A study of extreme ultraviolet lithography defectivity

Kevin D Cummings, Sang-in Han, Brian Niekrewicz, Thomas Laursen, Youri van Dommelen, John Zimmerman – ASML Albany

Sungmin Huh and Liping Ren – SEMATECH

Il-seok Son and Ted Liang – Intel

Sumanth Kini and Roland Hahn - KLA-Tencor

One of the remaining concerns for implementing Extreme Ultraviolet Lithography (EUVL) into manufacturing is the identification and reduction of defects. This concern started with the knowledge that multilayer EUV reticles would need to be created from pristine (defect free) blanks and kept that way during use - without the protection of a pellicle. This study builds on previous studies that at first were only able to simulate the effects of defects on imaging, which then later progressed to measure wafer defects using small field tools with programmed mask defects, and most recently to measure defects on devices where one of the layers was exposed with EUVL.

In this work we used the ASML EUV Alpha Demo Tool (ADT) at the College of Nanoscale Science and Engineering in Albany, NY, to investigate the capability of both wafer and reticle defect inspection tools, their correlations and to identify the gaps that exist between what is observed on a reticle and what is possible to detect on a patterned wafer. With over 100 completed experiments with EUV mask blanks we have extensively studied our capability to handle and move reticles external and internal to the ADT with regards to the numbers and types of defects that could appear on a reticle. This effort allowed us to develop our current capability of manually moving reticles into and out of the ADT without any added particles to the exposure area and with only 0.03 particles added to the entire surface per reticle cycle. Finally, we will discuss monitoring of our EUV tool resist processes and our efforts to establish a baseline with low defectivity levels to allow studies that provide insight into the use of recently introduced EUVL pilot production machines.

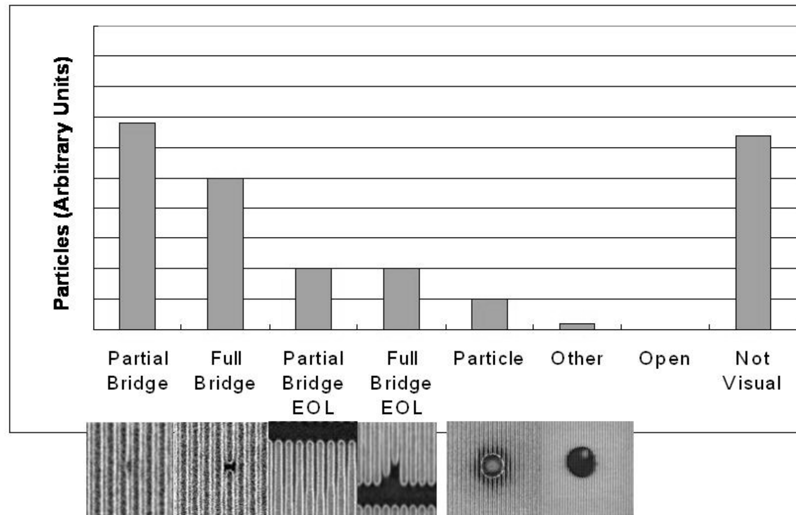

Figure 1. Pareto chart and SEM of example defects types from an unoptimized EUV resist process observed in the Alpha Demo Tool. This is the typical starting point for defect reduction studies in EUVL.