Slicing-Aided Hyper Inference for Defect Inspection in Hexagonal Contact Hole Arrays Using Voltage Contrast Metrology

Bappaditya Dey, Shubhankar Das, Victor Blanco, Sandip Halder
imec, Kapeldreef 75, 3001 Leuven, Belgium
bappaditya.dey@imec.be

Ke Han, Jiangping Wang, Lingling Pu, Roger Lahaye
ASML, San Jose, California, USA

Abstract-At the latest technology nodes, defectivity has become crucial for improving device yield. Among the most challenging defects to detect are those buried beneath the surface in EUVL patterns. Previous research work[1] demonstrated the use of a computer vision based manual defect analysis algorithm applied to an AEI dataset of hexagonal contact holes (CHs) with a 36 nm pitch, acquired using voltage contrast (VC) metrology. The main drawback of the algorithm is its reliance on trial-and-error for selecting hyperparameters and threshold values, which leads to sensitivity issues related to gray-pixel level variations and impacts the accuracy of defect classification and detection. In this research, we investigated the use of the Slicing Aided Hyper Inference (SAHI) framework[2,3] to enhance VC-SEM-based defect detection of resist wafers at EUVL process pitch scales and beyond. We evaluate SAHI's performance on hexagonal CHs with varying critical dimensions (CD), pitches, fields of view (FoVs), and resolutions to quantify the defect density, measured as the number of defects (NoDs) per million CHs. As a model-agnostic inference framework, SAHI can be integrated into various ML-based Automated Defect Classification and Detection (ADCD) systems. We applied the SAHI framework to three different YOLO models, with various architectural variants and configurations, to demonstrate improved defect detection performance, particularly for challenging nanoscale defect types in the presence of subtle grayscale variations. Additionally, a user interface (UI) has been developed to help users upload their raw images, run the defect inspection framework in the background, and generate a metadata file (CSV) that provides the total counts of defects per class and their corresponding locations (XY-coordinates). A key advantage of this framework is its distortion invariance and independence from GDS alignment, as well as its ability to operate without the need for explicit fine-tuning or training from scratch for different FoVs, resolutions, or pitches. Our proposed ADCD framework has the potential to facilitate the detection of defects with varying grayscale intensities using VC metrology at both ADI and AEI stages, aiming to demonstrate its robustness and generalizability.

[1]S. Das, V. Blanco, B. Dey, X. Liu, G. Schelcher, and D. De Simone, Proc. SPIE 13215, 66 (2024).
[2]V. D. Ridder, B. Dey, V. Blanco, S. Halder, and B. V. Waeyenberge, AIP Conf. Proc. 3164, 030009 (2024).
[3]F. C. Akyon, S. O. Altinuc, and A. Temizel, Proc. IEEE Int. Conf. Image Process. (ICIP), 966 (2022).

Preliminary Results and Analysis:

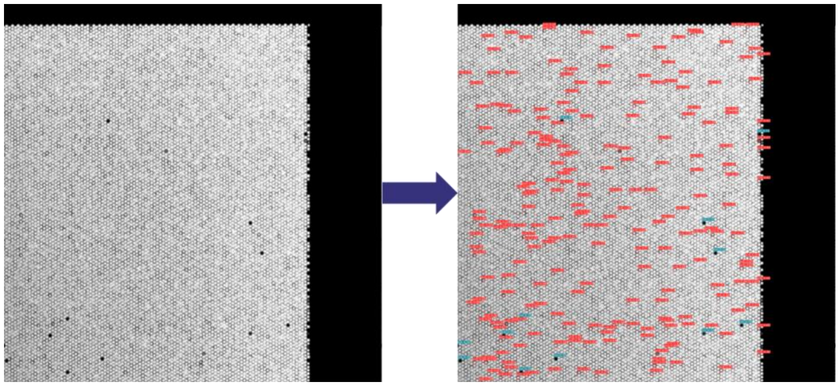


Figure 1: Example defects (*fully closed*, *partially open holes*) predicted by proposed ADCD framework with YOLOv8n. Pitch 36 nm.

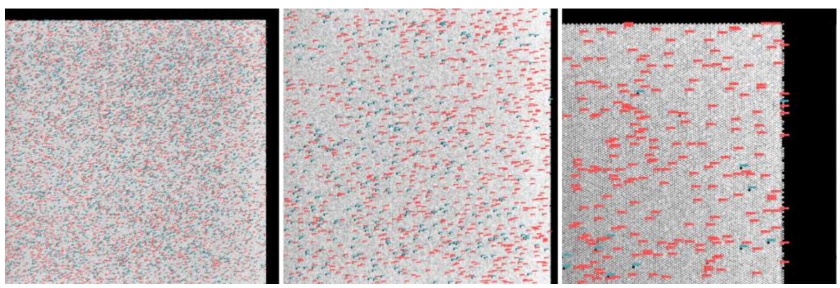
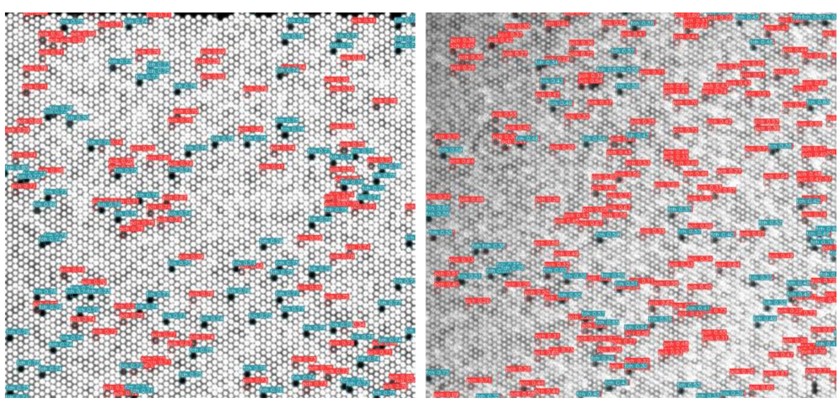


Figure 2: Example defects (*fully closed*, *partially open holes*) predicted by proposed ADCD framework with YOLOv8n, for different FoVs/resolutions. Pitch 36 nm.



[Left] [Right]

Figure 3: Example defects (*fully closed*, *partially open holes*) predicted by proposed ADCD framework with YOLOv8n, for different Pitches, [Left] 36 nm, [Right] 32 nm.