



# **REALIZATION OF EUV PELLICLE WITH SINGLE CRYSTAL SILICON MEMBRANE**

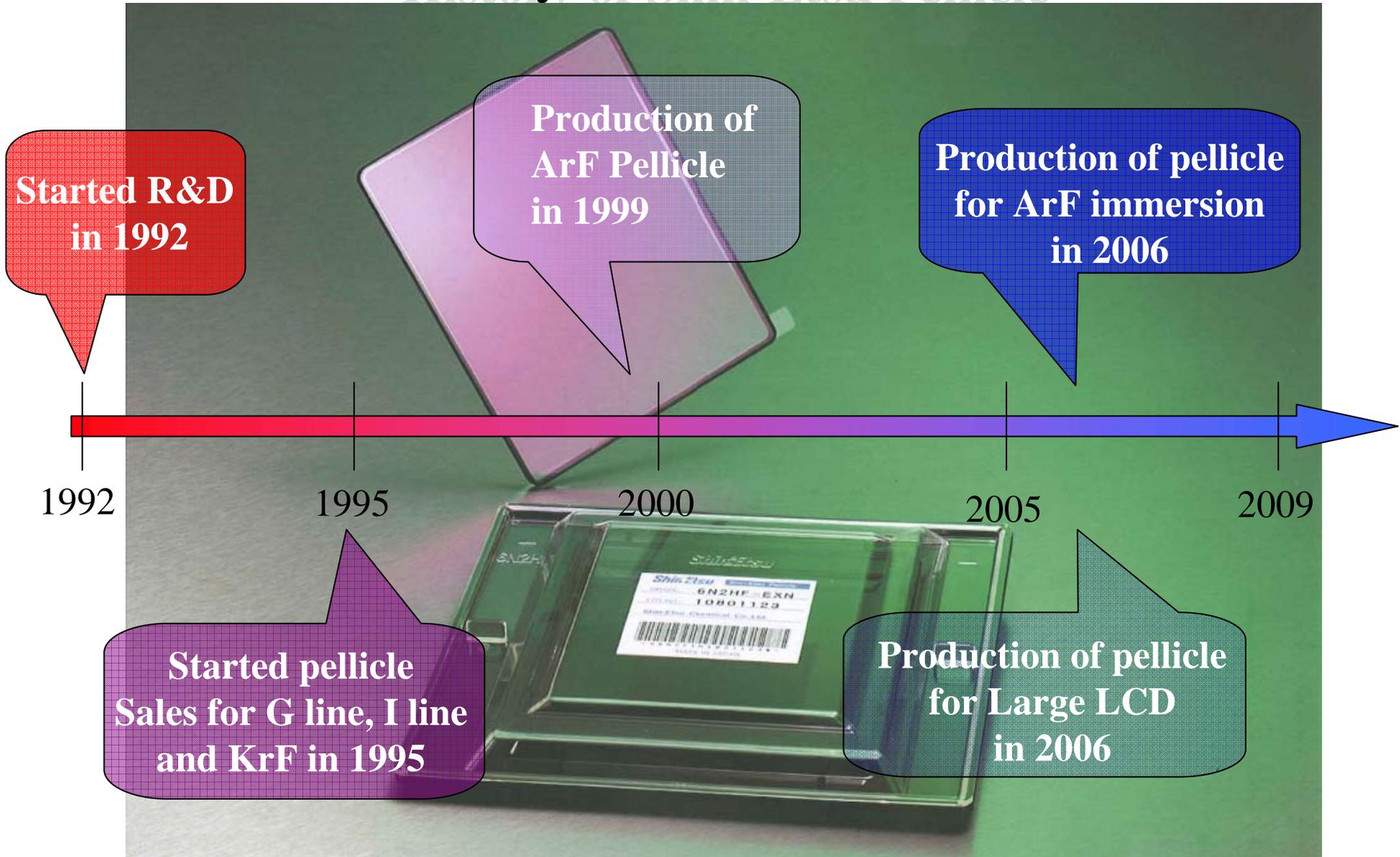
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# Why Pellicle for EUV Lithography?

- **Extensive studies on particle addition during “reticle transfer” have been done so far with superior results.**
- **What about particle addition or carbon contamination during “EUV exposure”?**
- **Most EUV programs have been in progress based on the assumption that “there is no particle contamination in EUV chamber”**
- **How can device manufacturers guarantee “Production yield”?**

# History of Shin-Etsu Pellicle



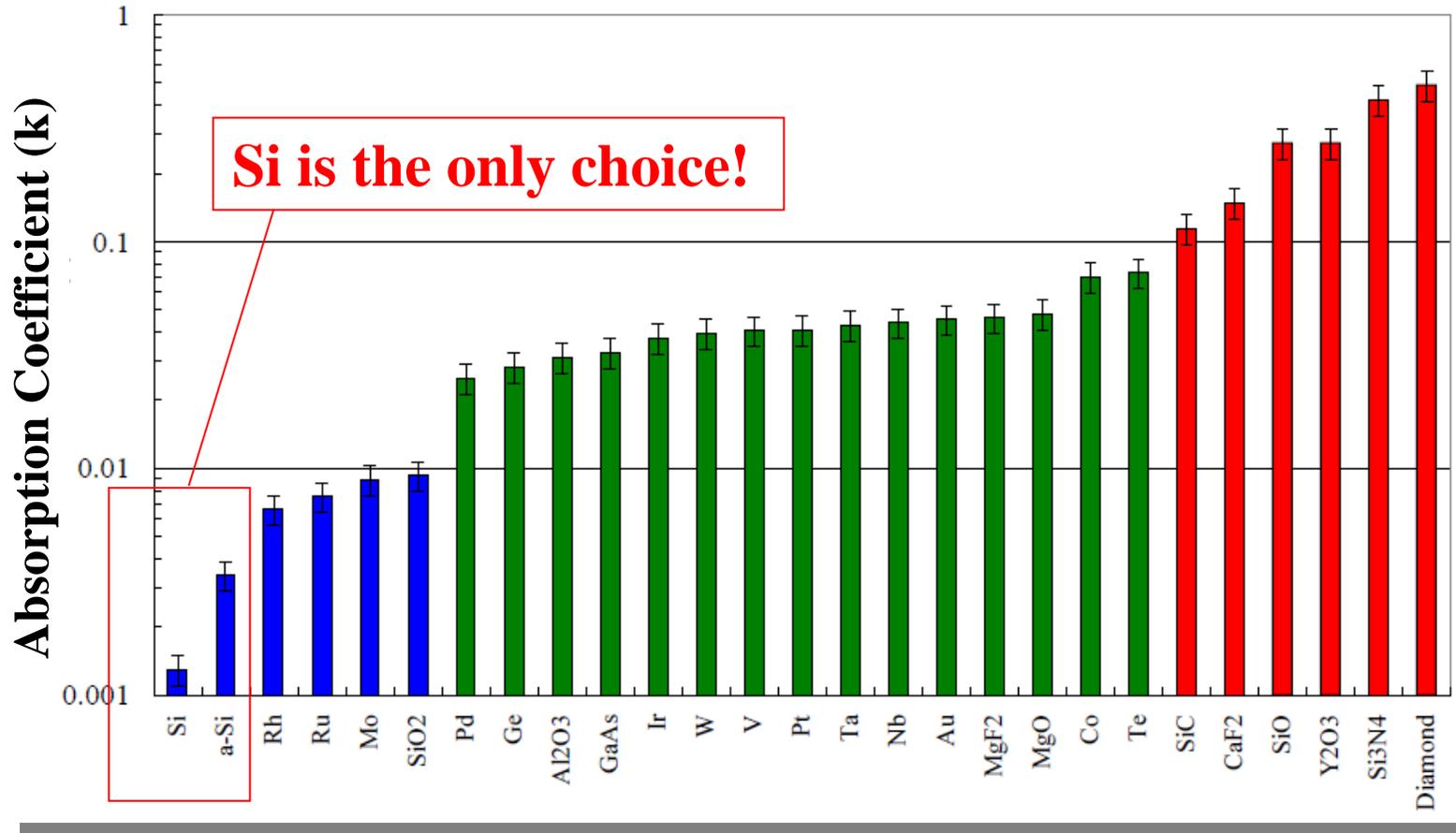
“Realization of EUV pellicle with single crystal silicon membrane” Shoji Akiyama, Yoshihiro Kubota  
2009 International EUVL Symposium Prague, Czech

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# Basic requirements for EUV Pellicle

- **No organic component included**
- **High transmissive film for EUV domain**  
⇒ **single Si crystal is one of the choices**
- **No wrinkle on pellicle film for easier inspection**  
⇒ **Slight tension in pellicle film needed=Precise stress control necessary**
- **High numerical aperture (NA)**
- **Mature Semiconductor fabrication technique utilized**

# Absorption of Inorganic materials



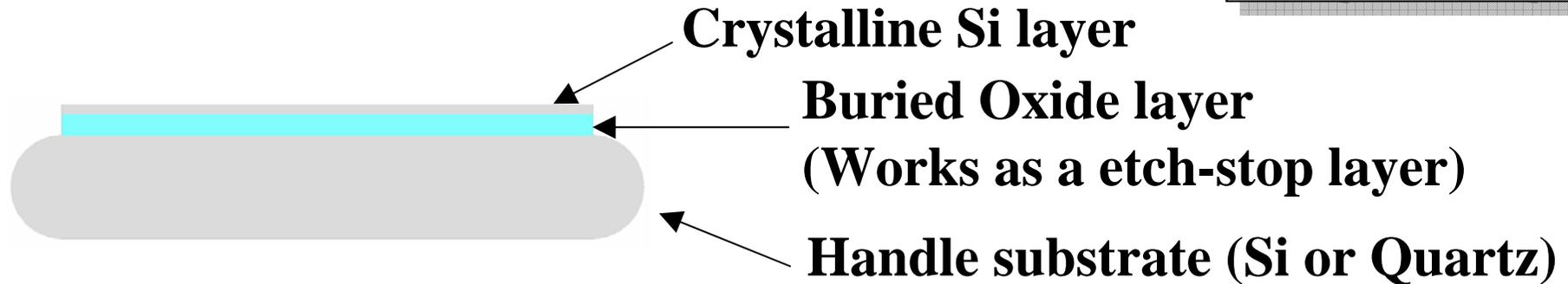
Palik et al. "Optical constants of solids"

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# Preparation of EUV pellicle

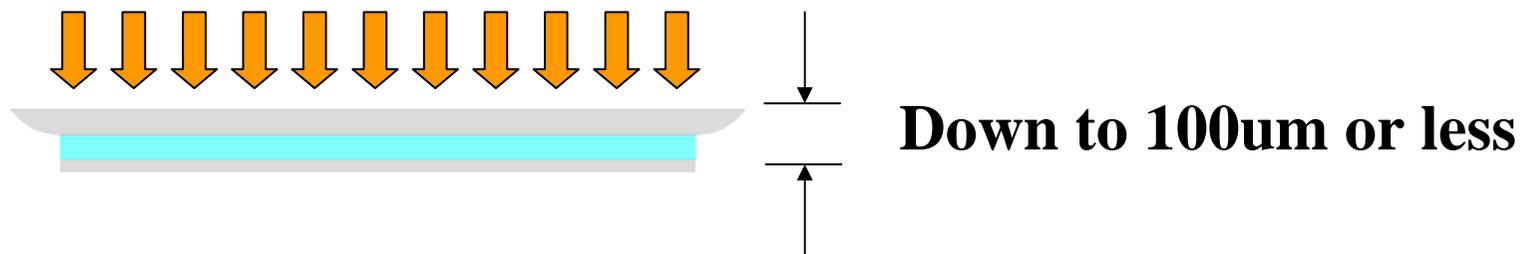
## 1. Preparation of starting substrate (SOI or SOQ)

SOI = Si On Insulator  
SOQ = Si On Quartz



SOI layer is hybridized so that slight tensile stress is introduced

## 2. Thin down handle substrate by grinding and polishing



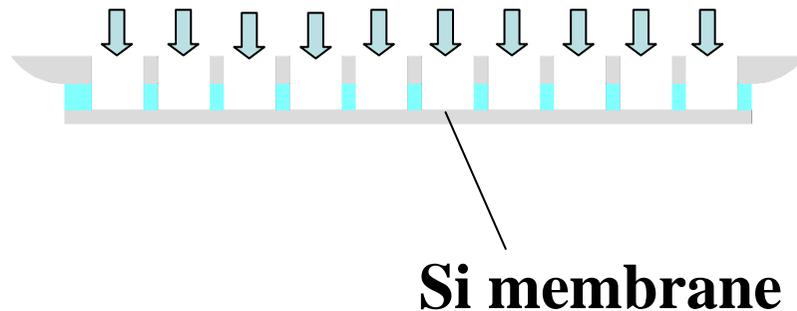
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# Preparation of EUV pellicle

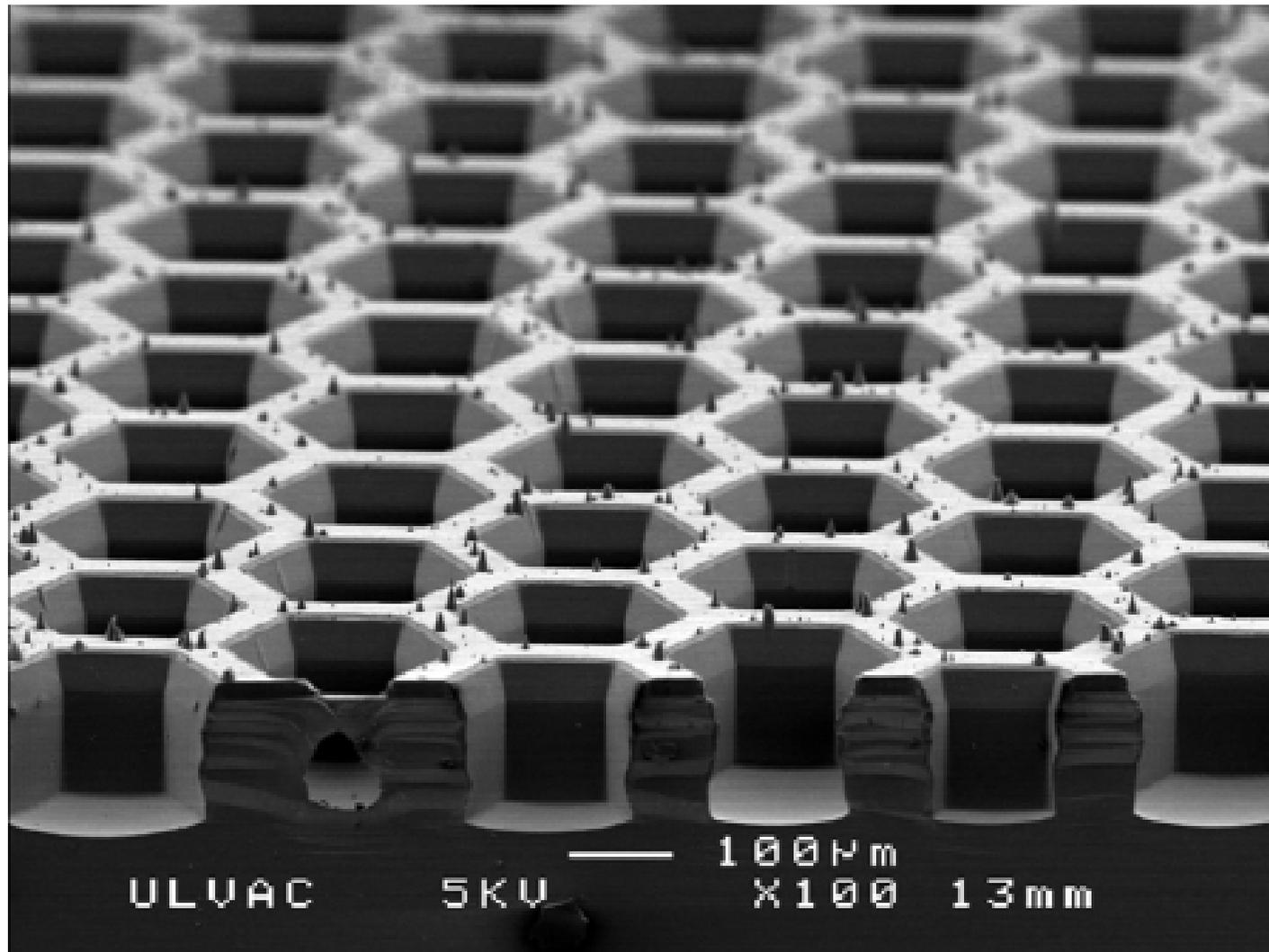
## 3. Fabrication of honeycomb by etching technique and removal of buried oxide (BOX)

### Handle substrate honeycombing



**We have established simple but effective fabrication process!**

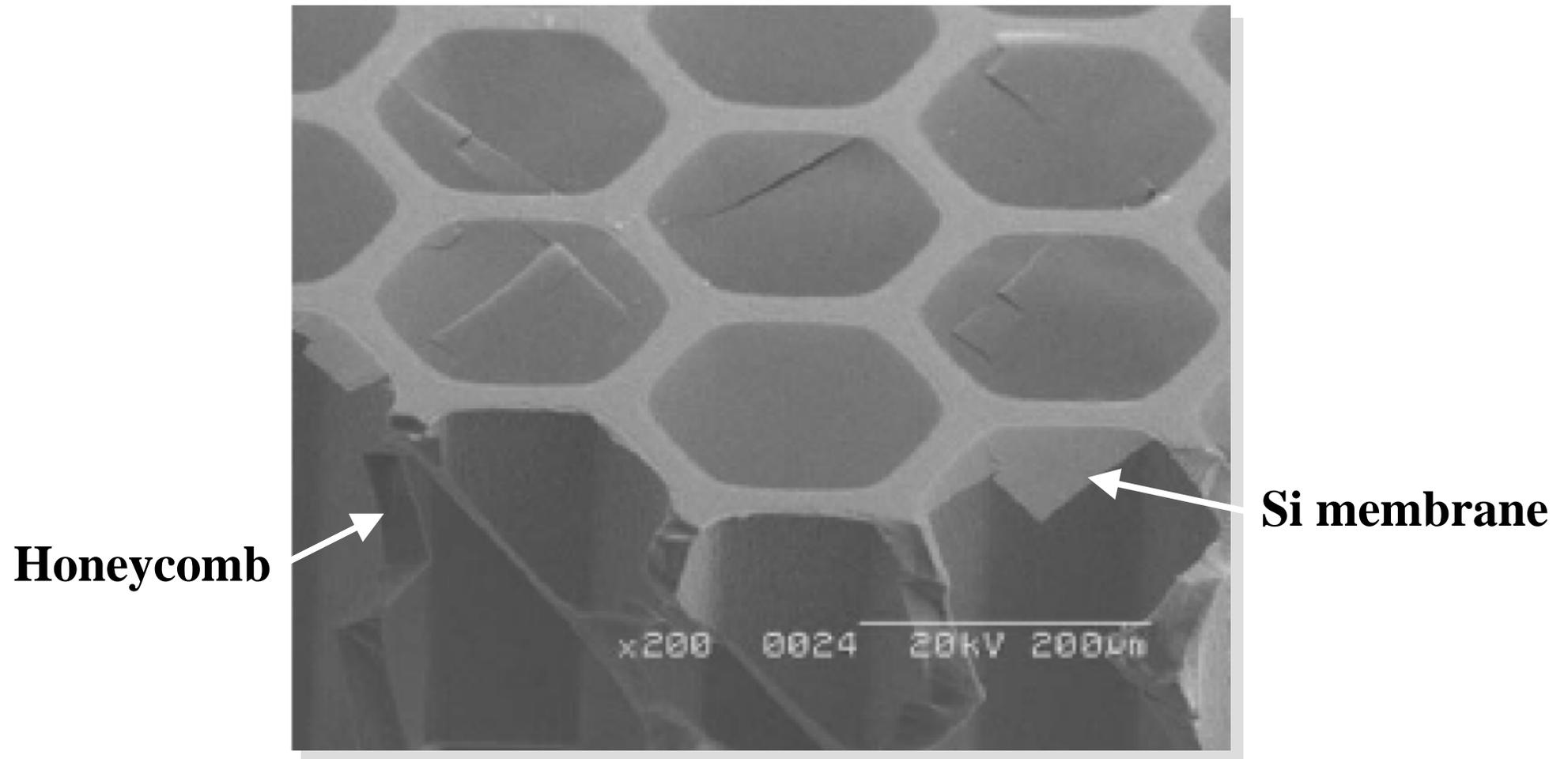
# Etching on the way...



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# Scanning Electron Micrograph of EUV pellicle

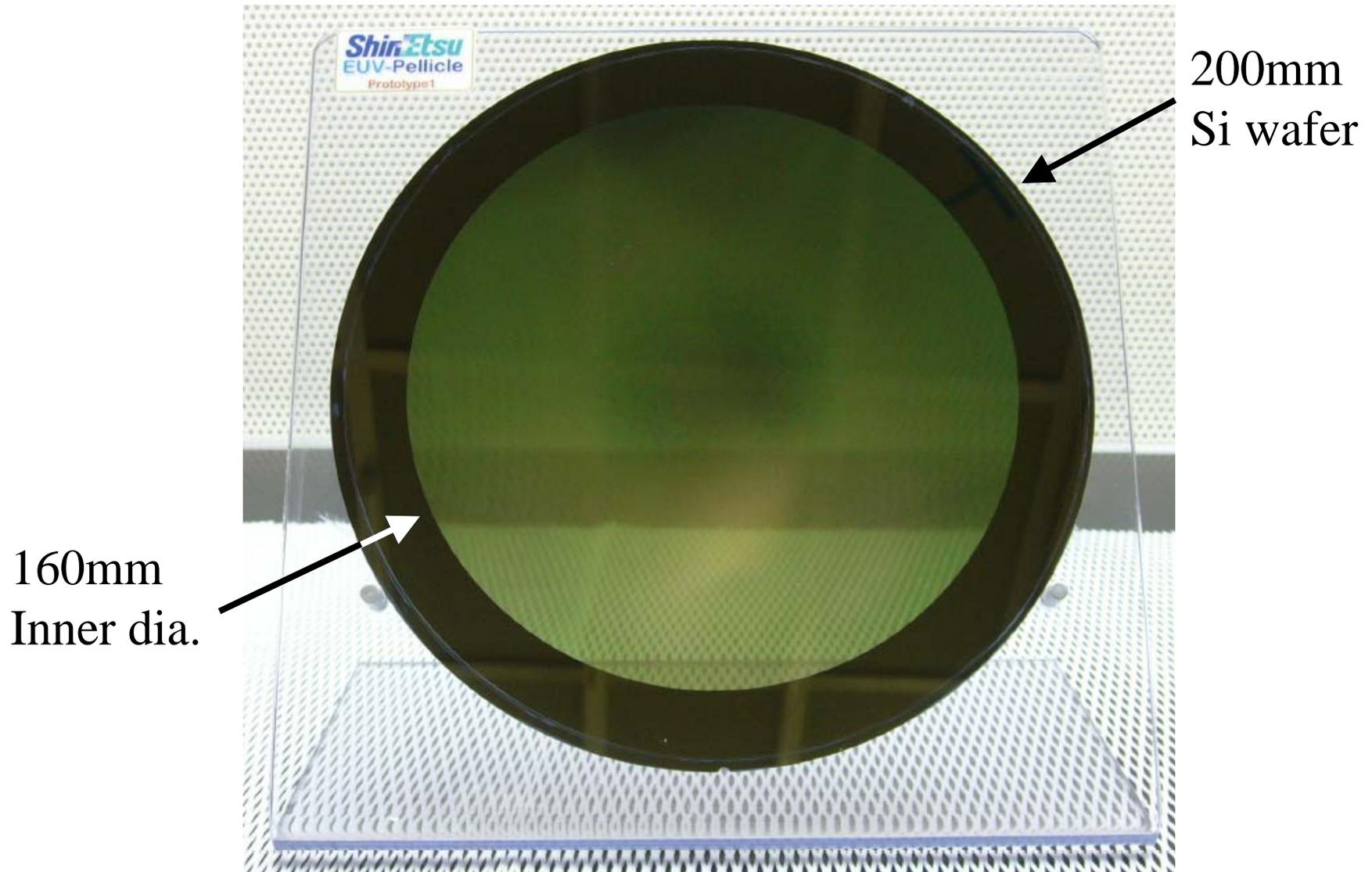


Sample was intentionally broken for SEM observation

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# Prototype of EUV pellicle (circular shape)



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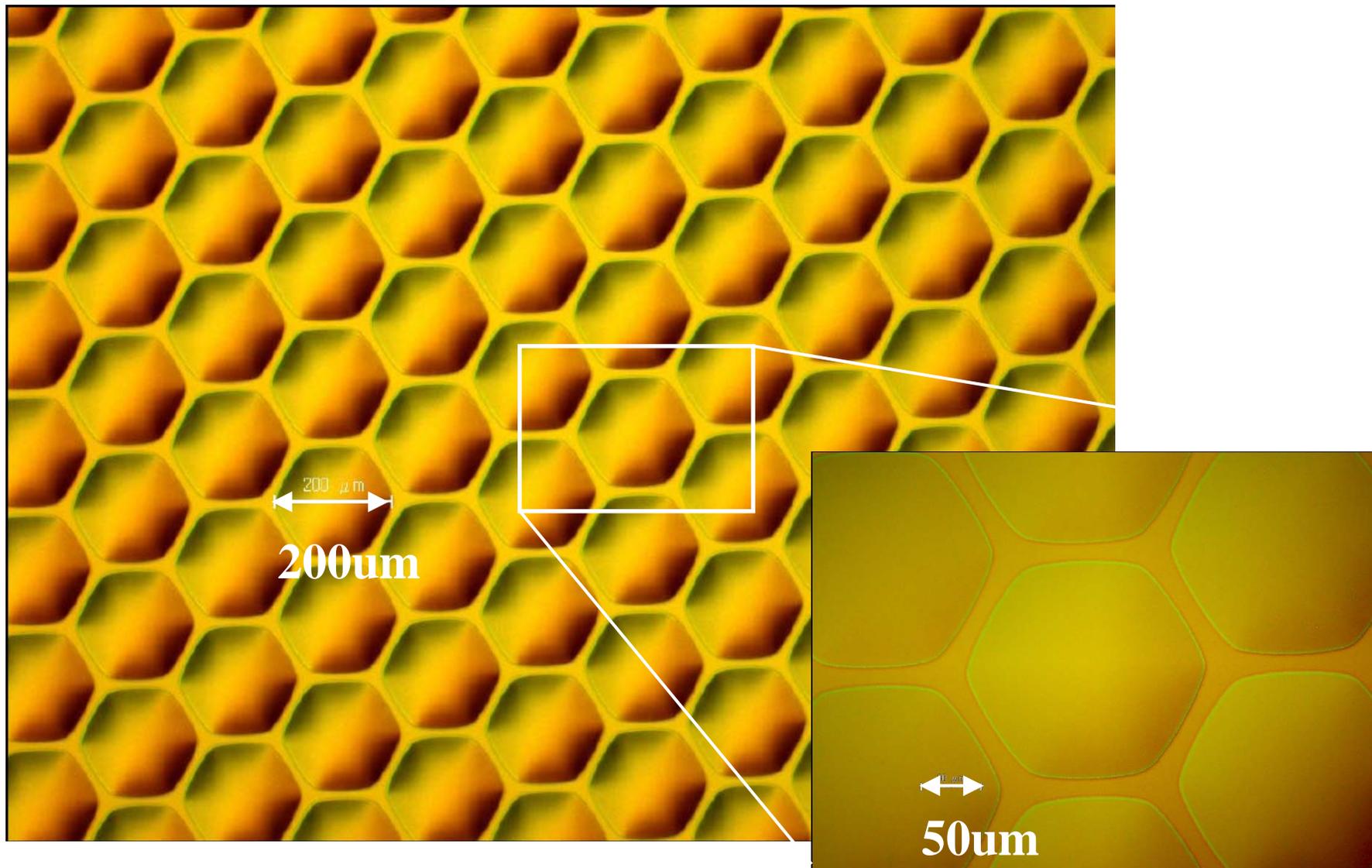
## Prototype of EUV pellicle (framed)



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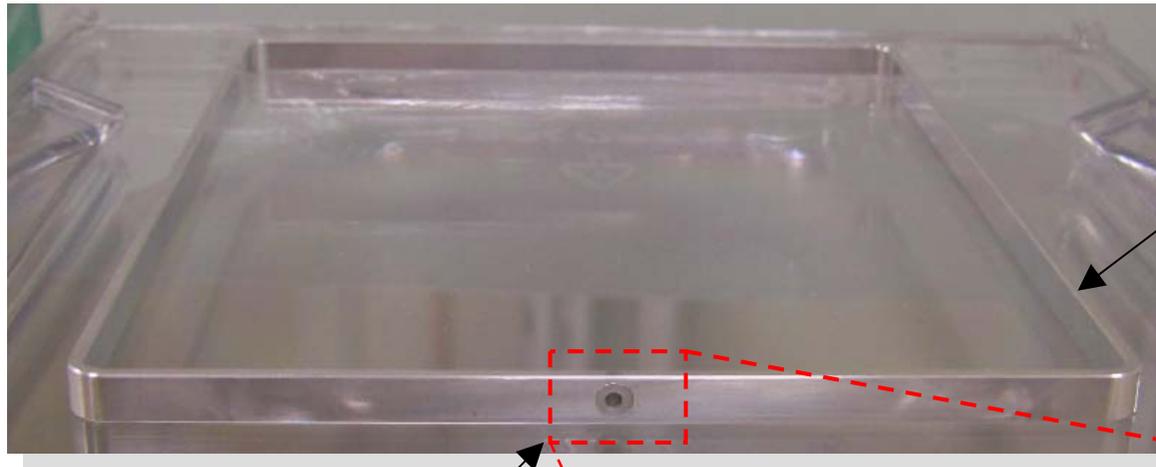
# Optical Microscope View



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# EUV Pellicle frame with air filter



**Aluminum  
frame**

**Air filter  
made from  
layered metal fibers  
(No organics used)**

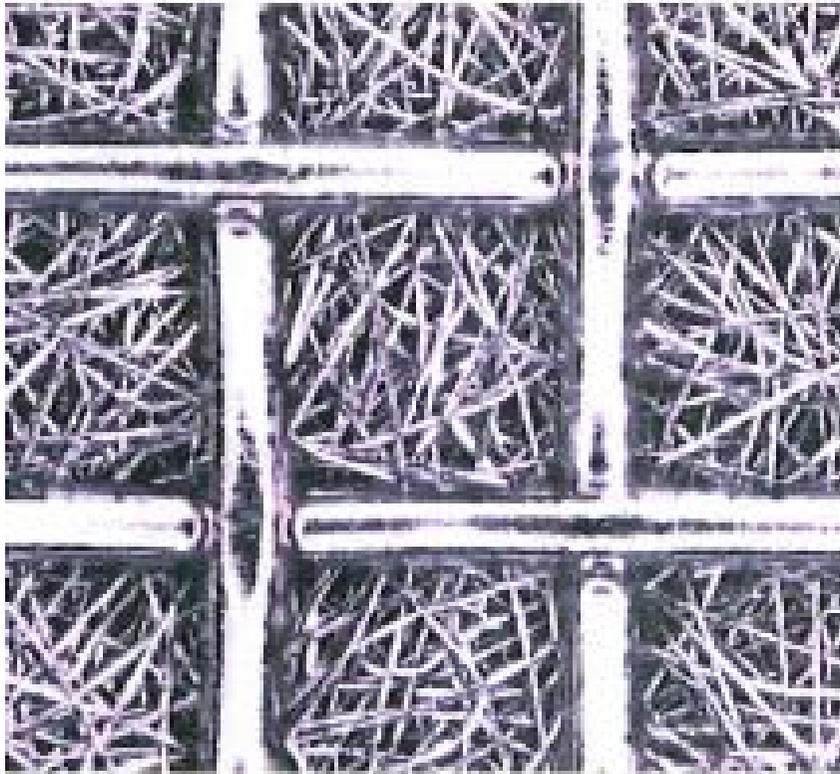


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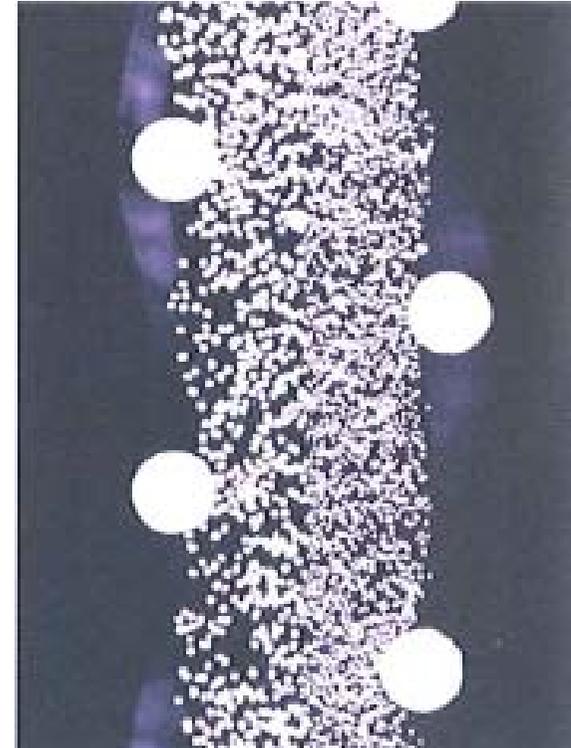
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# Metal Air Filter on Pellicle Frame

Front View



Cross section



Metal fibers are layered so that small size particles can be captured

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# Summary

- The first SOI-based EUV pellicle was demonstrated.
- EUV Pellicle with single crystal silicon membrane was realized using mature CMOS technology
- Pellicle frame with air filter was first proposed.

# Future Plan

- Achieve higher Numerical Aperture
- Achieve EUV pellicle with thinner single crystal Si film down to 50-100nm
- Check the mechanical strength
- Achieve acceptable uniformity across the pellicle.