TXRF Reference Materials for Cascade Impactor Air Quality Monitoring Systems

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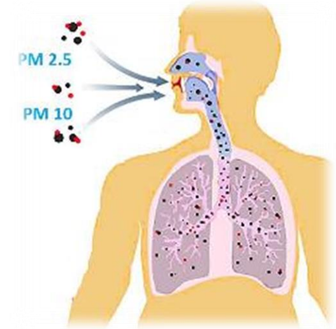
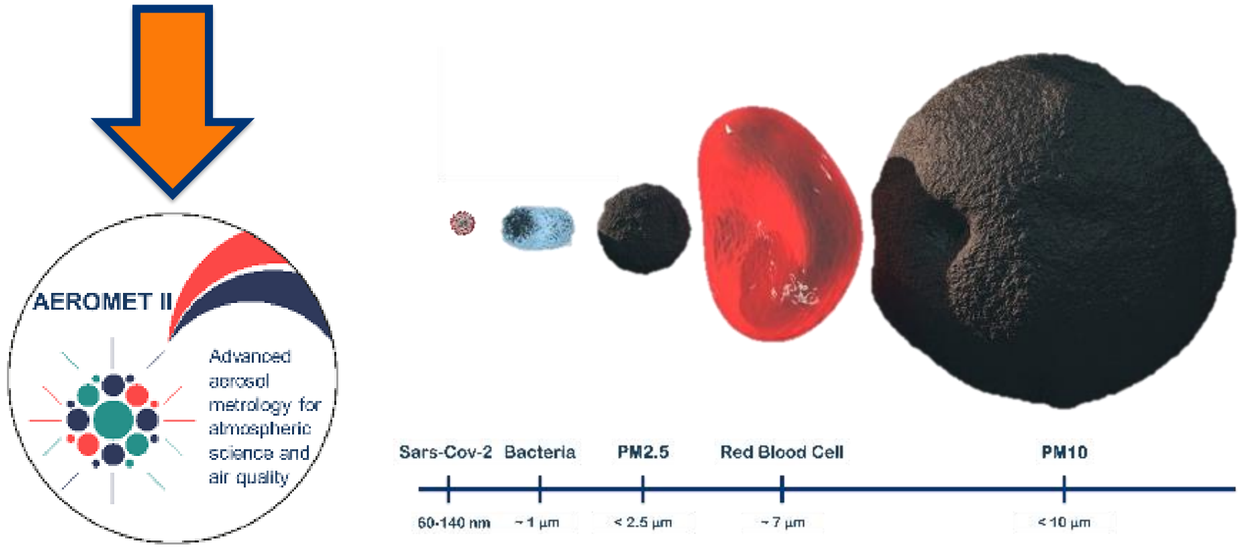
The Problem

- **Air pollution** is the leading cause of environmentally related **health effects** and **climate change** issues.
- Inhalable **aerosol particles** are the **largest contributors** and are very harmful.
- EU has developed some **air quality regulations** that needs **to be met**.
- **Quantitative measurements of aerosol particles** are of a **vital importance**.
- **Lack** of traceable **standards** and harmonized **calibration procedures** for measuring PM.
- The most important metric to monitor particulate air pollution is **mass concentration**.

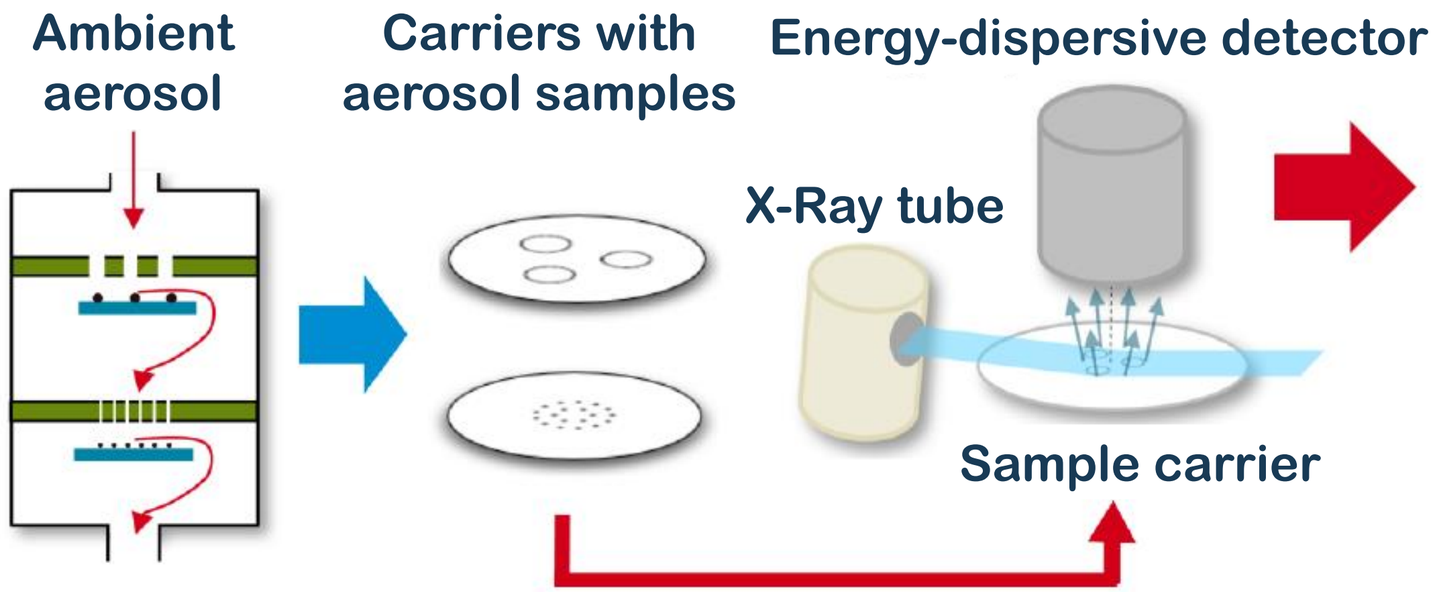


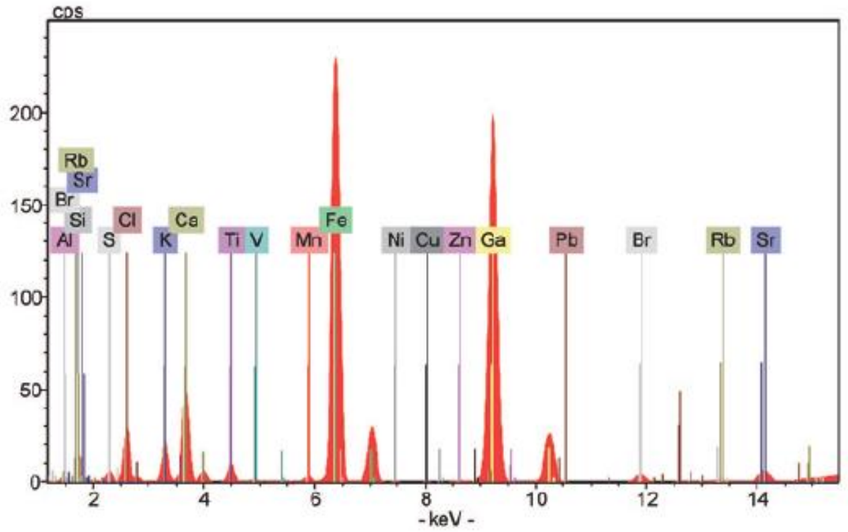


The challenge for metrology

Cascade impactor sampling

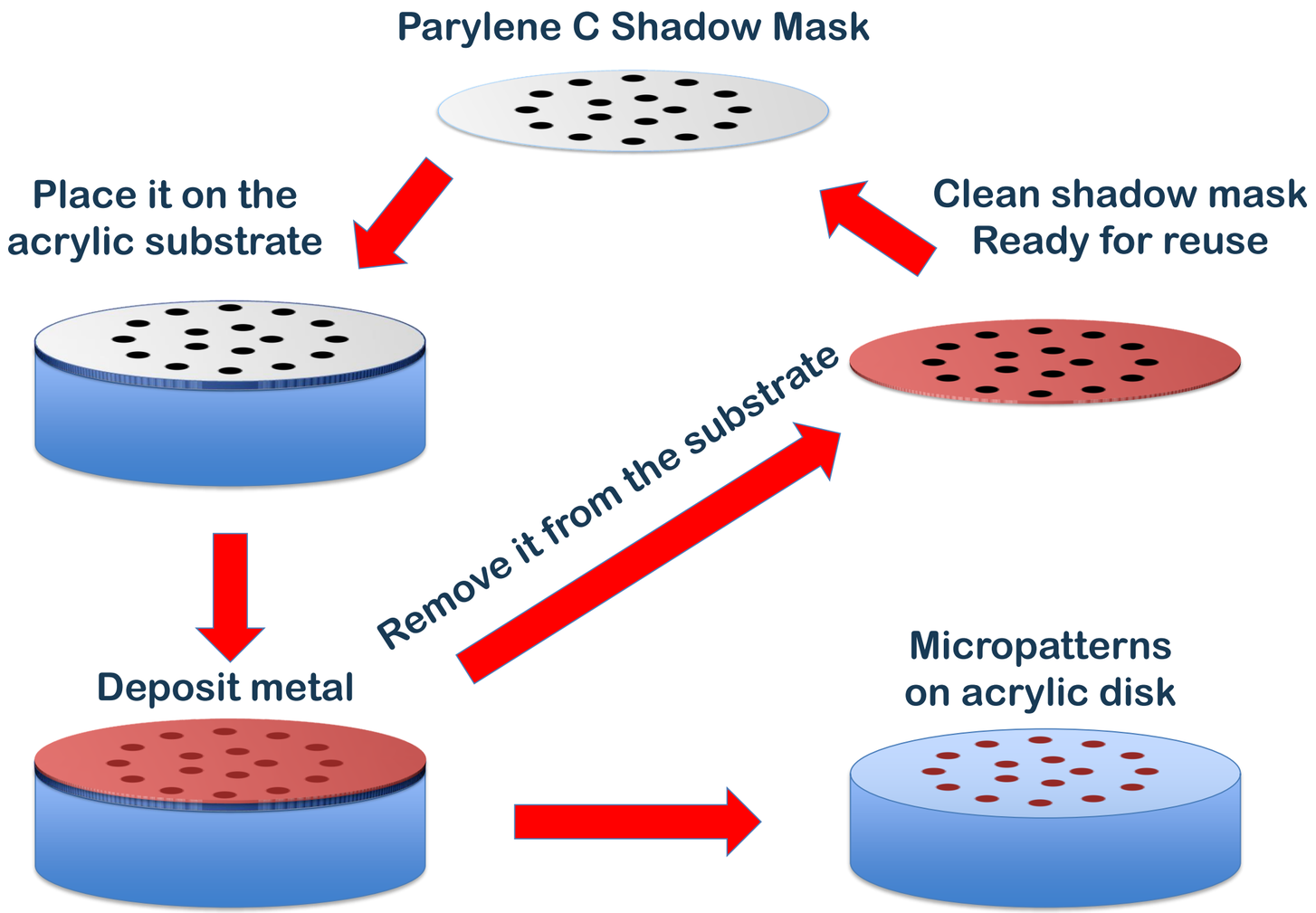
Mobile TXRF



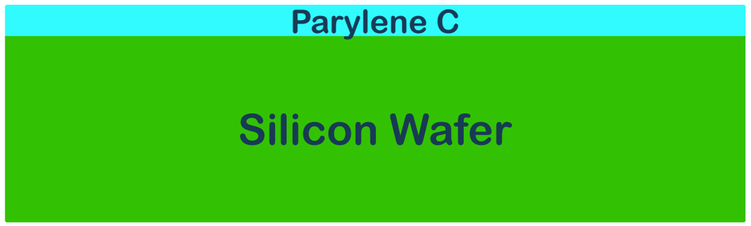


The goal is to develop **certified reference substrates** and traceable measurement techniques for the quantification of regulated and unregulated elements in ambient air with cascade impactor sampling and XRF.

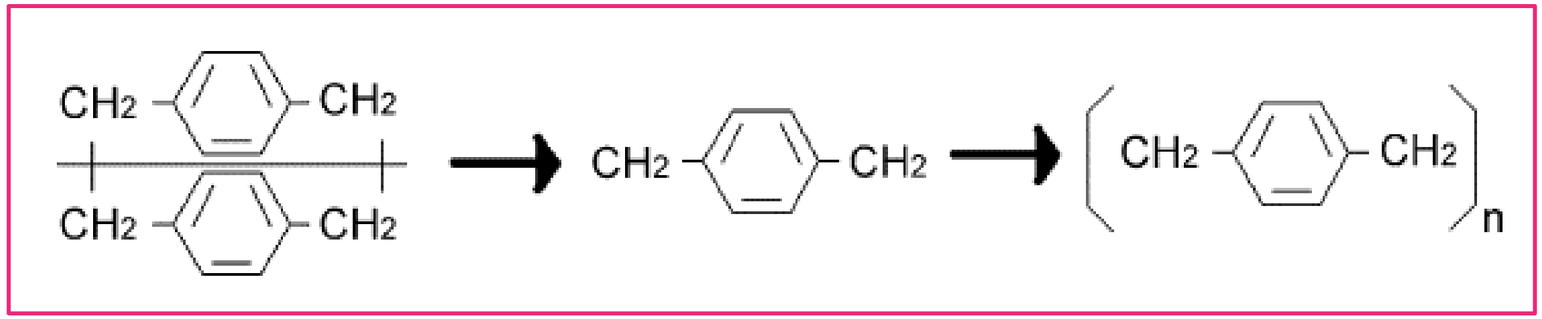
The idea: micropatterning using reusable flexible parylene shadow mask



Parylene C Deposition



Deposition of 7 µm Parylene C layer on a 4” silicon wafer by means of a CVD process performed at room temperature

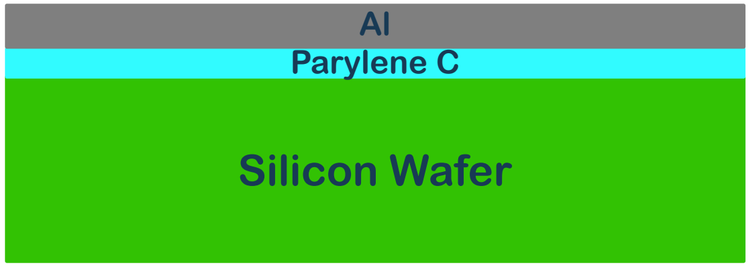


Vaporization process: a solid parylene dimer is vaporized at 175 °C

Pyrolysis process: the parylene gas is decomposed into the parylene monomer at 690 °C

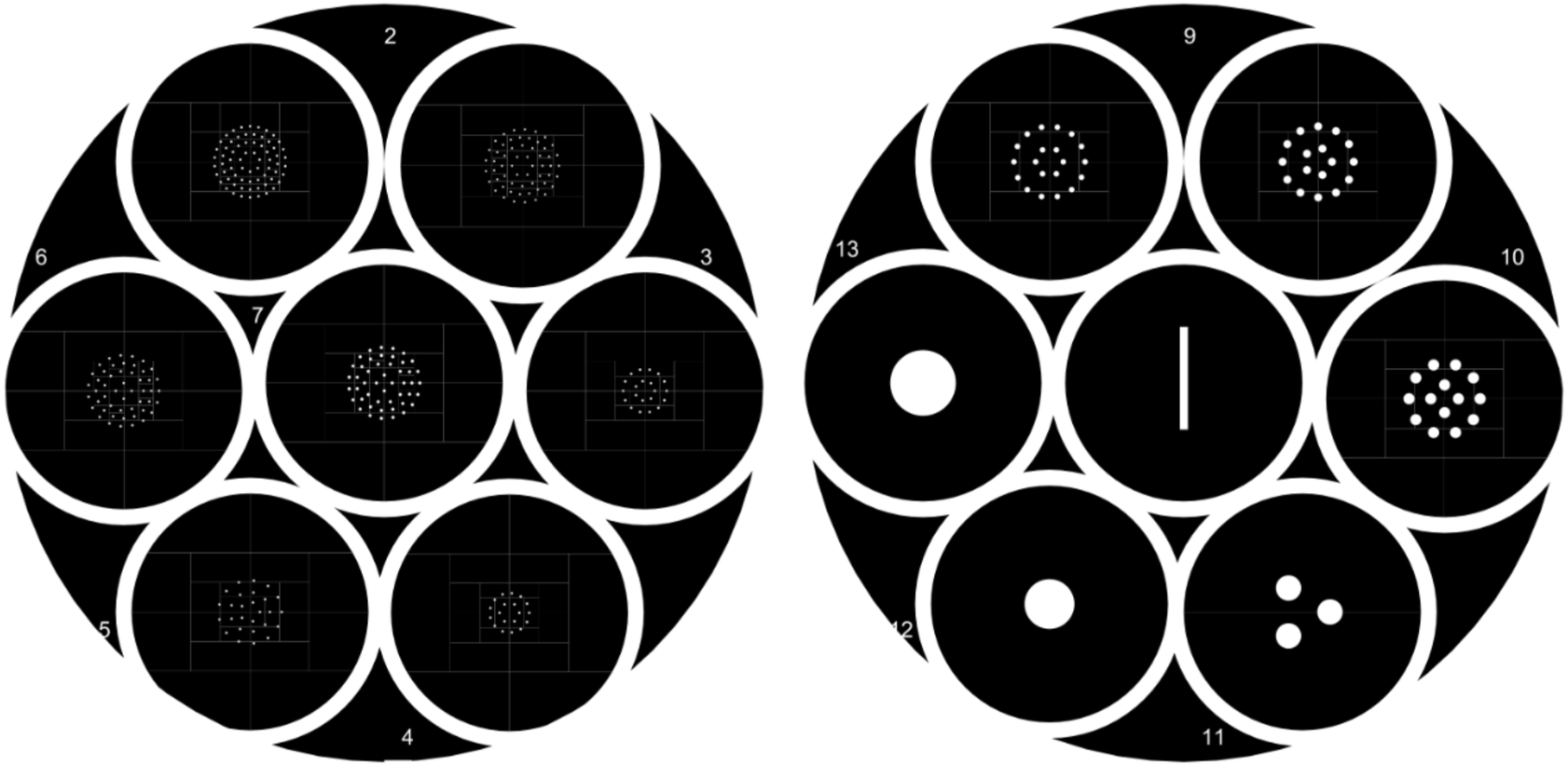
Deposition process: the parylene monomers get adsorbed on the substrate surface and polymerize at RT

Al Deposition



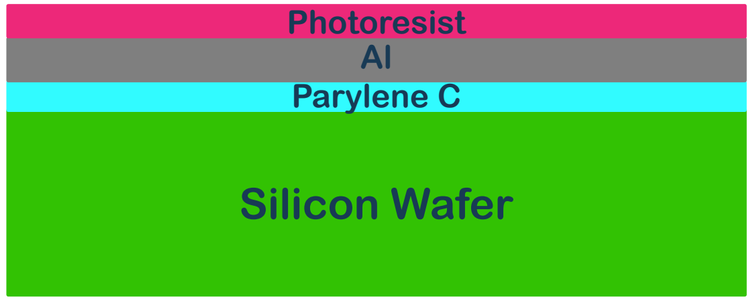
Deposition of **100 nm** of Al
used as sacrificial layer
through an e-beam evaporator

Mylar Masks

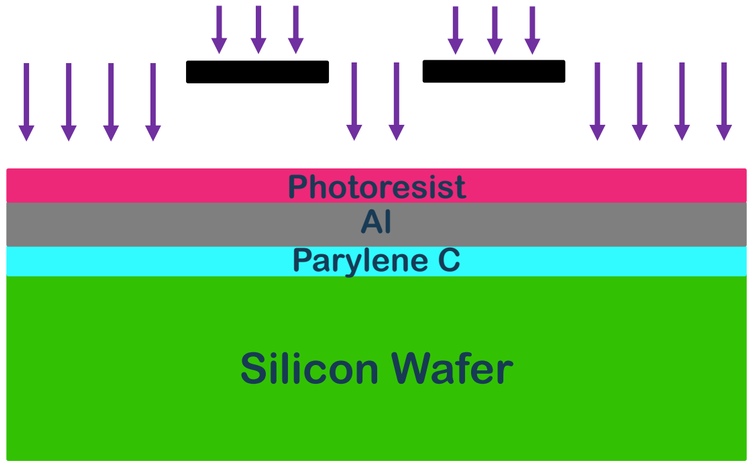


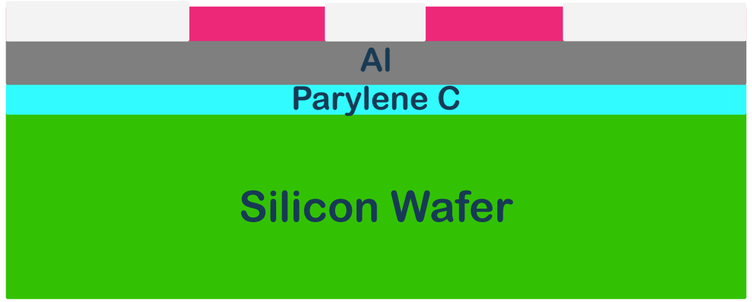
Realization of 2 Mylar masks in order to pattern the 14 stages of the reference samples

Photolithography Step

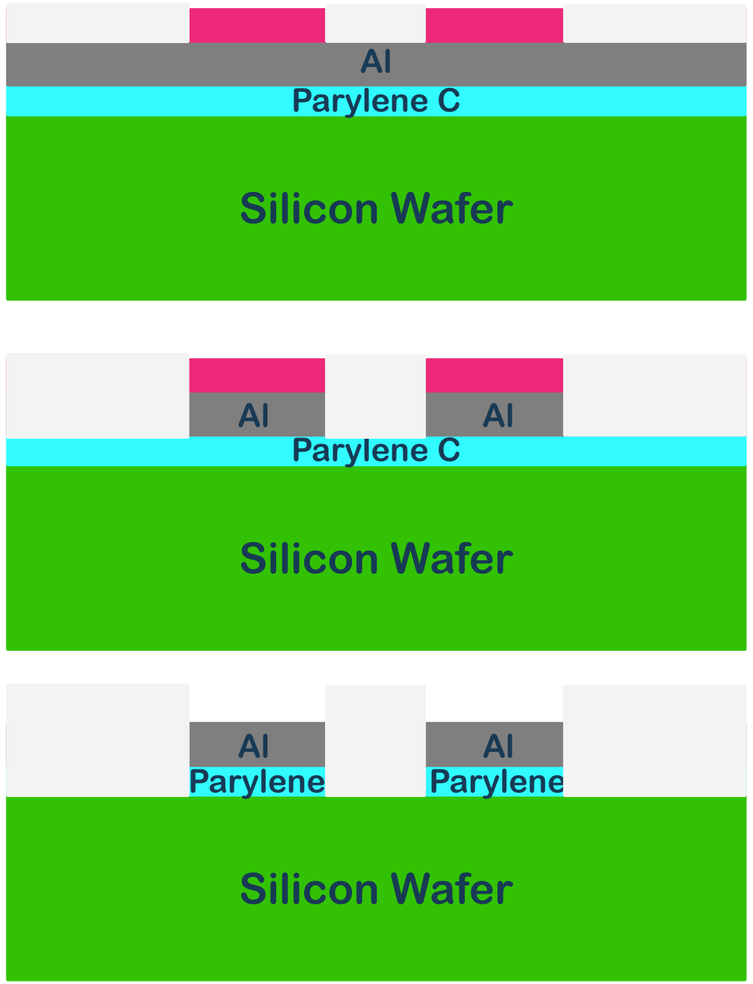


- Positive photoresist AZ1518 deposition through a spin coater
- UV exposure for 7” at 10 mW/cm^2
- Photoresist development

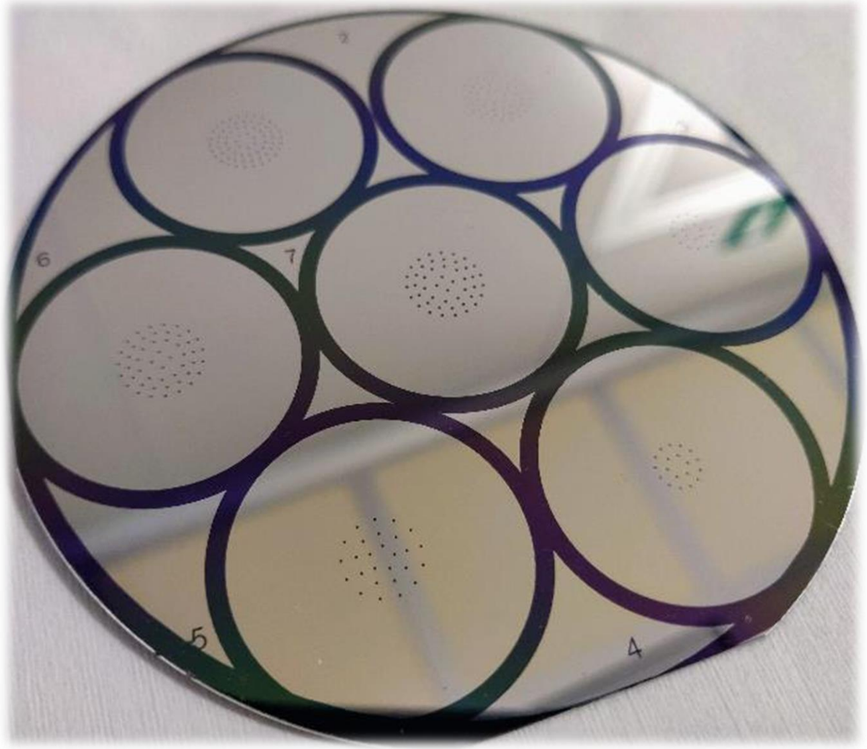




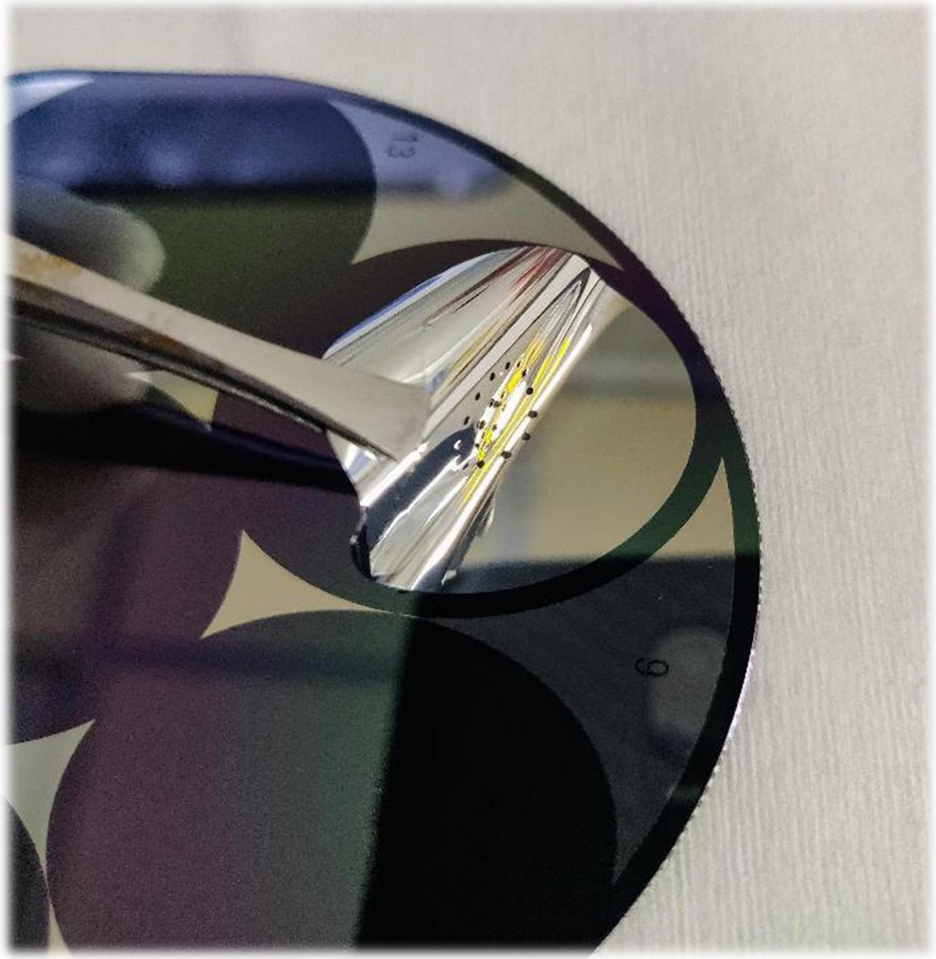
Etching

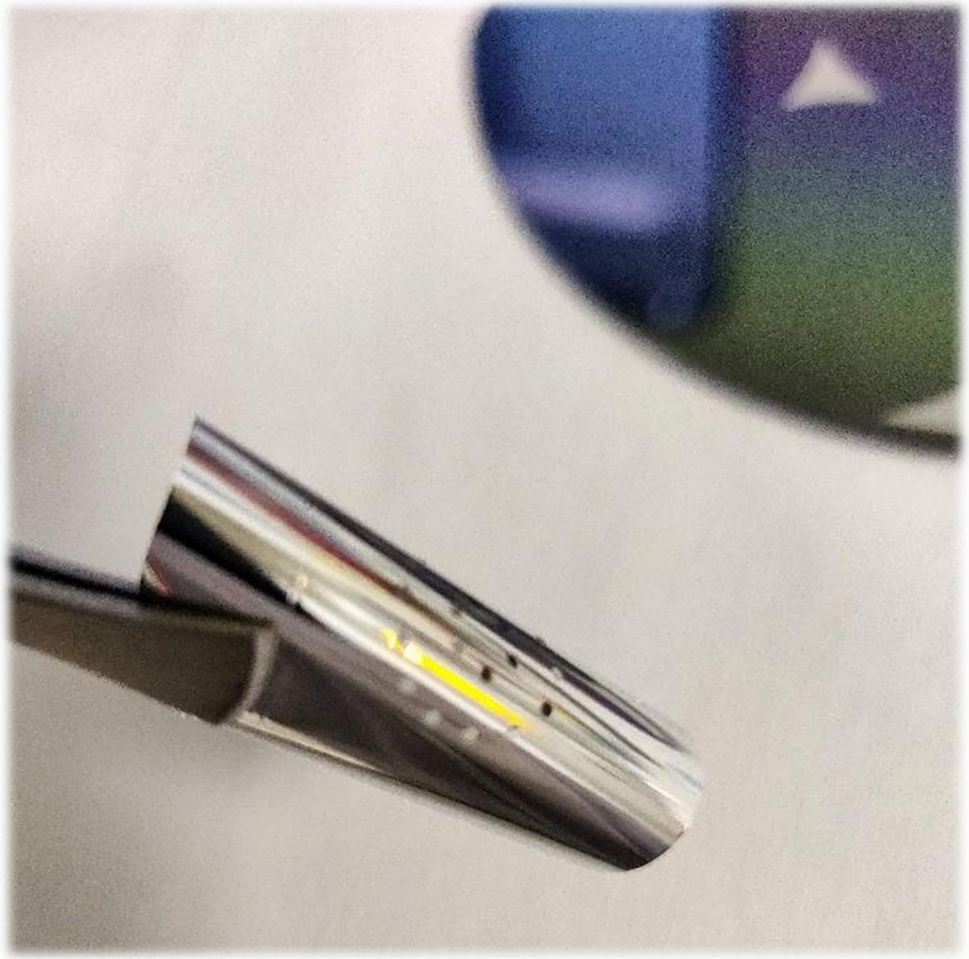


- Al wet etching
- RIE dry etching

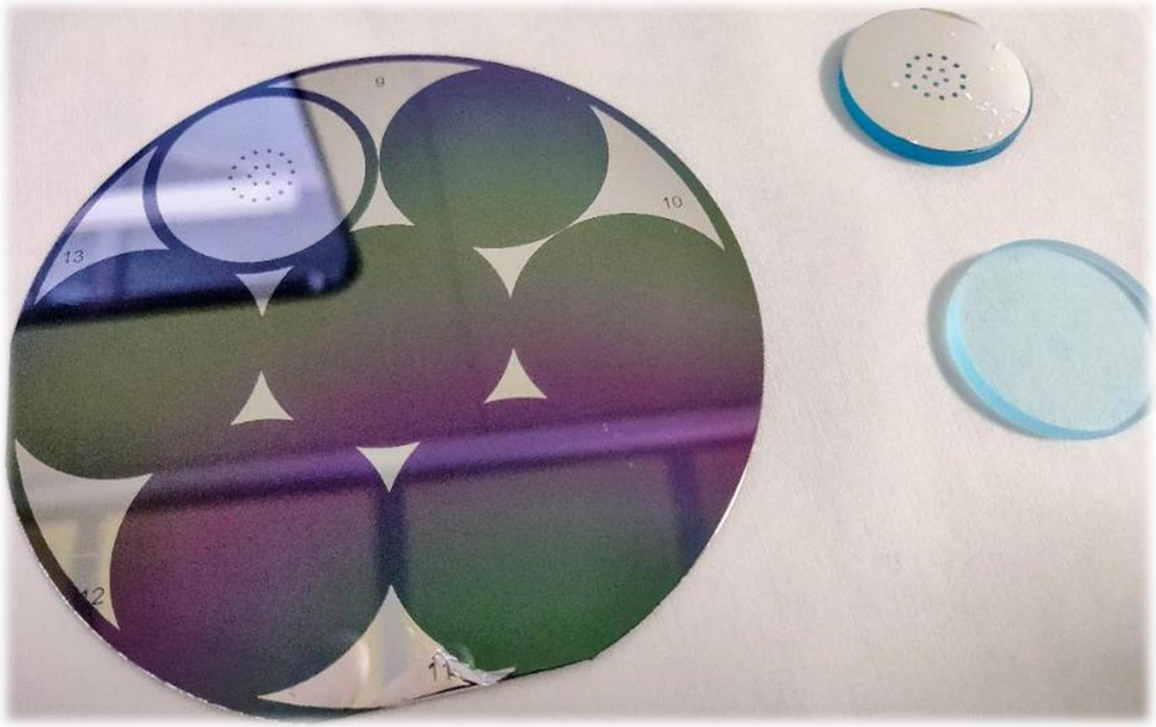


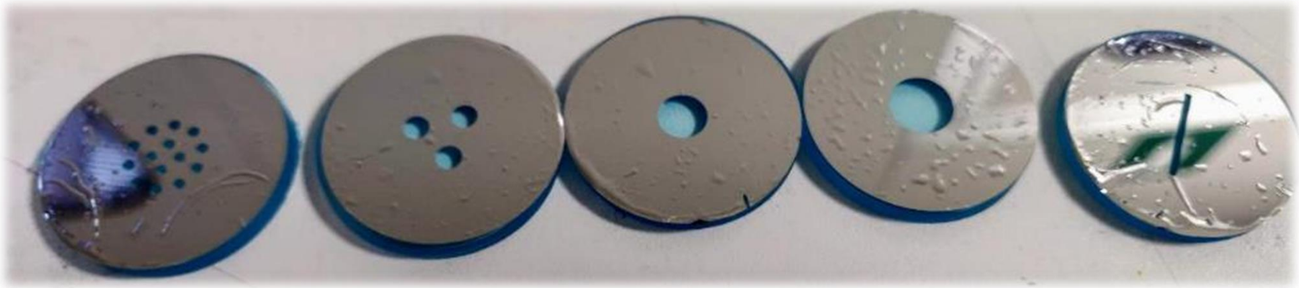
Peel-Off





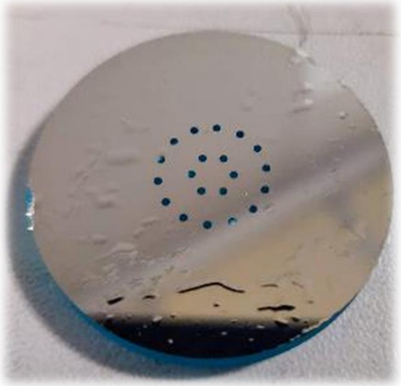
Transfer Step



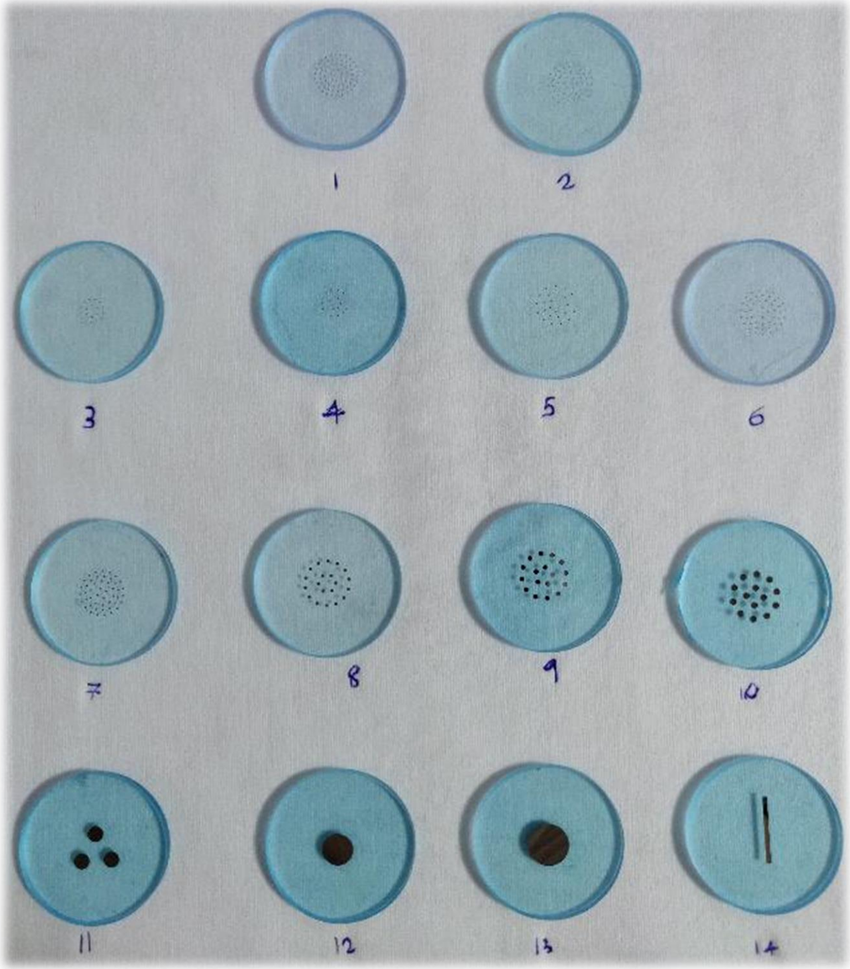


After fabrication, single parylene C masks have been peeled off and transferred on the PMMA disks

Metal Evaporation



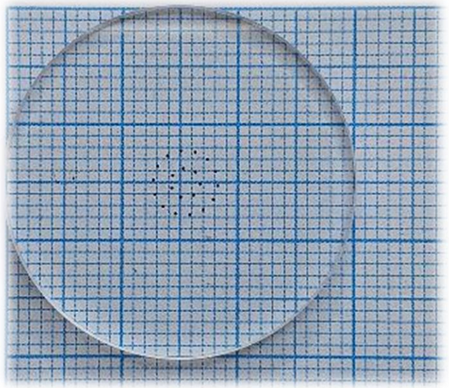
Deposition of <u>80-90 nm</u>
of Ti through an
e-beam evaporator

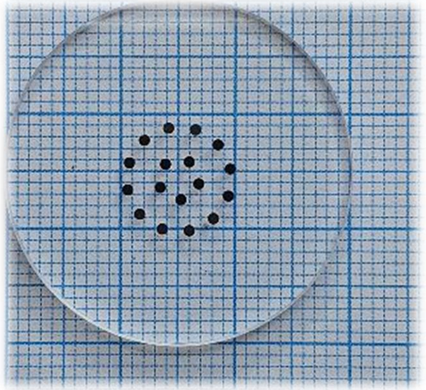


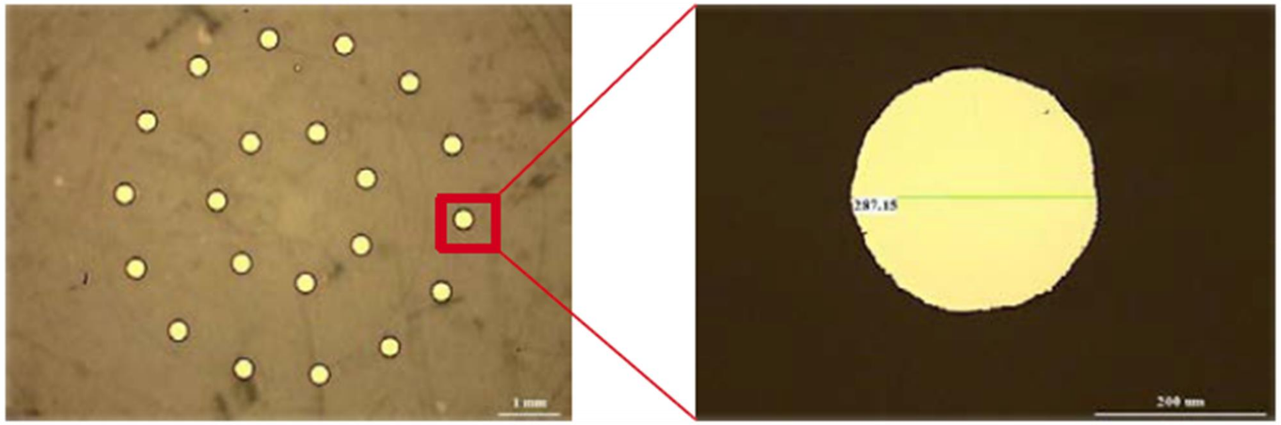
Available metals:

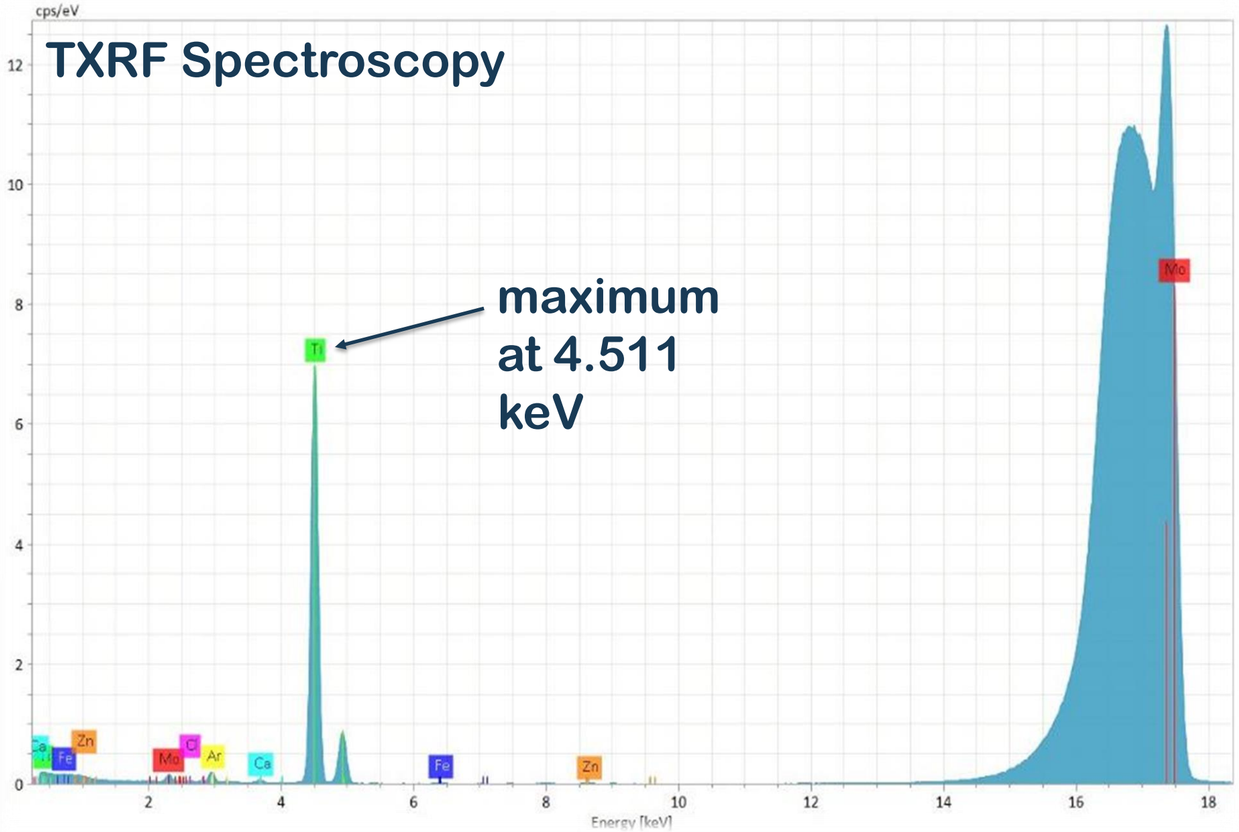
- Al
- Ag
- Mo
- Au
- Pt
- Ni
- Cu
- Sn

Reference samples characterization



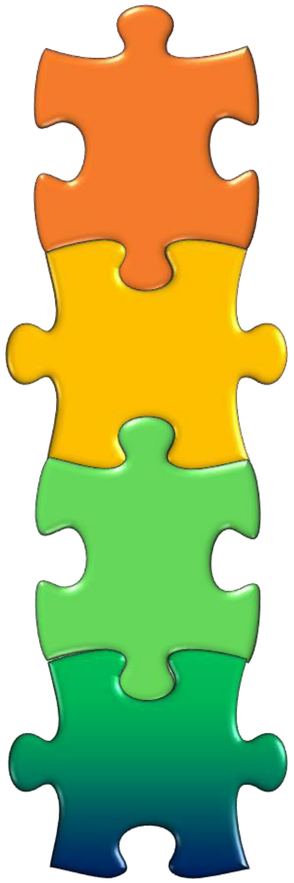






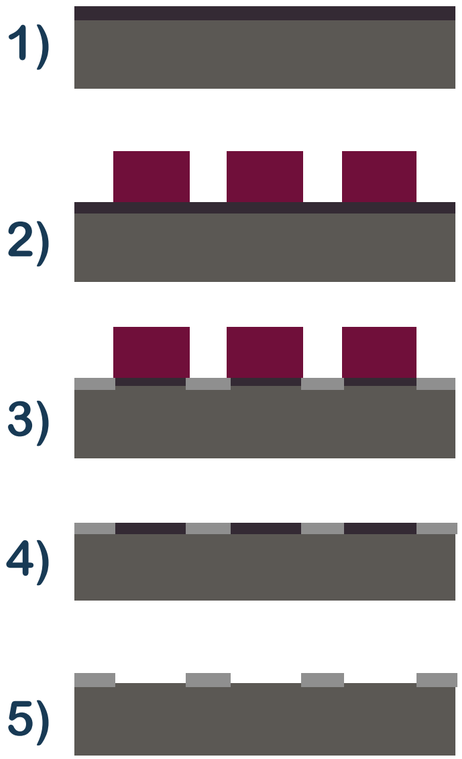
Conclusion

Lasciare o eliminare slide??



- Reference samples with different cascade impactor stages patterns were successfully realized with this technique.
- Highly flexible direct patterning of acrylic substrates otherwise impossible with conventional photolithography procedures.
- Parylene C micro-stencils were successfully reused multiple times without any damage or contamination.
- Good accuracy achieved on features down to 250 μm with an error less then 4%.

Artificial reference samples by using SIS method inside diblock copolymers



1) Si + thermally grafted PS-r-PMMA

2) Positive laser litography with Dekati pattern

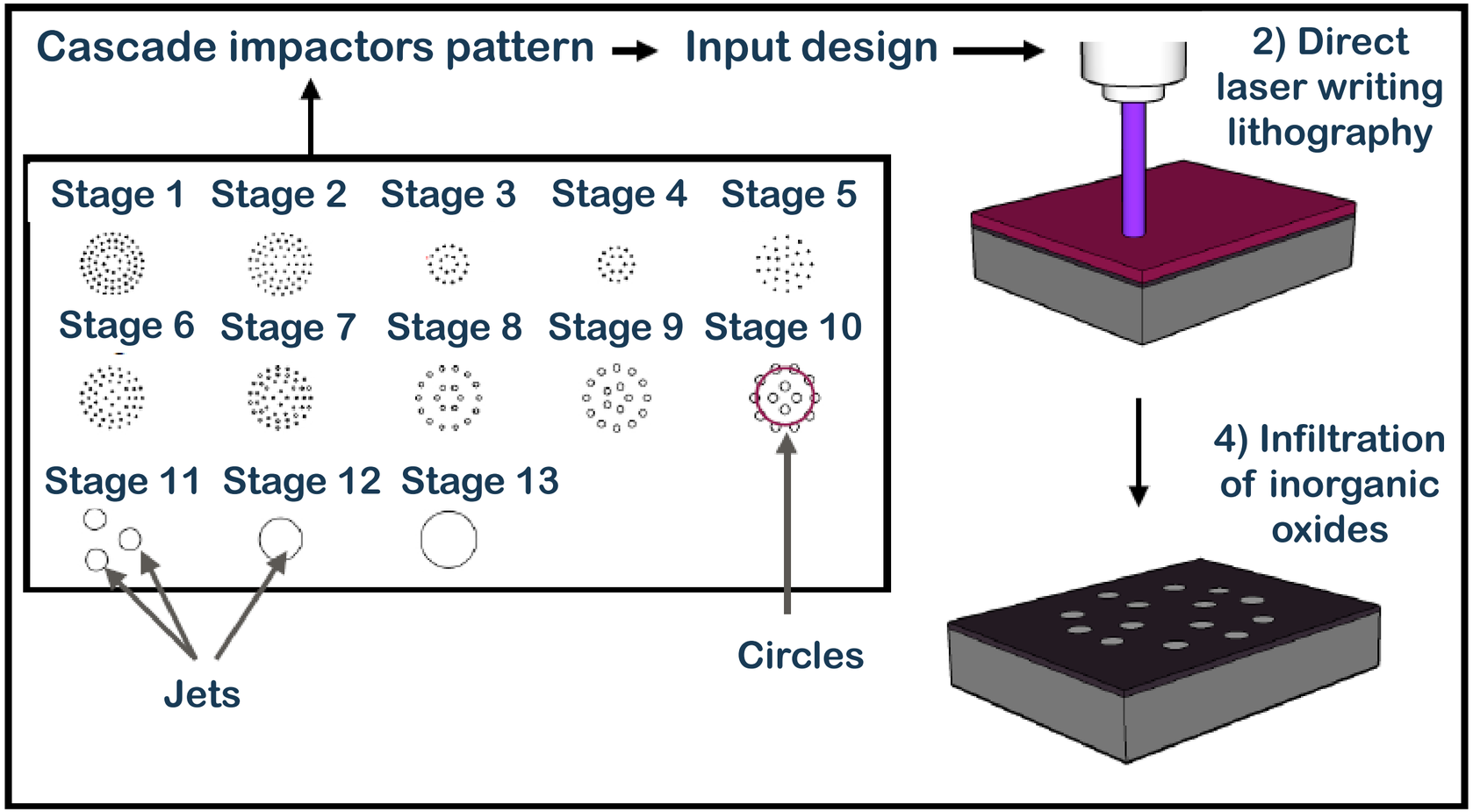
3) Infiltration of metal oxide inside the Dekati pattern

4) Acetone bath to remove the resist

5) Oxygen plasma to remove the uninfiltrated Ps-r-PMMA

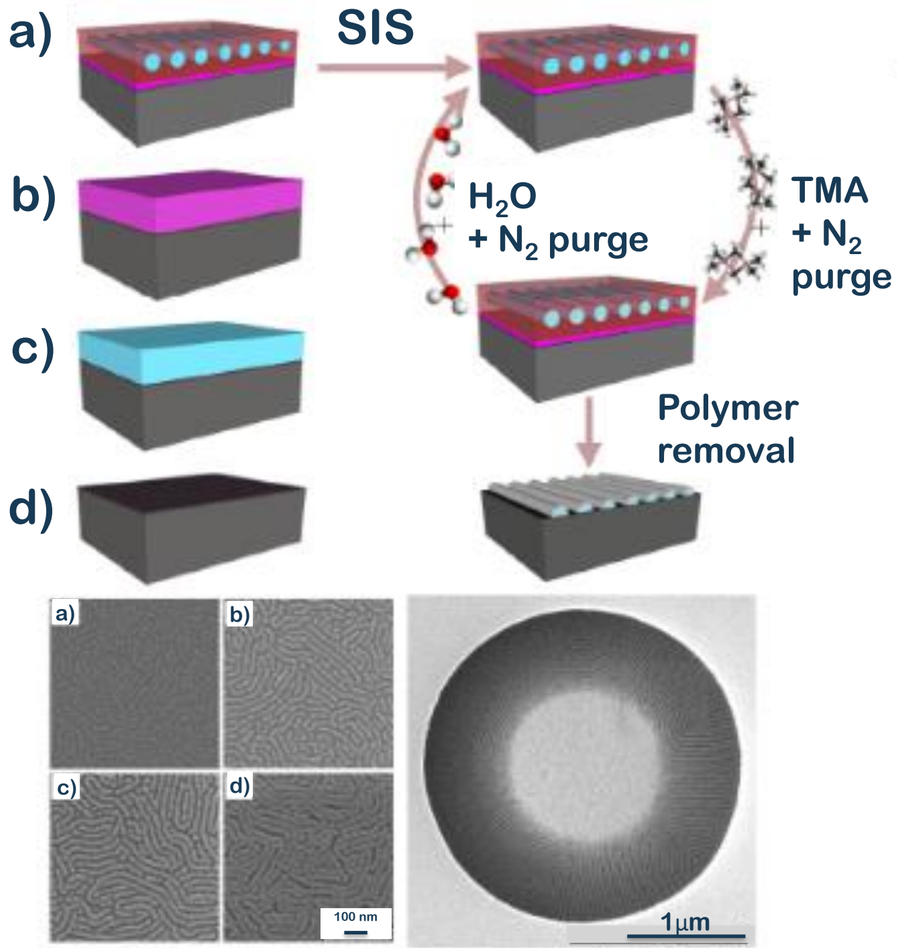
Available metallic oxides for ALD-based infiltration are TiO_2, Al_2O_3, ZnO
Chemical affinity between the precursor and the polymer functional group is required for the infiltration.

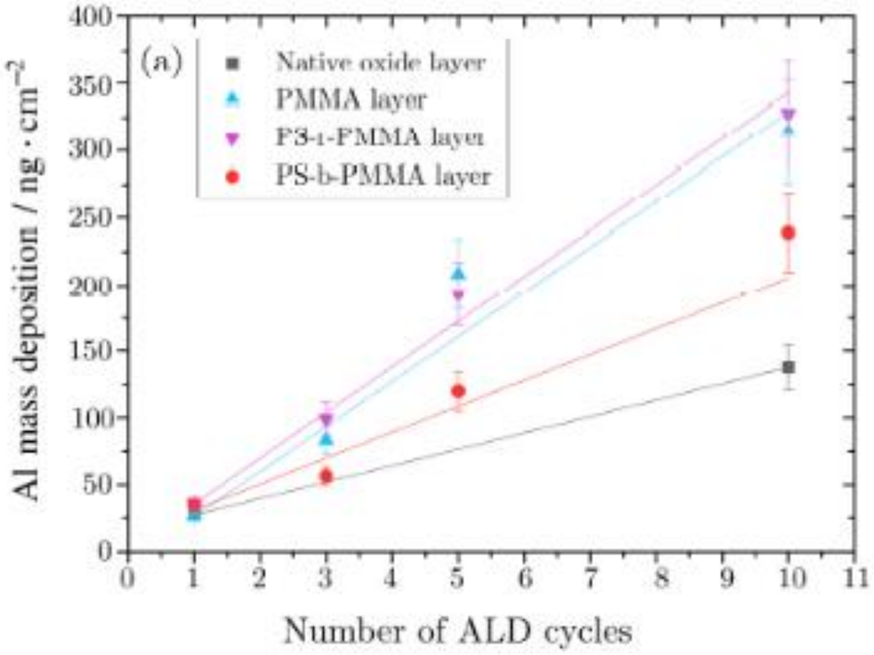
Artificial reference samples by using SIS method inside diblock copolymers



Artificial reference samples by using SIS method inside diblock copolymers

10 cycles of ALD on PS-r-PMMA yields 300 ng/cm² of Al





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Thank you for your kind attention!