Implementing Dual Pod Handling Capability on a Film Deposition Tool for Defect-free EUVL Mask Blank Development

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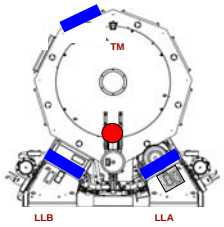
Introduction

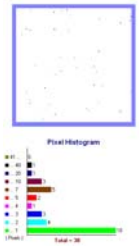
- One of the critical issues that must be solved to enable extreme ultraviolet lithography (EUVL) production lines is the manufacture of defect-free EUV masks.
- Protection from particles throughout the entire mask-making process is a critical task that must be overcome for an EUVL mask pilot line to be successful.
- SEMATECH and major reticle handler stakeholders have worked together to build SEMI-compliant dual pod reticle carriers that incorporate an outer and inner pod into a complete reticle protection system.
- A supplier has provided a commercial version of its dual pod and the results of storage, handling, and shipping tests of this pod, which show promising particle protection capability.
- A segment of SEMATECH's Defect Reduction Program is focusing on developing the next generation front-end (FE) module of the EUV ML mask blank deposition tool. As this module has been identified as one of the main contributors to contamination from the EUV mask blank Ml deposition process, implementing a dual pod handling capability on such a FE is essential. This paper will present a realistic design concept and report on current front-end blank handling status.

Current ML Deposition Tool FE

A Schematic of FE Modules

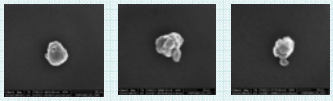


M1350 Inspection Plot



Defect Composition from MW

- The majority of particle adders from the current front-end have been determined to be carbon.



- A small portion of large adders: AlOx, SiOx, stainless steel, etc.

(a) AlOx (b) SiOx (c) Stainless Steel

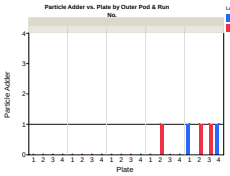
Issues with ML Deposition Tool

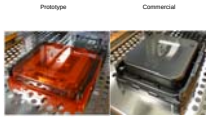
- Large volume of load locks
  - Each cassette holds five substrates for a thin film deposition process
  - Times for pump-down and venting procedures are long for large volumes
  - Possible cross-contamination issues with air flow during venting
  - Required: Small load lock for a single plate transfer
- Plate face-up during transfer
  - Due to gravity, the particle might fall on to the surface of substrates during transfer
  - Required: Dual pod with upside-down plate handling
- Common transfer module for incoming and outgoing plates
  - Possible cross-contamination with plates after film deposition
  - Required: Dual plate transfer modules

Dual Pod Development Efforts

- The SEMI PIC Standard Committee approved adoption of an EUV reticle carrier ballot (EUV-pod/4466B) as a new standard.
- The tests of EUV reticle pod carriers exhibited particle protection capabilities during robotic handling and storage tests [1, 2].
- MIRAI-Selete has been developing EUV reticle handling technology and evaluating EUV reticle pods designed using "Dual Pod Concept" for years and test results showed promising particle protection capabilities [3].

Additional Shipping Test using Commercial EUV Pod

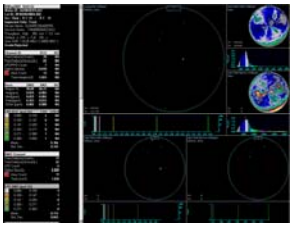




- Test Results:
  - Averaged particle adders were 0.3 per shipment for prototype outer pod and 0.2 per shipment for commercial outer pod.
  - The test results showed improved particle protection capability in that particle adder were reduced to 0.2 per shipment using a commercial outer pod from a previous shipping test.

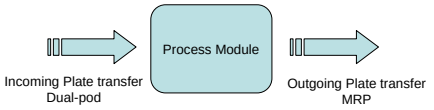
Dual Pod Handling in Atmospheric Environment

- The atmospheric robot-handling environment is a viable solution for the next generation tool with dual pod and small load lock
- SEMATECH owns a wafer AFM tool with the same EFEM and testing has demonstrated low particle density (0.2 defects/cm^2) from handling



Dual Plate Transfer Modules

- Separate plate transfer is needed for incoming substrates and outgoing blanks to minimize cross-contamination
  - Incoming plates: Use dual pod and inner pod storage in vacuum
  - Outgoing plates: Use a multiple reticle SMIF pod (MRP)



Summary and Conclusion

- Establishing defect-free mask blanks is one of the key issues that needs to be resolved to enable adoption of EUVL.
- Improving the cleanliness of the FE module in the ML deposition tool is one of the critical engineering tasks to be completed for the next generation deposition tool.
- Based on dual-pod test results, the semiconductor industry has begun integrating dual-pods at blank manufacturers, mask shops, and wafer-fabs.
- It is crucial that the next generation deposition tool be fully integrated with the dual-pod front-end to meet mask blank defect requirements.

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References

[1] L. He, et al., *Proc. SPIE* 7271, 7271-18, 2009.
[2] G. Huang, et al., *Proc. SPIE* 7636, 7636-25, 2010.
[3] K. Ota, et al., *Proc. SPIE* 7636, 7636-1F, 2010.