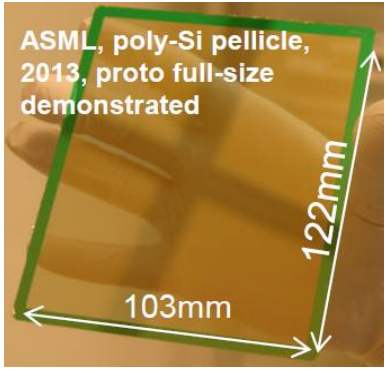
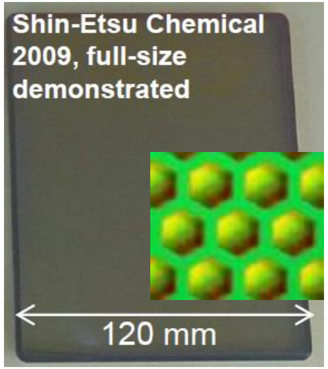
Pellicle membrane development at imec

Johannes Vanpaemel on behalf of pellicle team @ imec

04/10/2015

Focus of pellicle work at imec





Si-based solutions

F. Dhalluin et al., "Grid-supported EUV pellicles: A theoretical investigation for added value," Proc. SPIE 9658.

SiN-based reported at BACUS 2015

Most materials absorb strongly at 13.5nm

Developing an EUVL pellicle is difficult

Initial solutions exists

- Si-based (freestanding and grid supported)
- SiN (freestanding)

IMEC is developing **alternative** membrane materials that meet or exceed ASML specifications*

Screening of different material candidates

What does the ideal pellicle material look like?*

	Pellicle Requirement	HVM Value*
membrane	EUV transmission	90% single pass
	EUV T spatial non-uniformity	< 0.2%
	EUV T angular non-uniformity	<300 mrad angle @ pell.
	Withstand dynamic heat load	5 W/cm2 incident EUV
	Lifetime EUV+H2	3 Pa > 315 hours
with frame	2D size inner	110.7 x 144.1 mm2
	2D size outer	117 x 151 mm2
	Stand-off distance	2.5 +/- 0.5 mm
	Max acceleration	100 m/s2
	Max ambient pressure change	< 350 Pa/s

- Transparent for EUV light
  => very thin (nm-range)
- Mechanically stable
- Resistant to high thermal loads
- Chemically stable in 'EUV + H_2'

* *C. Zoldesi, et al., "Progress on EUV pellicle development," Proc. SPIE 9048 (17 April 2014)*

How to characterize these properties?

- Freestanding material (need for design of specific test structure)
- Supported film

Test structure

(1) Wafer with SiN on front and back
internal LPCVD SiN deposition

(2) Deposit protective on front (SiO_2)

(3) Flip; coat resist on back

(4) Pattern window in resist (different sizes possible)

(5) Dry Etch SiN; strip resist

(6) Flip wafer; wet etch SiO_2 (HF)

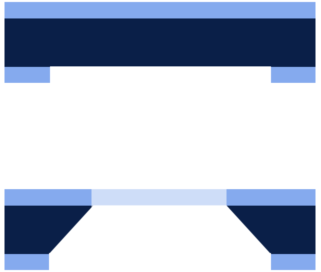
Lab processes

(7) Deposit membrane material

(8) Backside Si wafer etch (KOH)

(9) Wet etch SiN layer

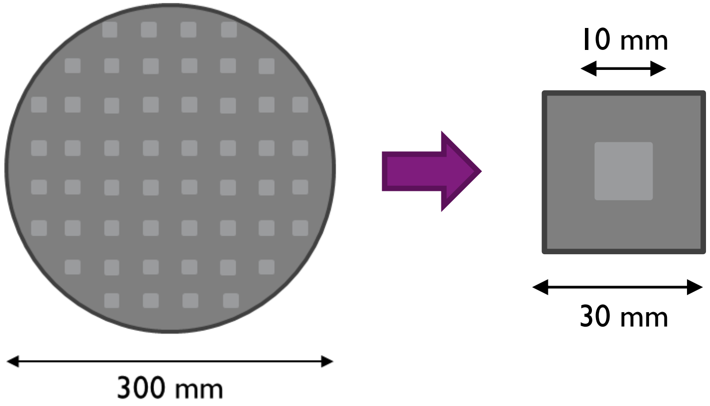
Test the structure without C-membrane



(6) Flip wafer; wet etch SiO_2 (HF)

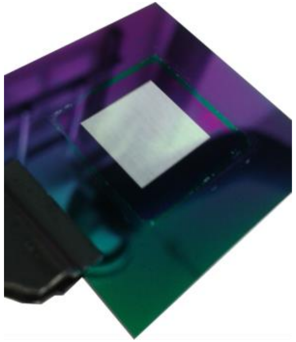
From FAB to LAB

(8) Backside Si wafer etch (KOH)



- Initial test structure dimensions:
  - 10 x 10 mm^2 window
  - 30 x 30 mm^2 frame

•Small window are ideal for screening a large number of membrane options in this phase

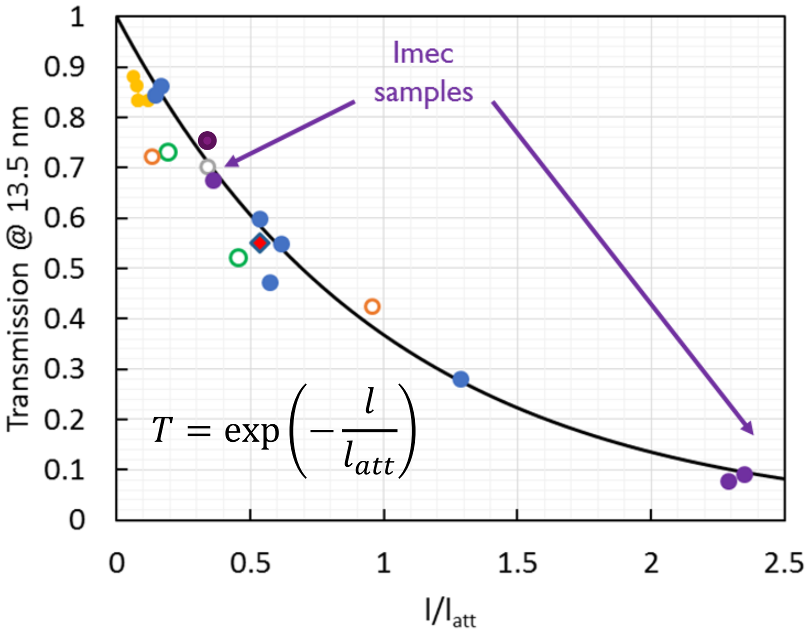


369 nm

60 nm

Characterization of SiN baseline

Results obtained for different pellicle materials

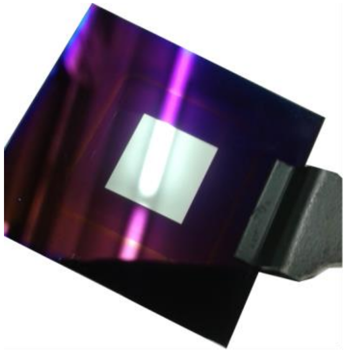


- Transmission follows theoretically expected trend
- More details on EUV transmission characterization can be found in poster P-MP-06 (I. Pollentier et al.)
- Test structure ready to characterize membrane materials at imec

Strategies to reduce absorption

Thin films

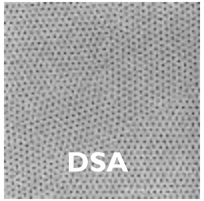
Start with low-absorption films and thin



Induce voids in continuous films

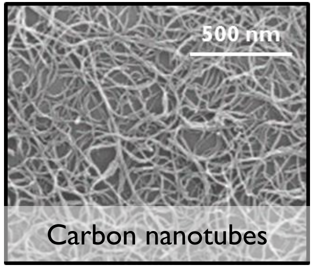
Etch into continuous film

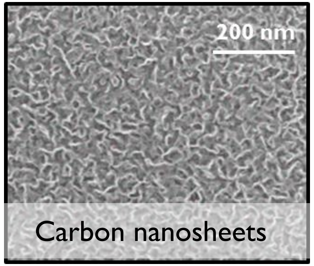
- DSA pattern
- Porous hard mask

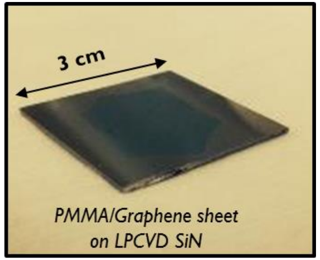


Deposit materials with inherent voids

Carbon-based nanomaterials







Summary and outlook

- **Fabrication** of SiN-membrane based test structure developed
- Synthesis of carbon nanomaterials on SiN substrate successful
- Beginning to ramp membrane fabrication and characterization of alternative pellicle option

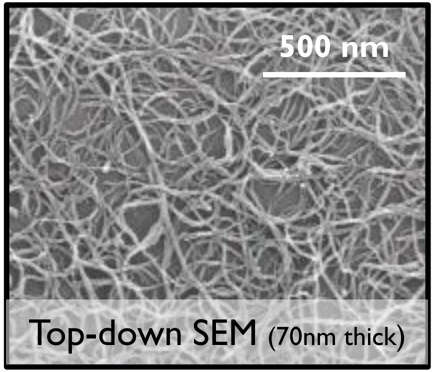
Readiness in 2015? Our pellicle work explores alternative options; not focused on a single candidate now

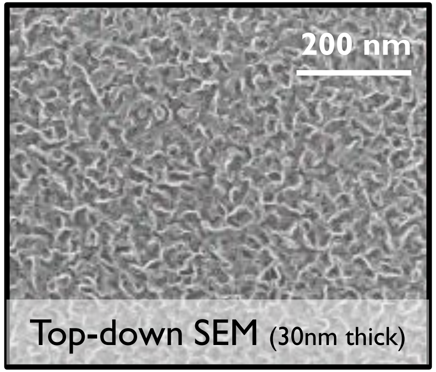
Readiness in 2020? Yes. Good options already available, with multiple efforts to explore alternative materials to mitigate risk

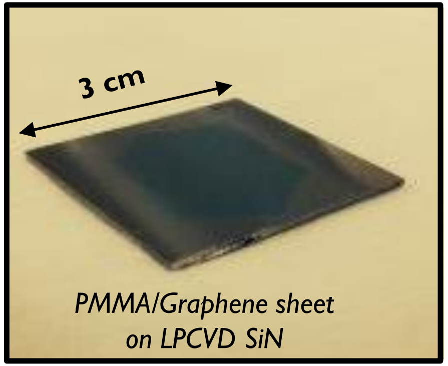
BACK-UP SLIDE

Carbon nanomaterials

(7) Deposit membrane material







	Carbon nanotubes **(in collaboration w/ university)**	**Carbon nanosheets** **(imec)**	**Graphene** **(imec)**
+	Lowest density	Grow on any surface, no catalyst	Uniform thickness
-	Extra processing required (transfer and/or catalysts)	Dangling bonds can react Density higher than CNT	Must be transferred
status	Spin-coating/drop-casting of CNT solution	Successful growth of carbon nanosheets directly on LPCVD SiN	Successful transfer of graphene from copper on LPCVD SiN