Si_3N_4 membrane - status

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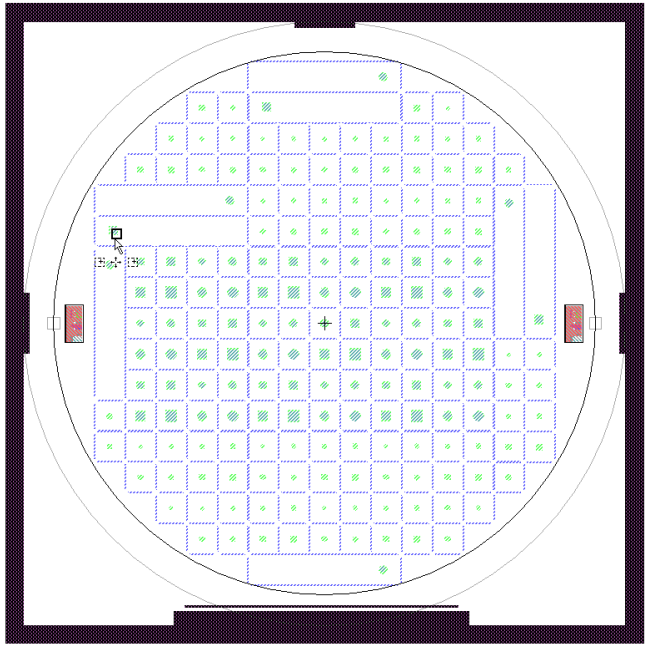
Fabrication process development

We are trying to fabricate suspended stoichiometric membranes (real part of the index of refraction n=1.99) of square/circular shape by using Deep-RIE process. This non-standard approach is important for integrating the insulation/balancing stage.

- Firstly, we have to verify the resistance of 50/100/130 nm Si3N4 stressed membranes (1.4G Pa) to a Deep-RIE using thermal oxide protection layer of 300 nm. Answer is: YES

- Secondly, is the critical release of the membrane. Answer is: test are still ongoing

Wafer layout for lithographic masks

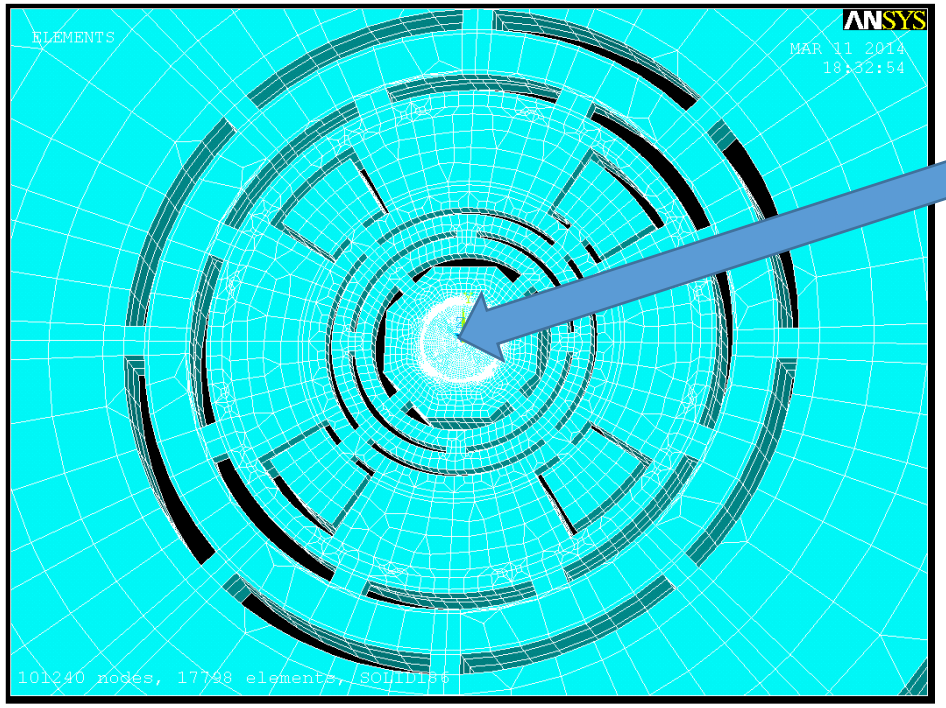


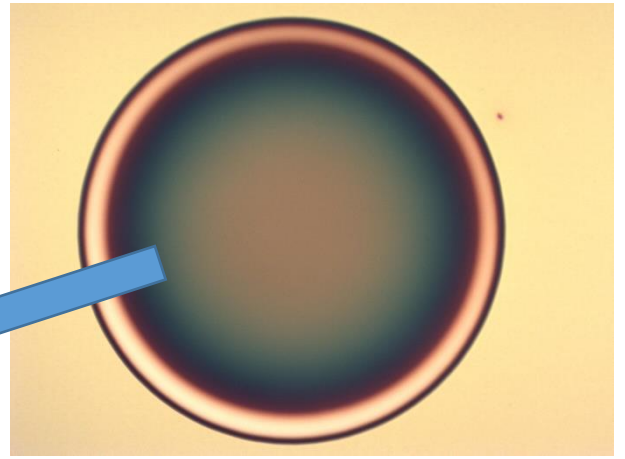
Frame dimensions
(a) 5 mm x 5 mm
(b) 5 mm x 25 mm

Membrane diameter/edge from 300 um to 1500 um

The membrane is covered by pure Al protection layer to preserve optical quality

Objective: thick devices with an insulation stage for membranes





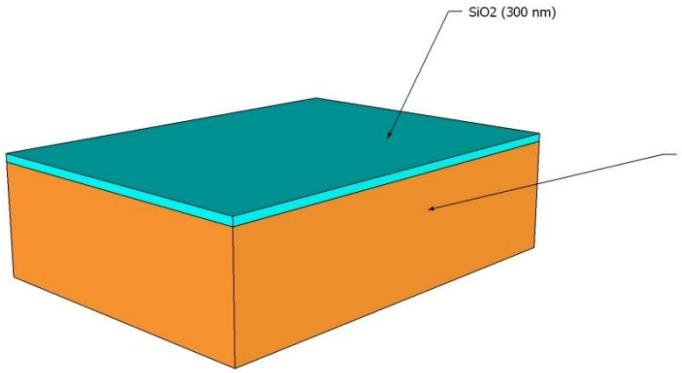
Integrate a thin Si3N4 (50/100/130 nm) membrane on a insulation and balance c-Si resonator. A dedicate process is needed for this task.

Now we are testing:

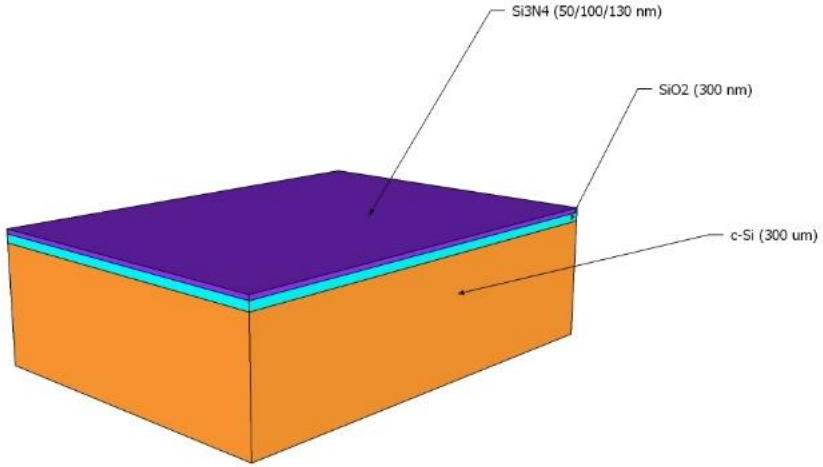
- Membrane stability
- The limit for the internal stress
- The integration of a Si_3N_4 on a deep-RIE micromachining process

Fabrication process

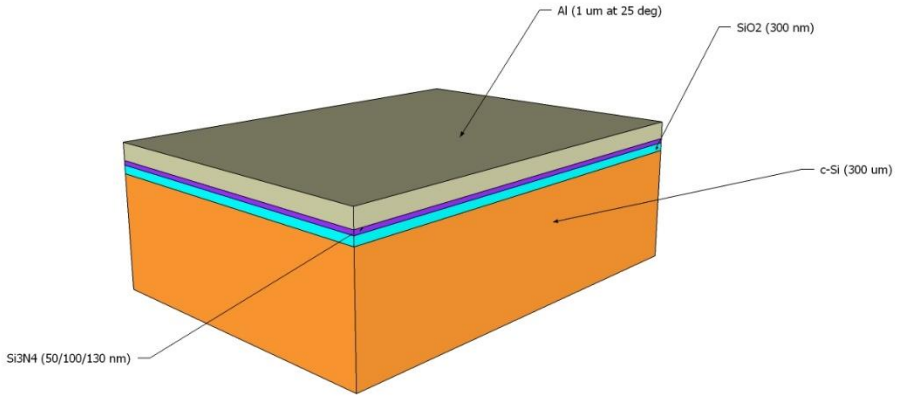
1st step – LPCVD SiO_2



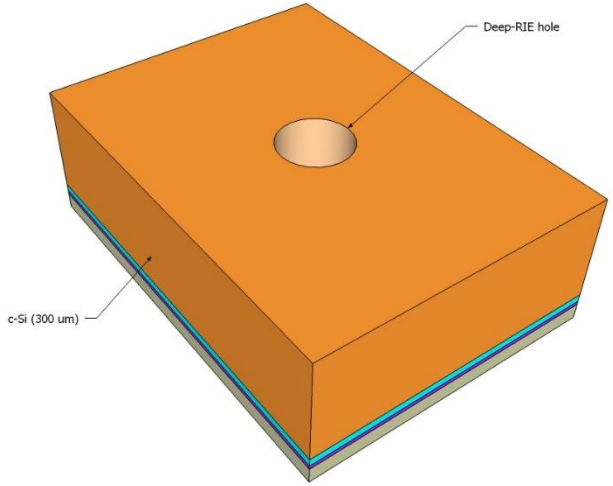
2nd step – LPCVD Si_3N_4



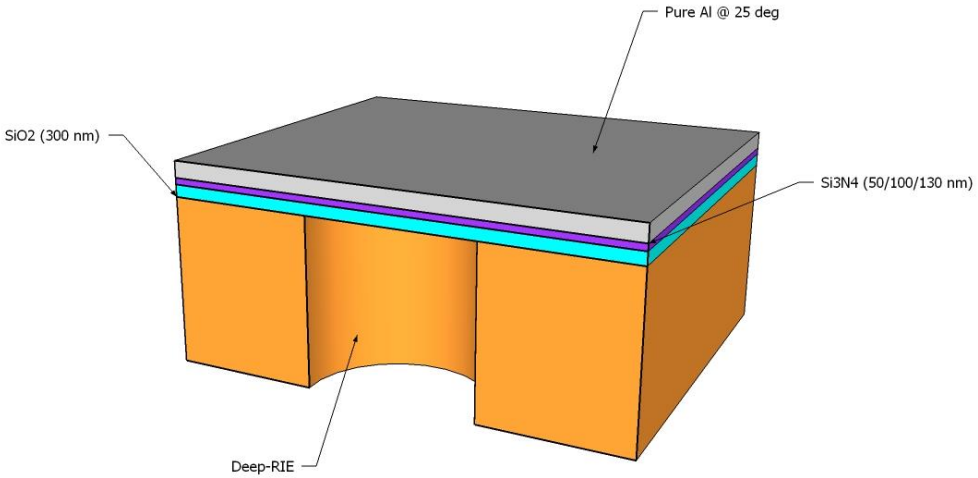
3rd step – pure Al @ 25 C



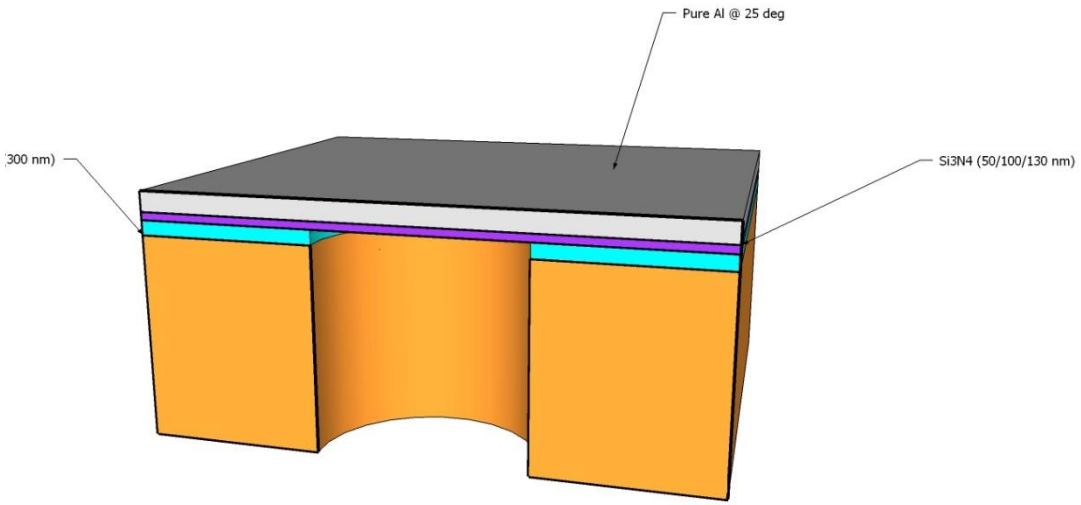
3rd step – Deep-RIE at -10 C



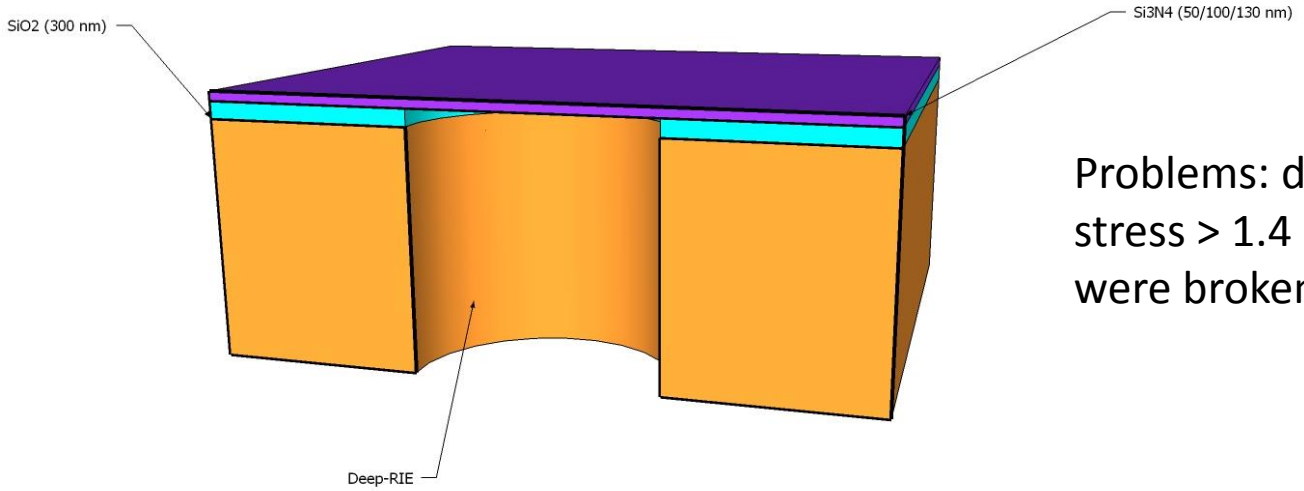
1st process flow



(1) remove oxide by BHF 1:7

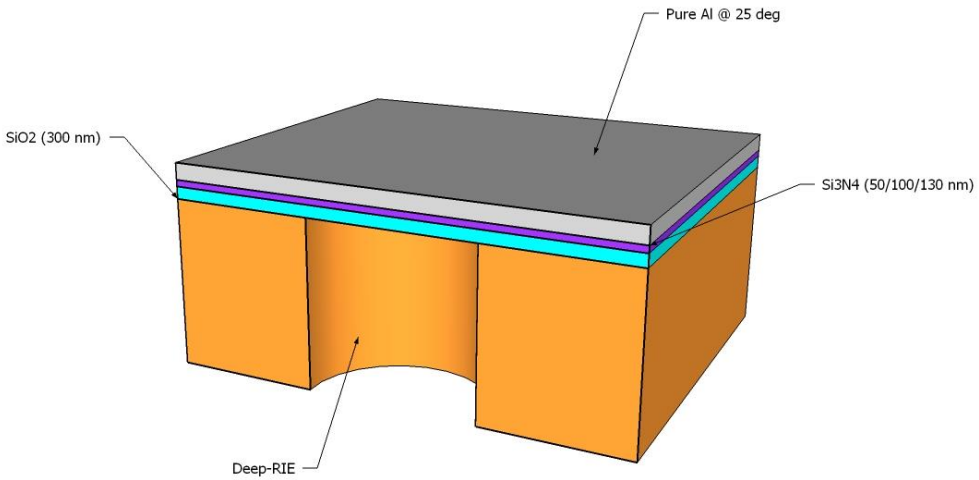


(2) remove Al by PES 77-14-04

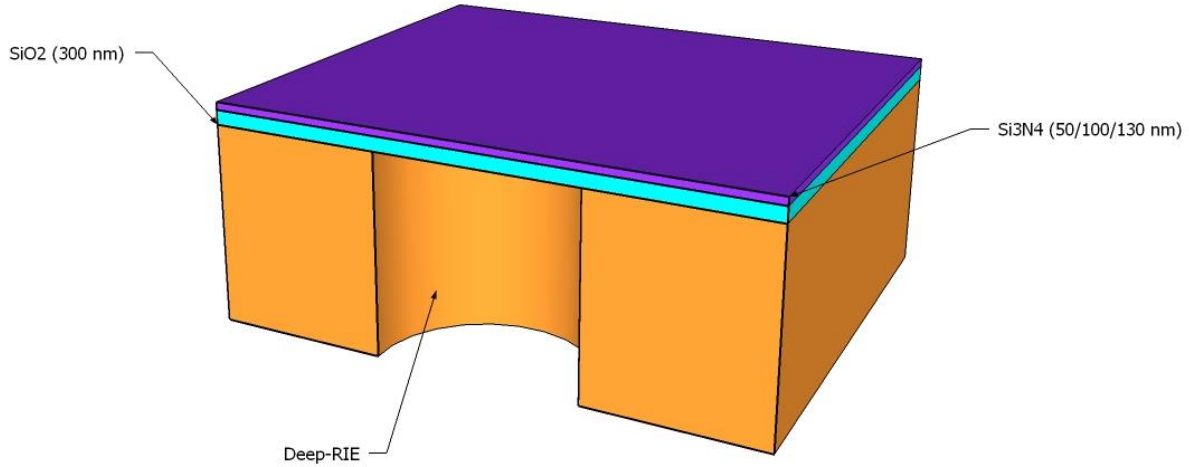


Problems: due to high tensile stress > 1.4 GPa 100% of membranes were broken

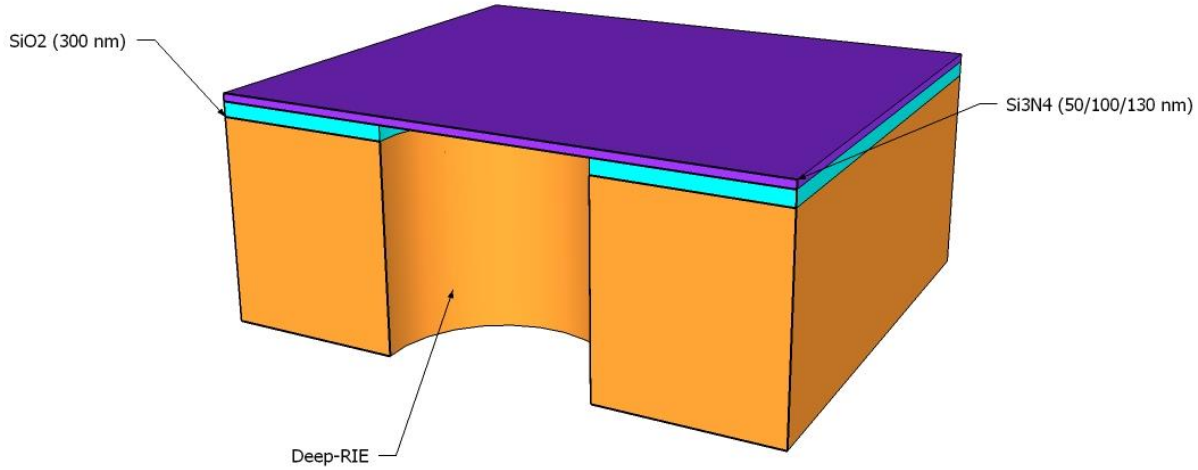
2st process flow



(1) remove Al layer by PES 77-14-04

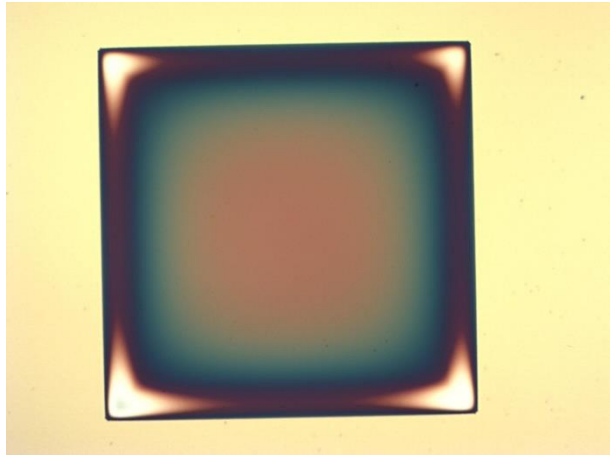


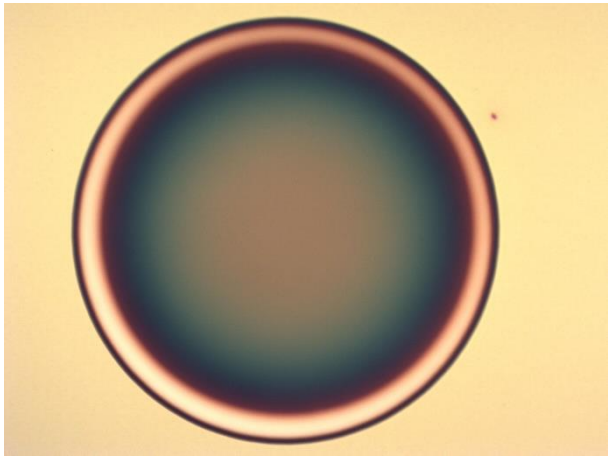
(2) remove oxide by BHF 1:7



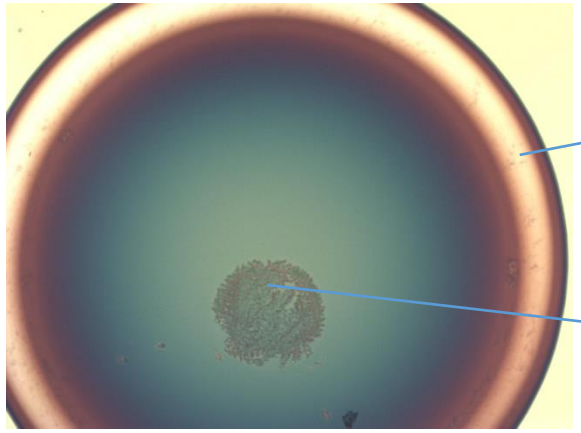
Problems: due to high tensile stress > 1.4 Gpa. About 50% of membranes were broken and Ammonium salt were present on the the surface.

Preliminary results on membranes (2nd process flow)





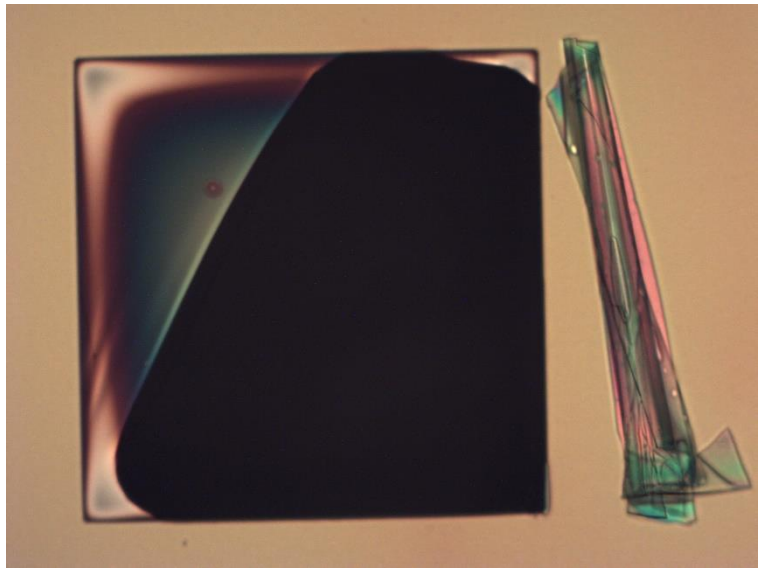
Square and circular-shaped membranes survive, but the process yield is lower than 50%.
This is mainly due to high stress during deposition and particular care during releasing is the key factor.



Silicon is still present on the back-side of the membrane (overetch by Deep-RIE is needed to get the correct hole dimensions)

Sometimes Ammonium salts are present after the BHF 1:7

Image of a broken 100 nm square-shape membrane



Actions to increase the process yield:

(1) Lowering the stress to 0.8 - 1.2G Pa (as in Norcada membranes) changing LPCVD process pressure and a little bit the stoichiometry. Is ongoing

(2) Using pure HF for the membrane release. To be tested

(3) Using a PECVD SiO2 , Si3N4, Thermal Oxide stack for the realease. To be tested