Design guided data analysis for summarizing systematic pattern defects and process window

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ABSTRACT

As the semiconductor process technology moves into more advanced nodes, design and process induced systematic defects become increasingly significant yield limiters. Therefore, early detection of these defects is crucial. Focus Exposure Matrix (FEM) and Process Window Qualification (PWQ) are routine methods for discovering systematic patterning defects and establishing the lithography process window. These methods require the stepper to expose a reticle onto the wafer at various focus and exposure settings (also known as modulations). The wafer is subsequently inspected by a bright field, broadband plasma or an E-Beam Inspection tool using a high sensitivity inspection recipe (i.e. hot scan) that often reports a million or more defects. Analyzing this vast stream of data to identify the weak patterns and arrive at the optimal focus/exposure settings requires a significant amount of data reduction through aggressive sampling and nuisance filtering schemes. However, these schemes increase alpha risk, i.e. the probability of not catching some systematic or otherwise important defects within a modulation and thus reporting that modulation as a good condition for production wafers. In order to reduce this risk and establish a more accurate process window, we describe a technique that introduces image-and-design integration methodologies into the inspection data analysis workflow.

These image-and-design integration methodologies include contour extraction and alignment to design, contour-to-design defect detection, defective/nuisance pattern retrieval, confirmed defective/nuisance pattern overlay with inspection data, and modulation-related weak-pattern ranking. The technique we present provides greater automation – from defect detection to defective pattern retrieval to decision-making steps—that allows for statistically summarized results and increased coverage of the wafer to be achieved without an adverse impact on cycle time. Statistically summarized results, lead to objective assessments of the output; and increased coverage, in turn, leads to a more comprehensive assessment of the impact of each pattern defect and each focus/exposure modulation. Overall, this leads to a more accurate determination of the process window.

Keywords: Process Window Qualification (PWQ), Contour Extraction, Contour-to-Design Alignment, Contour-to-Design Defect Detection, Pattern Retrieval, Pattern-Defect Overlay, Weak-Pattern Ranking

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