



Deflection of the full scale free standing EUV pellicle is OK

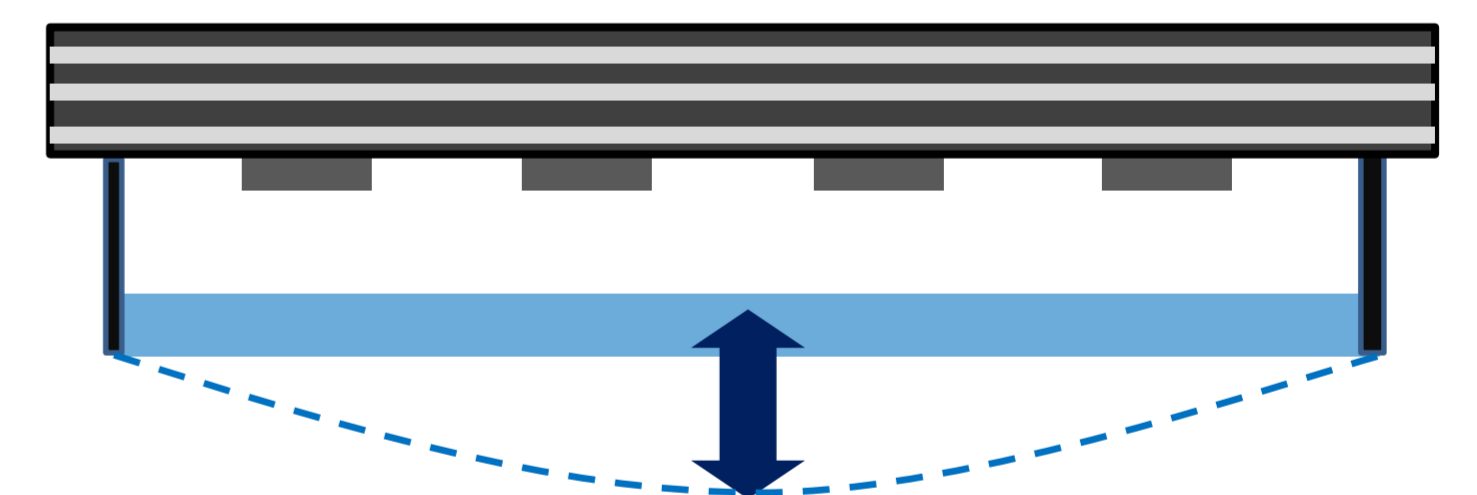
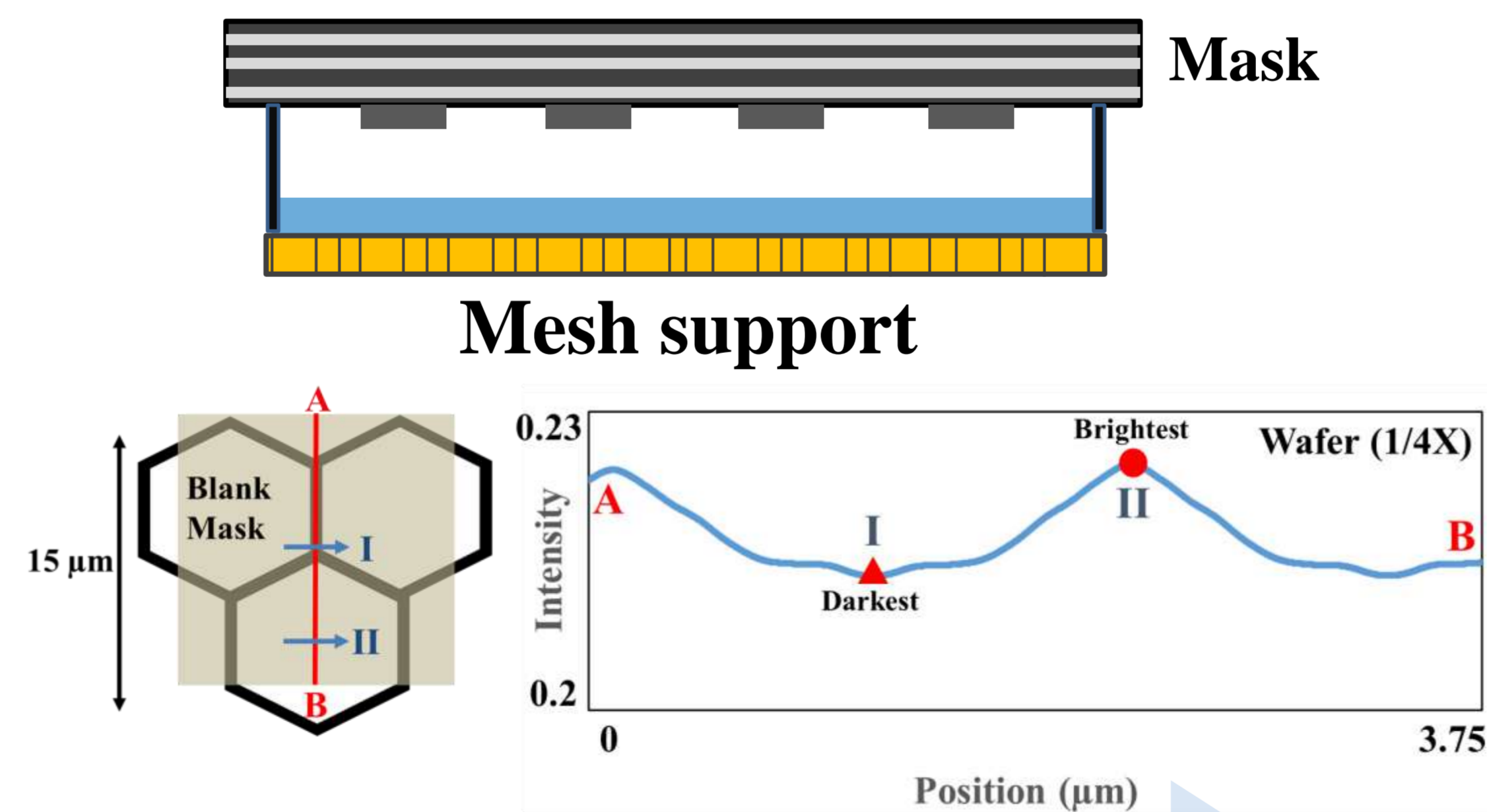
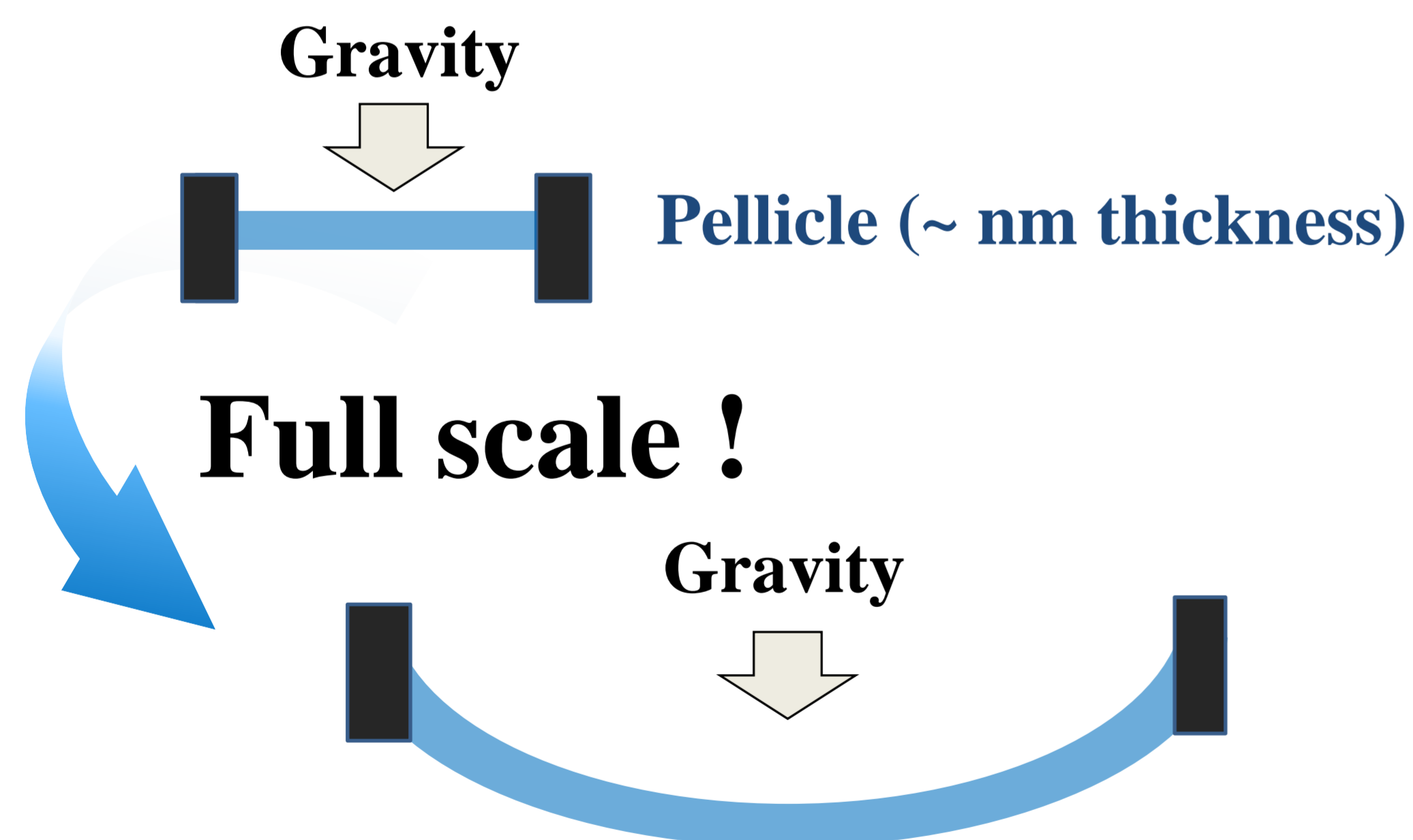
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Abstract

The pellicle is necessary to prevent defect printing and to increase the yield in extreme ultra-violet lithography(EUVL). The thickness of the pellicle should be nanometer thin and the deflection due to gravity was thought to be very large. Although the mesh support reduces the deflection, it could cause serious non-uniform intensity distribution and local critical dimension uniformity variation. Therefore, if possible, the free-standing pellicle is preferred. We revisited the possible large deflection of the thin membrane, and found that the non-linear deflection term was added to the deflection equation if the deflection was large compared to the thickness of plate. It turned out that the deflection of the thin free-standing full scale pellicle was less than the desired specification. Our result shows that a mesh grid support to prevent the deflection is not necessary for the EUV pellicle.

Motivation



**Free standing
without mesh?**

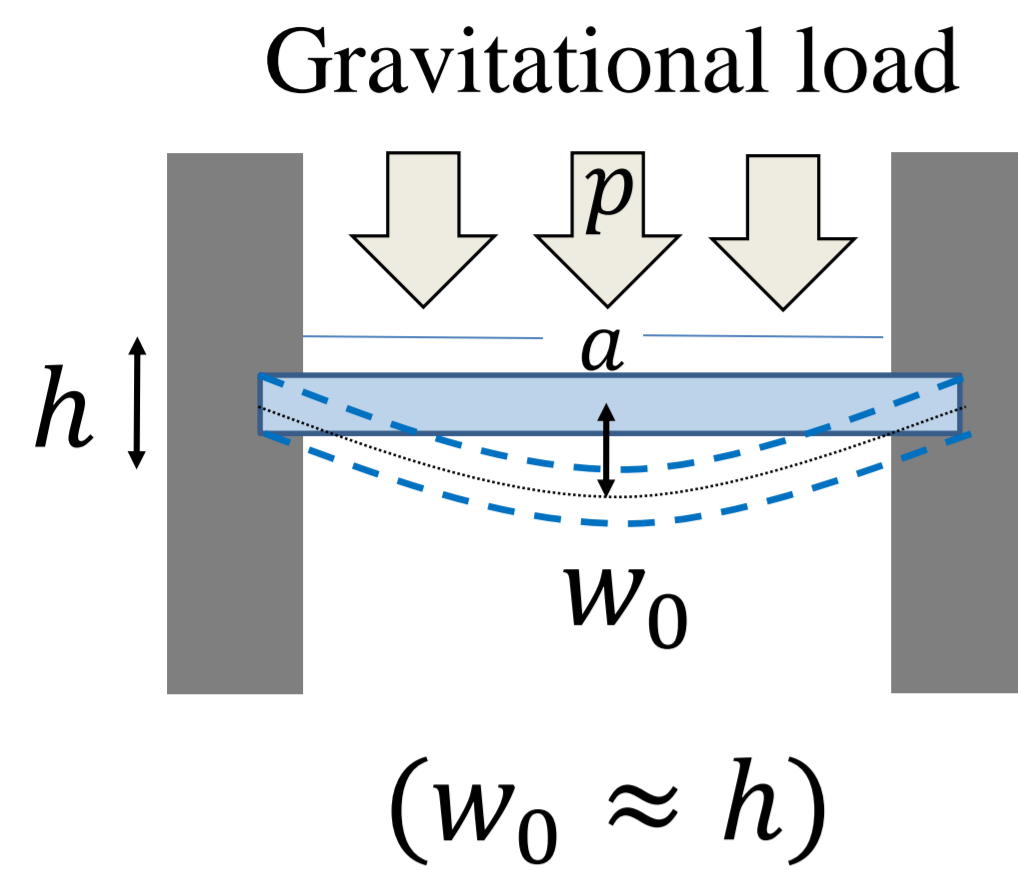
The thickness of the pellicle should be nanometer thin. Therefore if we grow to the full scale, **deflection would be large.**

Mesh support can reduce the deflection, however the non-uniform intensity distribution by mesh structure causes the **CD variation.**

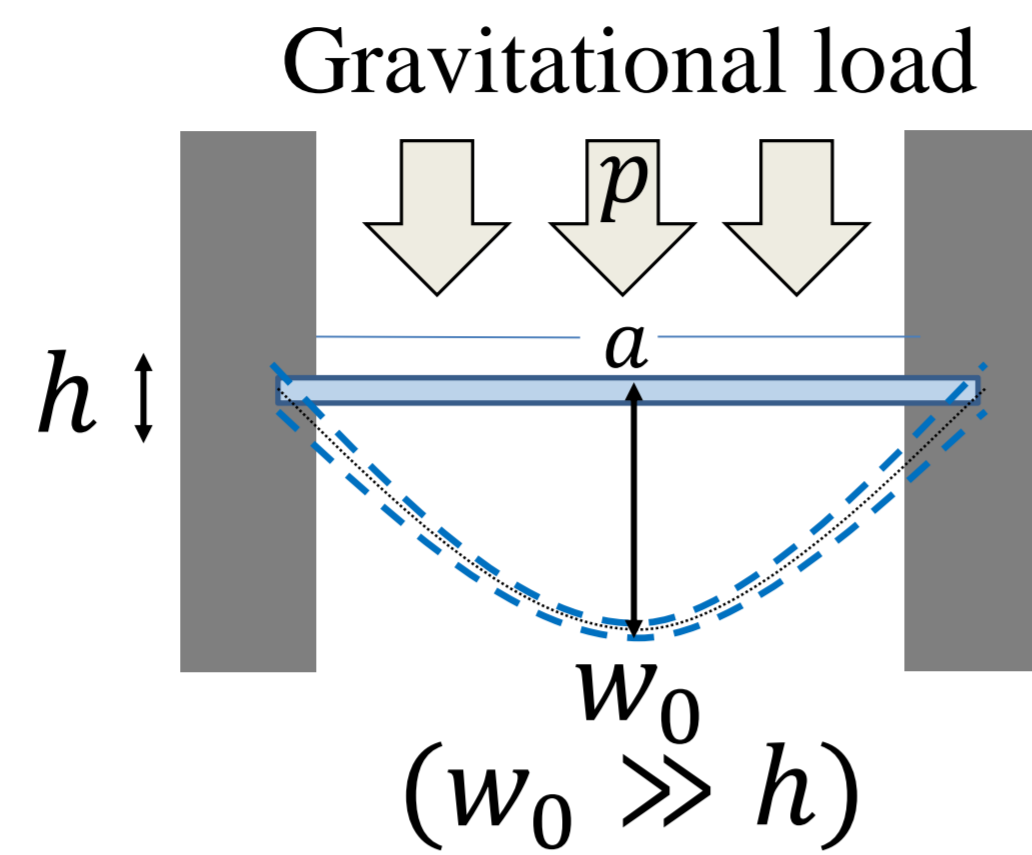
The deflection analysis of the **full scale free-standing pellicle** is needed.

Nonlinear deflection

Small deflection



Large deflection



Large deflection equation

$$w_0 + \boxed{0.488 \frac{w_0^3}{h^2}} = \frac{12(1 - \nu^2) p a^4}{64 E h^3}$$

Nonlinear 3rd order term

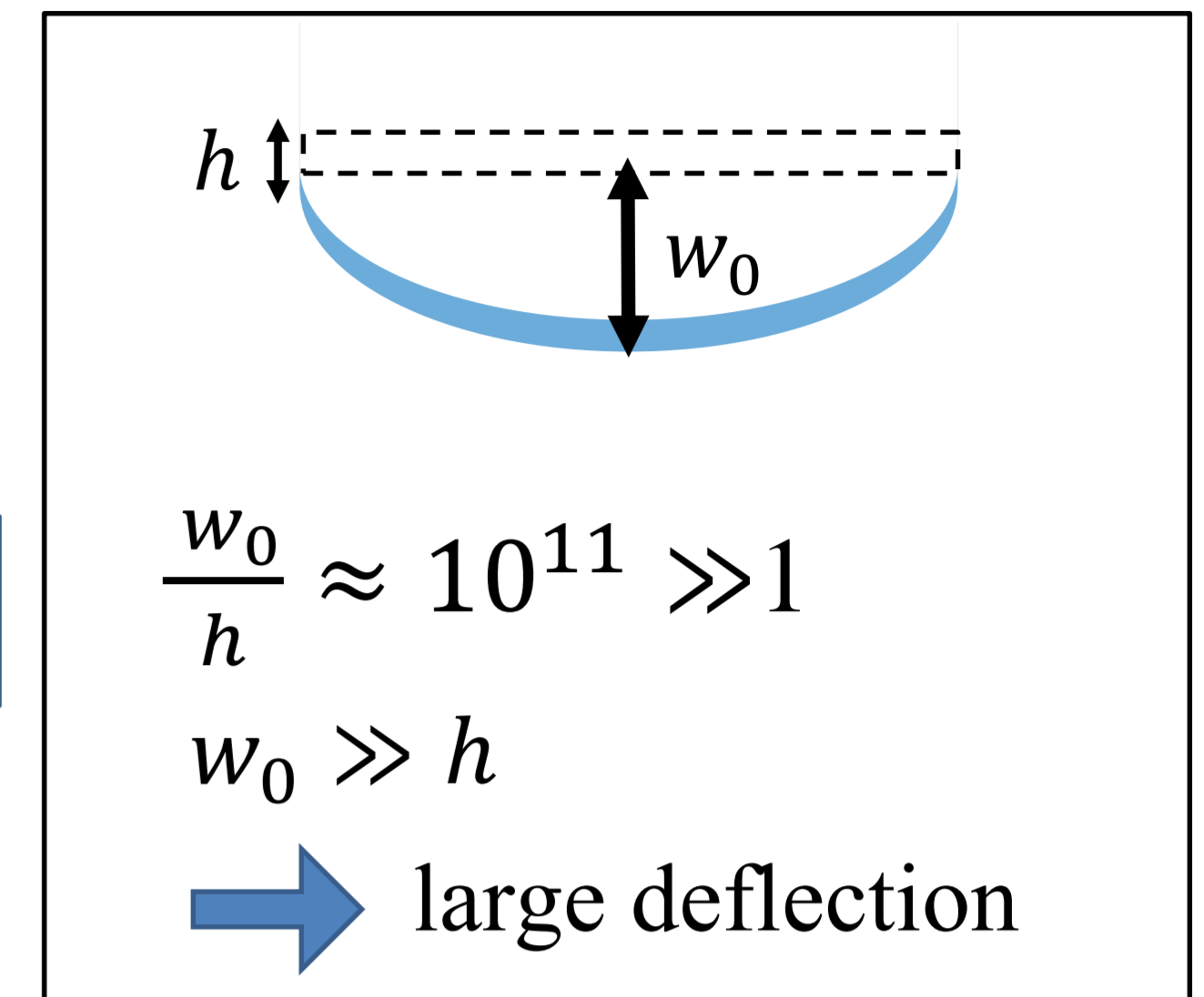
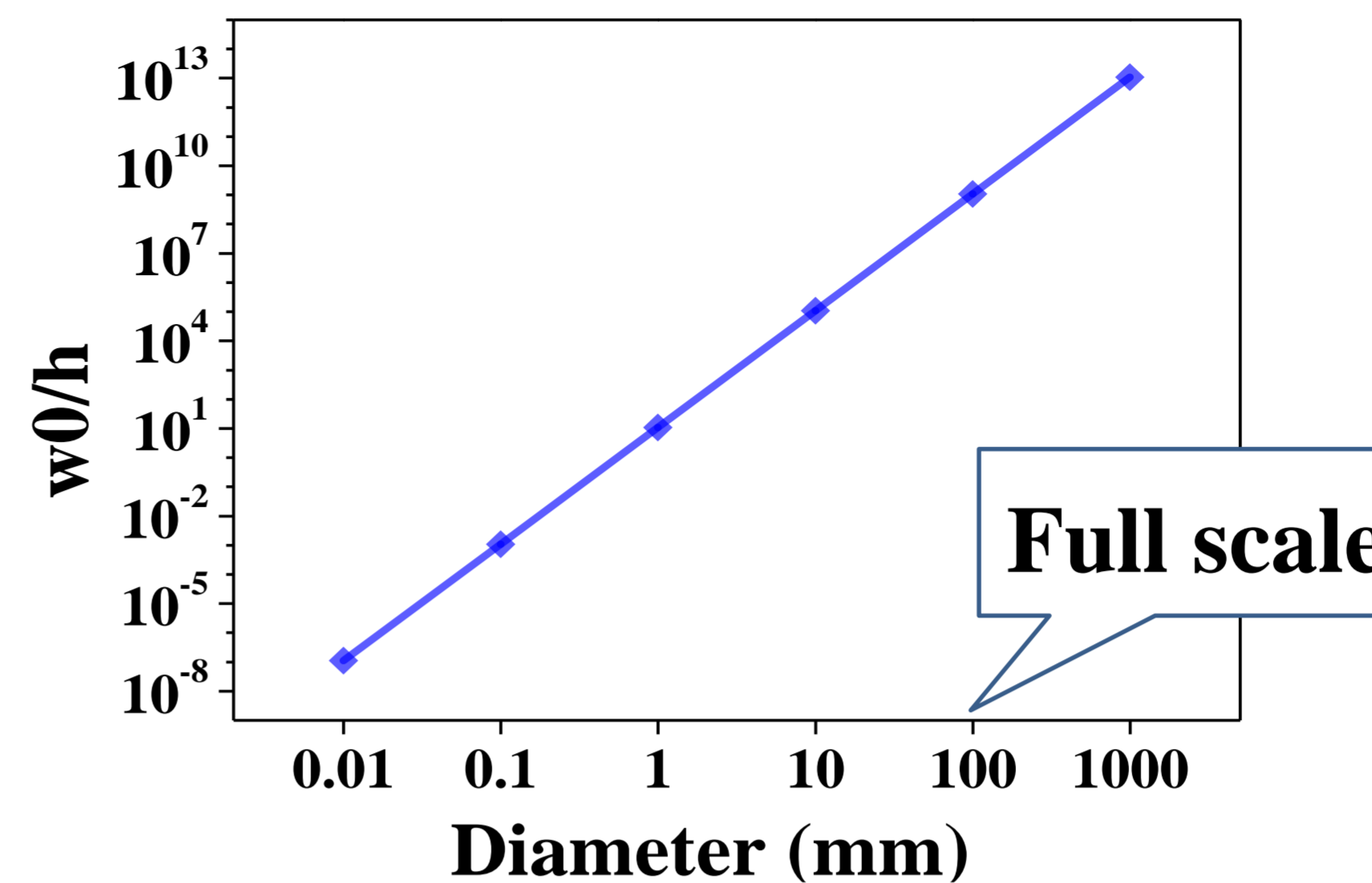
E : Young's modulus (Pa)
 ν : Poisson's ratio

Ref) Timoshenko, S. & Woinowsky-Krieger, S. "Theory of plates and shells". Vol. 2, New York: McGraw-hill (1959).

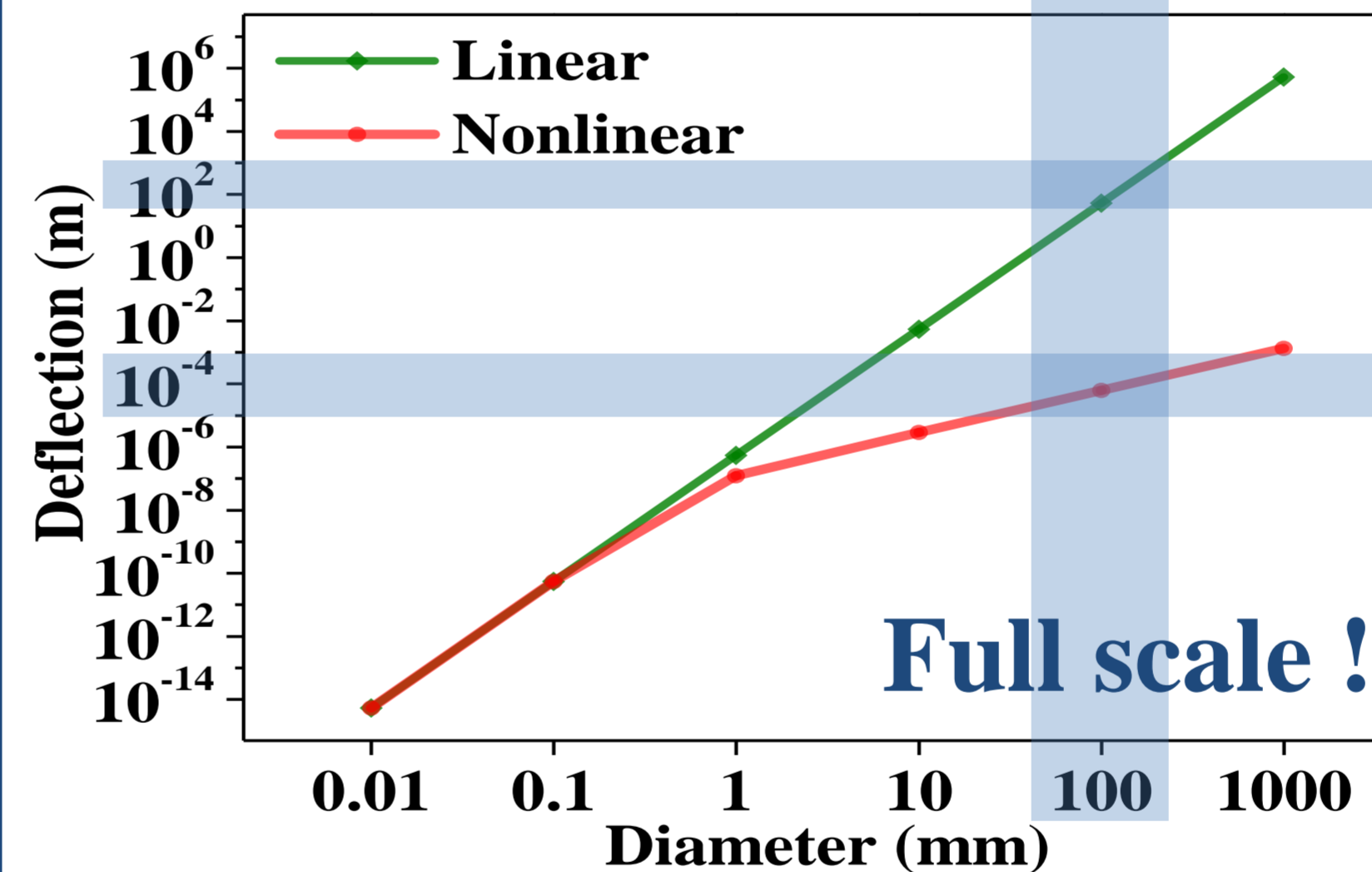
»» If the deflection at the center is large compared to the thickness of plate, the non-linear deflection term should be added to the deflection equation.

Results

»» Checking the large deflection condition at 100 mm diameter silicon pellicle



»» Dependence of pellicle size (@ 50 nm thickness)



With **non-linear analysis**, the deflection of the full scale free-standing pellicle is **~ 100 μm** , while the **linear analysis** shows **~ 1000 m** @ 50 nm thickness.

Conclusion

- ✓ The linear analysis shows the deflection of the silicon pellicle was very large, ~ 1000 m @ 50 nm thickness.
- ✓ The non-linear deflection term is added to the deflection equation since the deflection at the center is very large compared to the thickness of plate.
- ✓ The deflection of the full reticle scale free-standing pellicle is very small, ~ 100 μm @ 50 nm, with non-linear deflection.
- ✓ Therefore, a mesh grid support to prevent the deflection is not necessary for the EUV pellicle.