Development of closed-type EUV pellicle

Yosuke Ono, Kazuo Kohmura, Atsushi Okubo, Daiki Taneichi, Hisako Ishikawa, Tsuneaki Biyajima

Mitsui Chemicals Inc., (Japan)
580-32 Nagaura, Sodegaura, Chiba 299-0265, Japan
Phone: +81-438-64-2336 FAX:+81-4383-64-2355 e-mail: yosuke.ono@mitsuichemicals.com

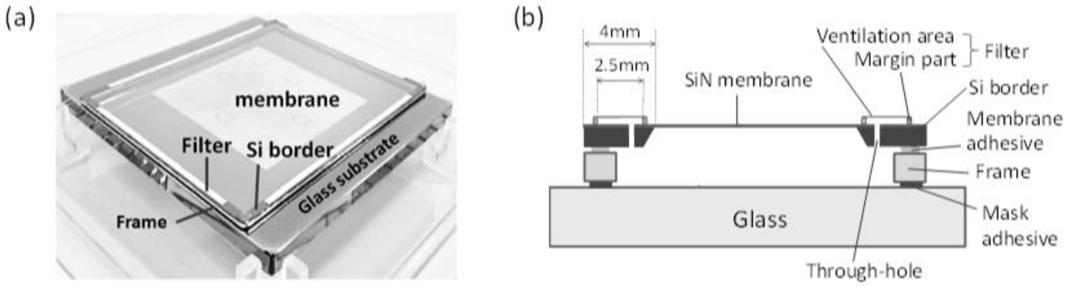
Pellicles have been normally used as a dust cover film of the photomask for photolithography manufacturing from g-line lithography to ArF immersion lithography. Existing pellicle can in principle protect the pelliclized mask surface from particle pollution by completely covering the mask surface without any gaps, and then printing defects on wafers has been steadily reduced. As a result, it is a well-known fact that the design concept of this closed pellicle brings remarkable contribution for the improvement of productivity and yield in the manufacture of semiconductor chips. One of the most important features of pellicle is the closed structure to guarantee the clean-keeping performance of mask surface. As for the EUV pellicle, closed pellicle structure which has fundamentally no penetration path of particles is needed to guarantee the particle pollution free performance in EUVL manufacturing.

In the current ArF pellicle, small ventilation hole for adjusting the pressure inside and outside the pellicle are provided on the side surface of the pellicle frame, and a filter is attached on the ventilation hole to prevent the particle insertion into the inside of pellicle. In the case of EUV lithography, pelliclized EUV mask experiences the significant pressure change from atmospheric pressure to high vacuum range in the EUV scanner. Pellicle membrane deflection due to the pressure difference between the inside and outside of pellicles must be below 0.5mm. Expansion of the total filter area of pellicle will be generally effective for the suppression of membrane deflection. However, there is also an additional restriction that the stand-off of EUV pellicle must be 2.5mm. The height of the frames supporting the Si border becomes very low when we take into account the thickness of Si border which supporting a pellicle membrane. Therefore differential pressure cannot be suppressed by the method to put filters on the “side of the frame” like conventional ArF pellicle.

In the present study, we fabricated a novel closed EUV pellicle without any gaps by forming the vent holes in the Si border part and putting the sufficiently wide area filters on the top side of Si border. Sizes, areas and locations of filters were designed by taking into account the differential pressure during the pumping down and ventilation condition. Full-size closed EUV pellicle sample was installed in vacuum chamber and deflection of pellicle membrane was experimentally examined from the atmospheric pressure to vacuum pressure range during the pumping/ventilation condition. As the result, we found that the closed EUV pellicle can depress the membrane deflection below 0.5mm under the practical pumping down condition.

Furthermore, as for EUV pellicle, contamination growth on mask surface during EUV exposure should be suppressed. In order to suppress carbon contamination growth to the EUV mask surface, generation of outgassing of organic matter generated from the mask adhesive, in particular, hydrocarbon type should not be permitted.

We fabricated EUV pellicle with coated adhesive as the mask adhesive to suppress the outgas generation which causes the contamination on mask during EUV exposure. EUV irradiation was performed to the base plate which has similar component of the EUV mask surface inside the pellicle space. Contamination growth was not observed for the sample with coated adhesive, but observed for the sample with general adhesive as mask adhesive. Coated adhesives for mask adhesive of EUV pellicle, which keep the adhesive properties, will be suitable for fixing method to suppress the mask contamination during EUV exposure.



Concept design of closed EUV pellicle. (a) Fabricated closed pellicle sample on glass substrate,

(b) Cross sectional image of fabricated closed pellicle.