tw - kcchen@mxic.com.tw - cylu@mxic.com.tw
donghua.liu@anchorsemi.com* – swfan@anchorsemi.com* – lvrong@anchorsemi.com*
Macronix International Co. Ltd, Technology Development Center
Anchor Semiconductor, Inc.*
No. 16, Li-Hsin Road, Science-Based Industrial Park, Hsinchu, Taiwan, R. O. C.
Phone: +886-35786688 -#53597 Fax: +886-3-5789087
Keywords:Systematic Defect, FEM, PWQ, Pattern Grouping, Hot Scan

Abstract – Yield impacting systematic defects finding is no longer just relied on Design Rule Checking (DRC) provided by designer or Lithography Rule Checking (LRC) provided by post-optical proximity correction (OPC) results. An inspection flow is proposed in this paper, which is combining the inspection KLA tool and Hotspot Pattern Analyzer (HPA) database software to do the systematic defects filtering, sorting, grouping, and classification on the data base after hot scan inspection. 2nd time high sensitive inspection is done with new care area, which is reduced into one ten-thousandth of original inspection area. Following this inspection flow, we can identify the process window more accuracy.

Introduction – As device features continues to shrink, the process complexity increases tremendously, which results in design-process are difficult to predict and control. For a long-term period it was assumed that as long as a designer passed DRC or LRC provided by post-optical proximity correction (OPC) verification that it would have acceptable yields when it was manufactured. However, when the dimension of the critical design rule become much smaller than the wavelength of the light, the edge placement integrity of the original design induced by light diffraction or process effect are harder to compensate for even using the properly OPC technique. Therefore, the process window verification on the printed wafer becomes an important way to provide the OPC accuracy improvement [1-2]. Various techniques are used to identify the process window like Focus Exposure Matrix (FEM), CD SEM and Process Window Qualification (PWQ). The accuracy information of the process window help people to make a right decision about whether to redesign the reticle or fine-tune inline defect, and then minimize the impact of the systematic defects on device yield. This paper illustrates a feasible inspection flow on a FEM or PWQ wafers to identify the process window accurately.

Experimental – Here demonstrated a new inspection flow of the FEM window on the damascene oxide trench of metal layer in NAND flash memory, shown in Fig. 1. This methodology is combining of the KLA 2830 inspection tool and Nanoscope HPA™ (Hotspot Pattern Analyzer) developed from Anchorsemi Co. Ltd., and then compares its performance with traditional FEM methodology.

Results and Discussion

Traditional Process Window Determination – Traditionally, FEM window is determined by inspecting the selected CD uniformity window predicted by lithography then reviewing the defects randomly with low percentage after wafer inspection. Sometime, it will have wider process window and lead to yield loss impact for critical layers if the review sampling rate is not enough, as shown in Fig. 2(a). Fig. 2(b) demonstrates smaller process window if we increase the review sampling rate. It takes much time and labor to review and analyze all of the defects detected at FEM or PWQ wafers to identify the process window accurately. Nanoscope HPA™ developed from Anchorsemi Company provides data mining methodology to handle the huge amount of defects with relative patterns into less than thousands of pattern groups. It can save a lot of tool time and labor hours for the analysis.

Inspection flow of FEM process window identification – Fig. 1 demonstrates that the new methodology of lithography process window determination. Hot scan of FEM or PWQ wafer is very important step for the first time inspection due it can inspect all the possible systematic and random defects in one scan, sometime it maybe over million defects located at different patterns. Fig. 3 shows over 700000 ea defects located on the FEM wafer. Defect filtering functions provided by Nanoscope HPA™ can filter out the unnecessary defects and reduce the high false rate. Fig.1 shows that the methodologies of data mining functions after hot scan inspection include pattern density filtering, pattern grouping, local critical area analysis, pattern uniformity filtering, pattern search, and design rule analysis, etc. Through regrouping, sorting, filtering, and classification methodologies, the huge amount of defects in hot scan can be diminished effectively by HPA tool smart sampling review methodologies. In this example, over 700000 defects in hot scan can be reduced by excluding defects located on the no pattern or loose pattern sites by pattern density analysis, as indicated in Fig. 4. Furthermore, the systematic defects in FEM wafer will be found repeatedly, HPA tool can classify and group these systematic defects according to the geometry or shape of features, it provide the fast viewing the pattern groups' types of these systematic defect location sites in the design layout. Therefore, it can help us to quickly identify repeating patterns among the huge defect results, as shown in Fig. 5. Exactly or similar pattern search can be executed to find out the risky similar pattern with similarity degree setting in the full chip according the types of risky pattern groups. Fig. 6 demonstrates the pattern search results with similarity degree 85%. Under these similar pattern searches, it helps us to find the risky sites which have similar design with issued pattern. The search results can put in the data base as a library for batch searching in next time if there has similar or re-version masks want to tape-out. After these actions of defect regrouping, sorting, filtering, the defect counts dramatically decrease and classify from over 700000 ea to 1288 types of pattern groups, and then we pick up 3 defects per group to do care area reduction. Fig. 7 (a)(b) show the original full chip care area change into a new scan care area and the care areas are diminished from 0.24 cm^2/die to 0.0000225 cm^2/die, i.e. the scan area decrease into 1/10000 of original inspected area. Therefore, we use the new care area to setup a high sensitivity inspection recipe to monitor the systematic defects in these risky care areas. After we complete the inspection flow as shown above, the FEM process window become much smaller than that of previous random review process window, as shown in Fig. 8.

Conclusion – Here demonstrates an inspection flow of yield impacting systematic defect finding on the damascene trench of metal layer FEM wafer in NAND flash memory, which is combing the KLA inspection tool and the HPA tool to do the sorting, filtering, grouping, and classification the defects to database after hot scan inspection. Care area is reduced into one ten-thousandth of original inspection area, and then set it with high inspection sensitivity to inspect again. By using this inspection flow, we can get much smaller process window and identify the process window more accuracy.

Reference

1. Jing Zhang et. al., Yield impacting systematic defects search and management, SPIE Vol. 8327-41 (2012).

2. Gyun Yoo et. al., OPC Verification and Hotspot Management for Yield Enhancement through Layout Analysis, SPIE Vol. 7971 (2011).

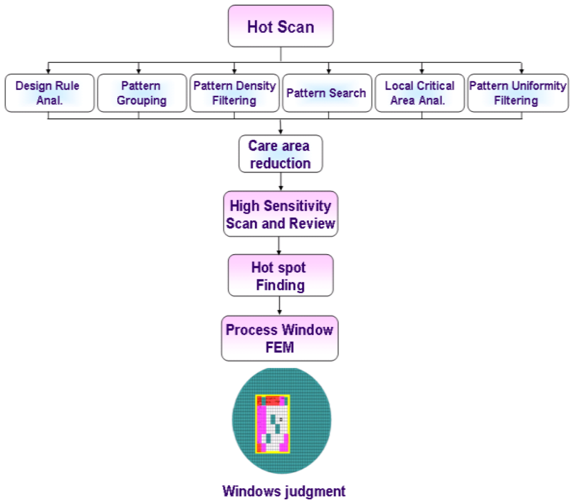


Fig. 1 Inspection flow of yield impacting systematic defects finding.

(a) (b)

Fig. 2(a) It will have wider process window if the review sampling rate is not enough (b) smaller process window if we increase the review sampling rate.

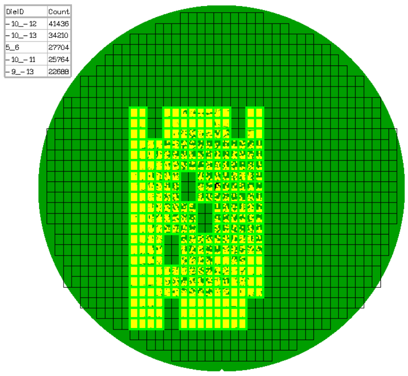


Fig. 3 There are over 700000 ea defects located on the FEM wafer after hot scan inspection.

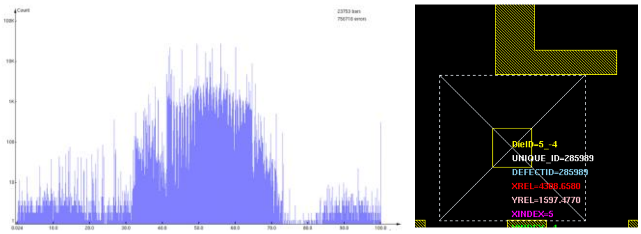


Fig. 4 review sampling can be reduced by analyzing the pattern density of defects surrounding polygon.

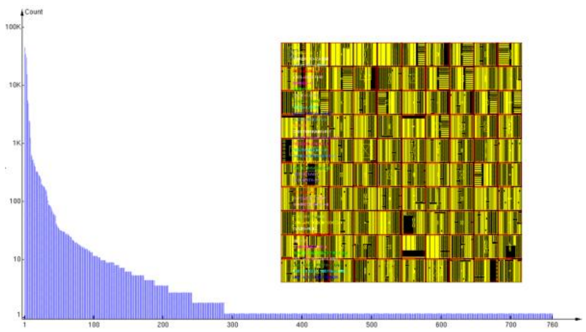


Fig. 5 Pattern group distribution of the defect data. The group counts are 760 (left). We group the defects which are located on the similar pattern. (right side).

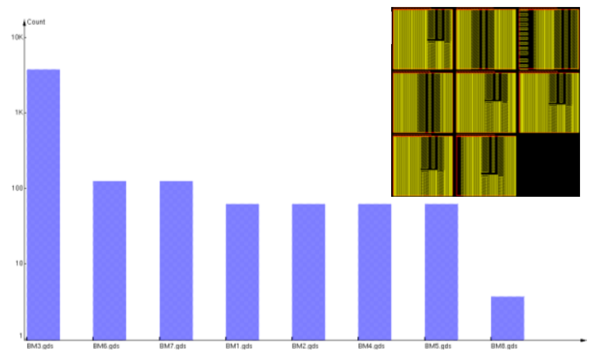
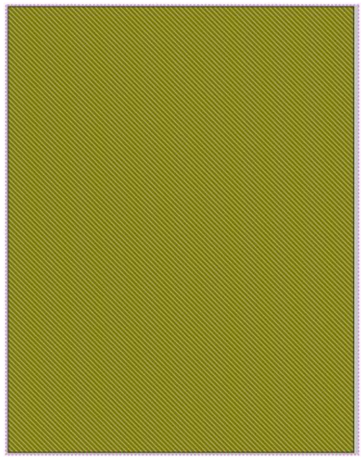
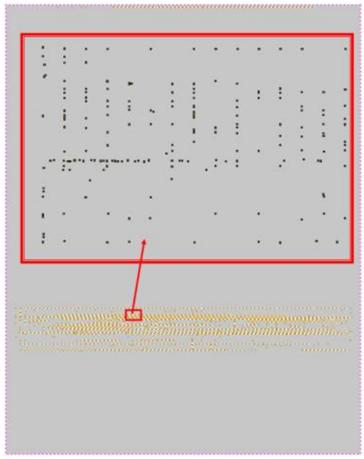


Fig. 6 demonstrates the pattern search results with similarity degree 85%.



(a)



(b)

Fig. 7 (a) Origin care area (b) After care area reduction, the areas diminished to 1/10000.

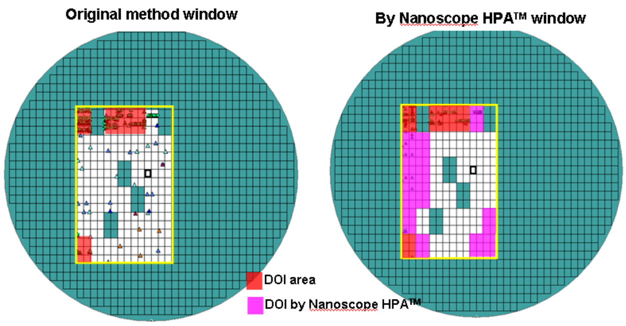


Fig. 8 Window comparison between traditionally random review method and the new inspection flow. After HPA operation, we can get a smaller window than the traditional one.