Particle-free mask handling techniques and a dual-pod carrier

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Acknowledgements

This work is supported by NEDO as part of the EUV mask program.
1. Introduction

Purpose of this work: Evaluation of dual pod

We have studied particle adders on a mask blank using Mask Protection Engineering (MPE) tool. We have compared a difference in number of particle adders between a dual-pod carrier and a naked mask blank.

I will present that a dual pod has a high performance to protect from particles and that the number of particle adders for various processes is generally one or zero.
For all processes and inspections, a mask blank and an inner pod were always transferred by the robot arm of the MPE tool or the M3350. They were never handed manually.

Sensitivity >90% @ 46nm PSL
>99% @ 50nm PSL

Lasertec M3350
RSP200 Carrier

Dual Pod Carrier
(Canon, Nikon, Entegris, Selete)
Air flow in an inner pod during purge

We confirmed the following two functions of an inner pod worked effectively.

1. Filter effect
   The cleanliness of the environment in the inner pod is considered to be independent of that of the outside.

2. Gap effect
   All particles enter through small gap. Particles adhered near the edge of the front side,
3. Transfer Experiments

3-1. Particle adders over total path

Purpose

To examine the number of the particle adders for dual pod and naked mask.

Experimental Conditions

1. Transfer path
   a. Air & LL (Port L/L (including pumping down / purging)
   b. Vacuum path (w/o chucking on ESC)
      Dual Pod ( L/L Opener ESC chamber )
      RSP Pod ( L/L ESC chamber )
   c. Full path ( = a+b )
   d. Put on ESC

2. Common experimental condition
   a. Carrier Dual pod, RSP
   b. Purge gas Dry air through a filter
   c. Mask blanks Quartz 152mm sq.
Particles >= 46 nm PSL, Inspection area is 142 mm sq.

This table shows the number of particle adders per cycle on the front side. The numbers in parentheses indicate the total number of handling cycles over multiple experiments.

We confirmed the number of particle adders over the path from the load port in air to the ESC chamber in vacuum could be reduced below 0.01 particles/cycle (>= 46 nm PSL).
3-2. Dependence of number of particle adders on outside cleanliness

**Purpose**

We examined how the number of particle adders during pumping down and purging varied with the cleanliness of the area outside of an Inner pod. To change the cleanliness of the area we repeated pumping down and purging the ESC chamber. The ESC chamber had not been pumped down or purged more than 10 times before this experiment.

**Experimental Conditions**

1. **Path : Port EFEM L/L Transfer**
   
   \[
   \{ \text{ESC (pumping down \\
   & purging) } \} \times 10 \sim 200 \text{ cycles}
   \]
   
   We transferred either a naked blank or the inner pod to the ESC chamber.

2. **Pressure (ESC) :** 1 E 5Pa \(\Rightarrow\) 5 Pa

3. **Purging gas :** Dry air (without filter)

4. **Pod :** RSP200 Pod (Naked blank), Dual pod (Inner cover + baseplate)
3-2. Dependence of number of particle adders on outside cleanliness (2) Result

The number in parentheses indicates the times of pumping-down and purging operation for each step. The data plotted as 0.01 (1/cycle) mean zero particles.

We confirmed that the number of particle adders on a blank in the Inner pod war not influenced very much by the cleanliness in the outside environment.
Most particle adders on the front were near the edges. This means particles easily stop near the edges even if particles enter the gap between the front side and the baseplate.
3-4. Histogram of particles adders

One measurement means one experimental routine that includes a pre-scan, an event (transfer, storage and so on) and a post-scan. Inspection area is 142mm sq.

The number of particle adders (>= 46nm PSL) during one measurement with a dual pod is generally zero or one and is very stable. In contrast, for a naked mask, the number is very unstable and varied from very few to very much.

A: Frequency of zero or one particle adders, B: # of times for all measurements

A/B  >80% @ dual pod
    20% @ naked mask
Summary

1. We confirmed a dual pod could protect a mask from particles very well. During the process from the step of taking out a mask from an outer case in air to a step of contacting with ESC in vacuum, the number of particle adders can be suppressed to less than 0.01 particles/cycle (>=46nmPSL).

2. A number of particle adders in experiment with a dual pod is generally zero or one and is very stable. In contrast, for a naked mask, number varied from very few to very much and is very unstable.

3. We confirmed the following two functions of an inner pod worked effectively.
   a. Filter effect
   b. Gap effect
1. This work is supported by NEDO as part of the EUV mask program.

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