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# Mesoporous materials under irradiation in wet conditions

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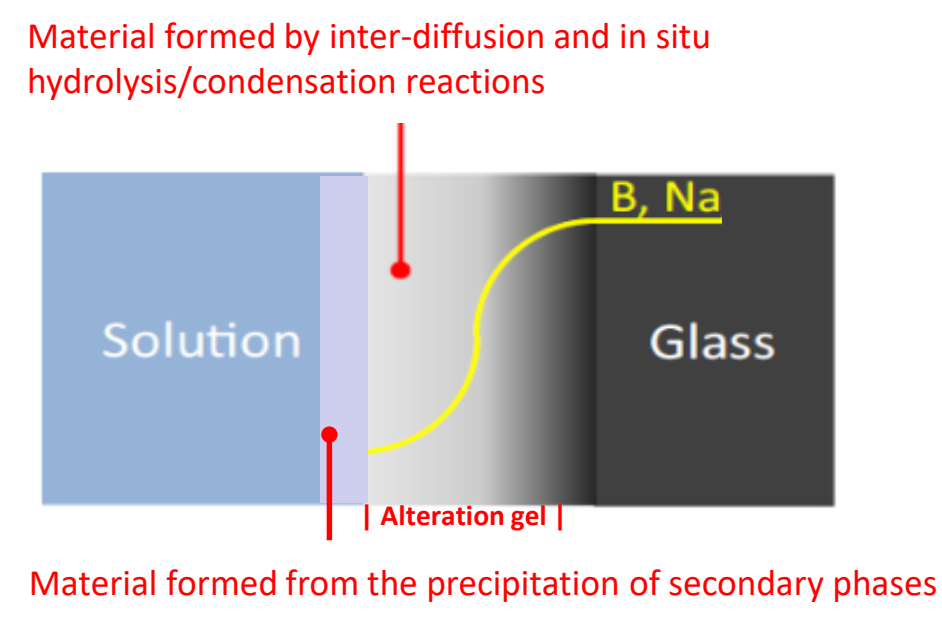


## Keywords

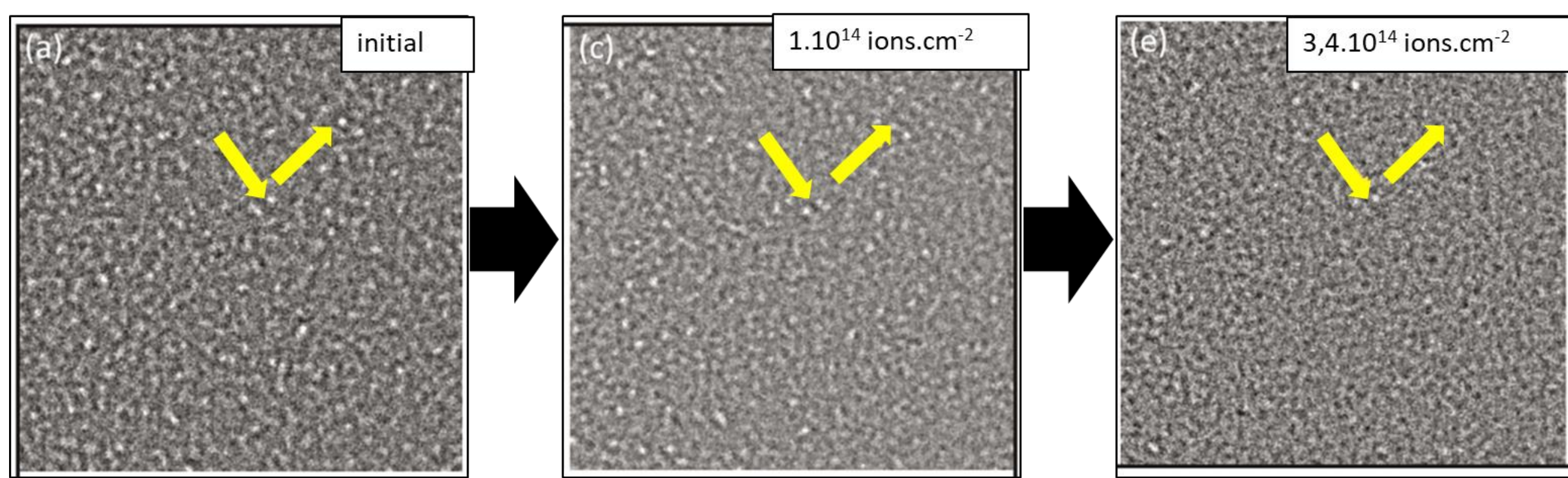
Mesoporous silica & sol-gel materials  
Irradiation-induced behaviour  
Nuclear glass alteration  
X-ray scattering & reflectivity

### Pore collapse in the altered layer of a borosilicate glass

Schematic of the altered layer and its elemental concentration profile for a CJ2-type borosilicate glass, adapted from 4.



Evolution of the TEM image of the long-term altered layer of a CJ2 glass under irradiation, reproduced from 3. Fluences of Xe, 600keV, range from 0 to  $4,6 \cdot 10^{14}$  Xe.cm<sup>-2</sup>. Yellow arrows serve as visual aid.

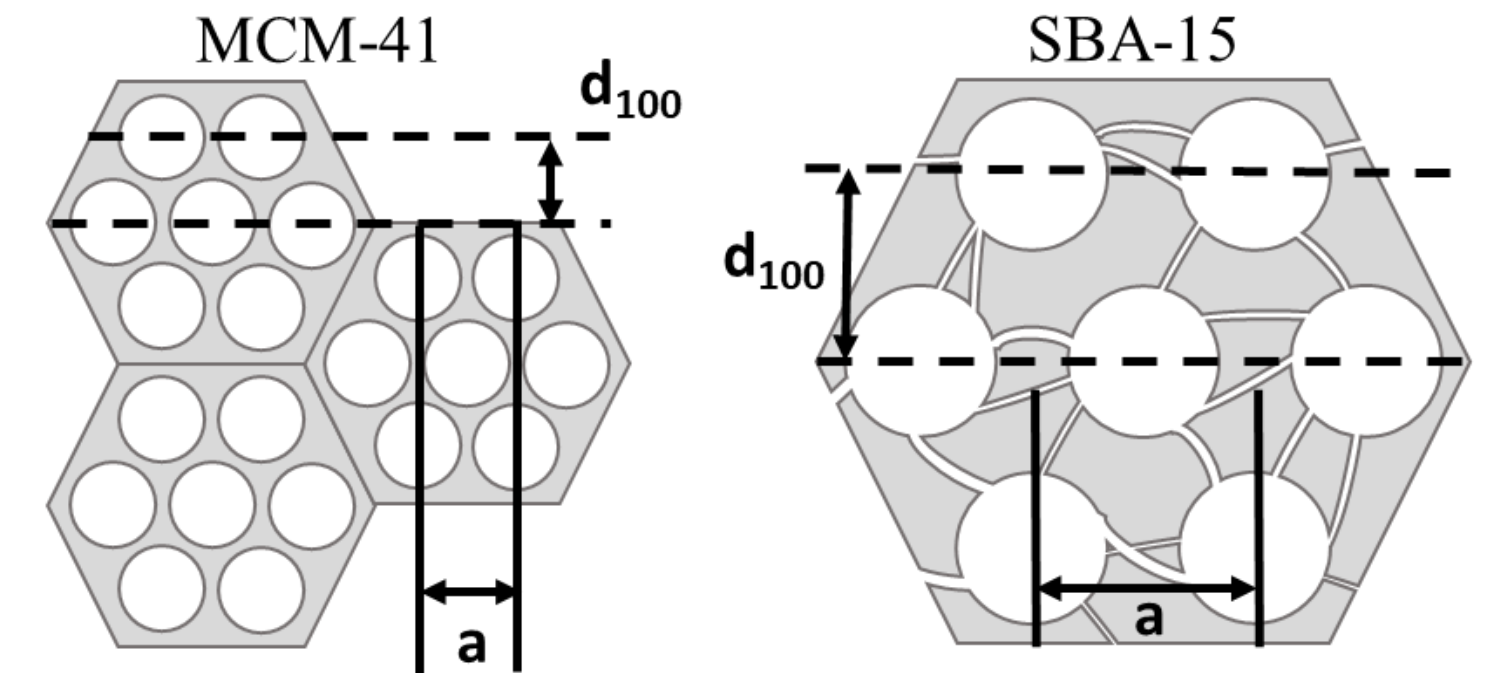
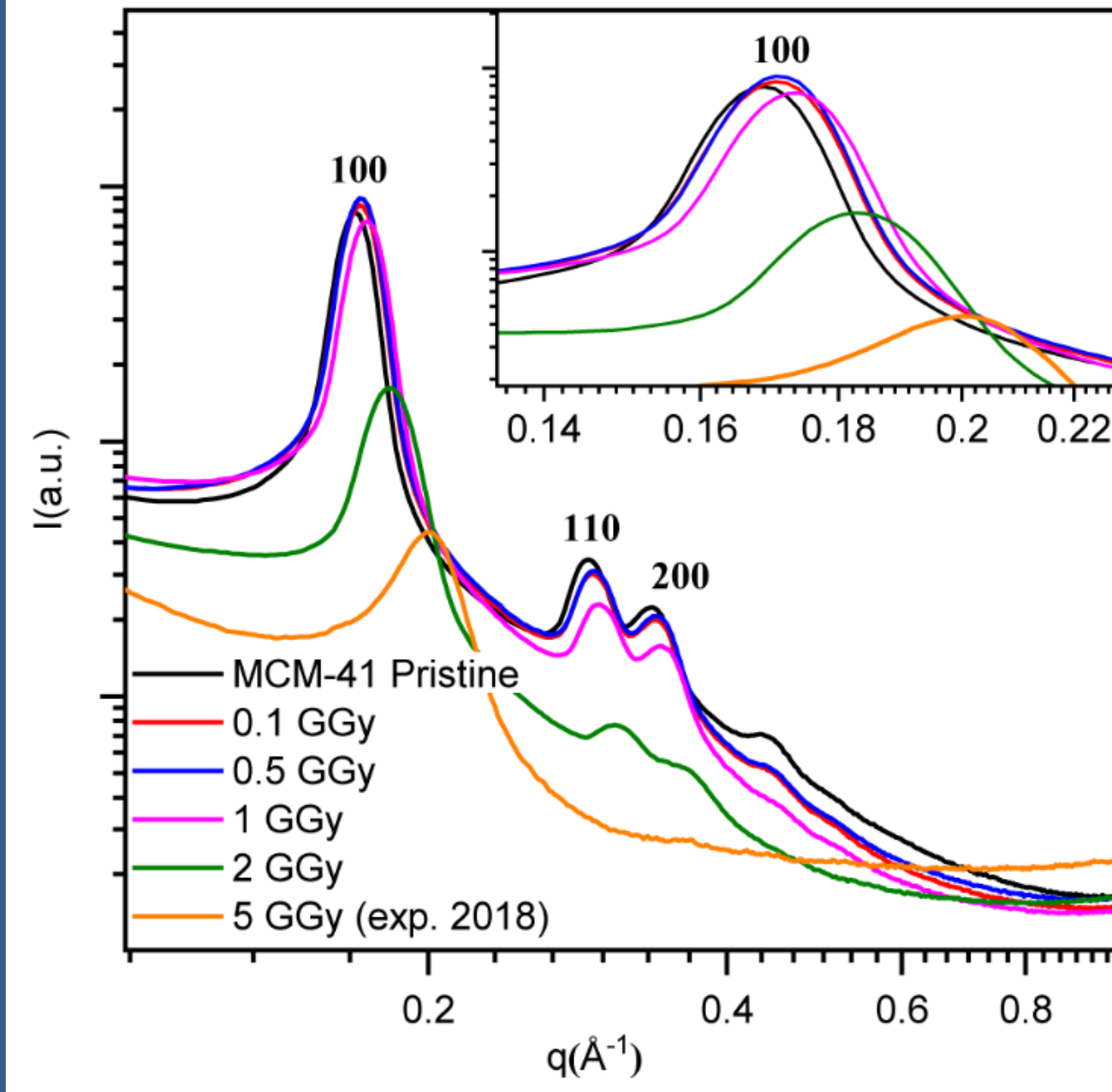


Pore shrinkage and closure was observed in the alteration gel of a CJ2 borosilicate glass.

- This effect could play a role in a potential **passivation** of the alteration gel.
- The influence of experimental factors such as temperature (-130°C), pressure and the **departure of initial water** due to the instrument's vacuum, must be investigated.

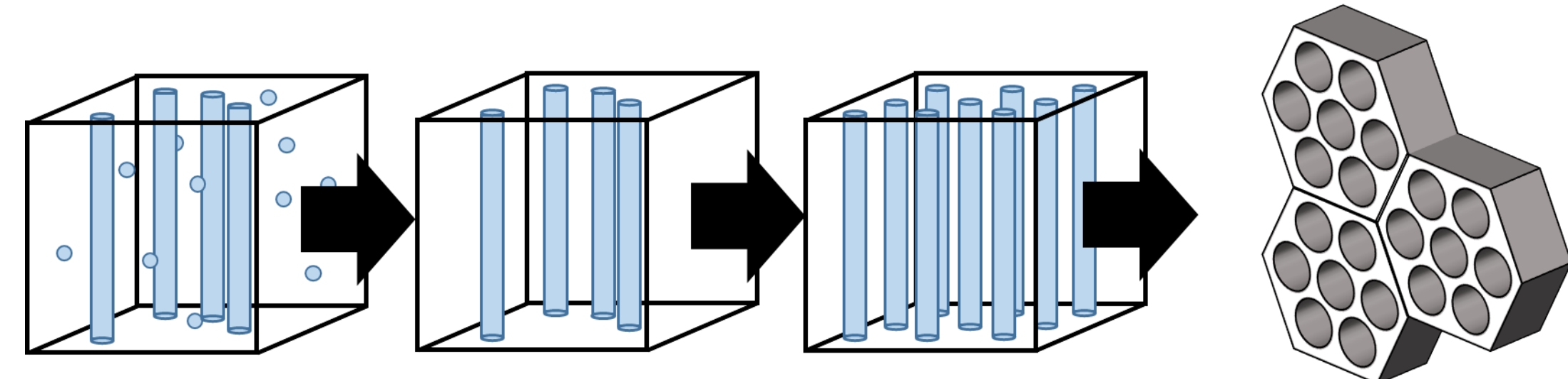
### Monitoring the irradiation-induced pore collapse of mesoporous silica

SAXS profiles of MCM-41 pellets under a 2 MeV electron beam at various doses, reproduced from 1. The initial profile features a well-defined hexagonal structure, as pointed by the peak labels.



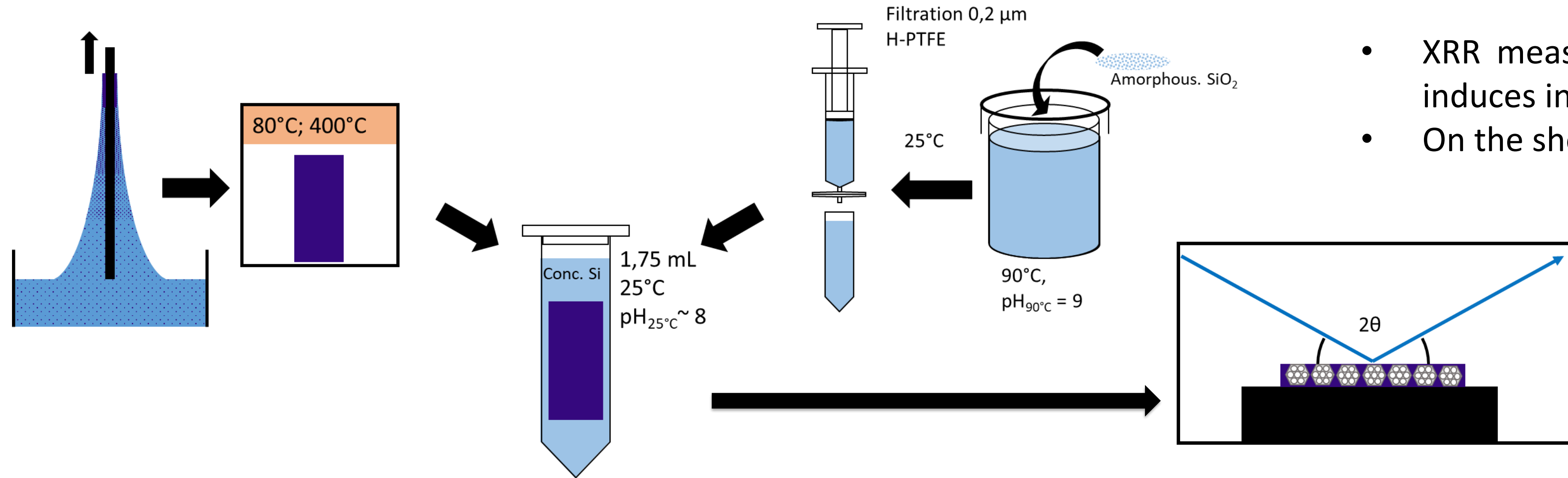
The collapse of (hexagonal, P6mm) porous structure of mesoporous silica, such as SBA-15 or MCM-41 can be monitored using X-ray diffraction techniques, such as SAXS (Small Angle X-ray Scattering, top left), or XRR (X-Ray Reflectivity, bottom left) for thin films.

Complex, disorganized porous structure of alteration gels



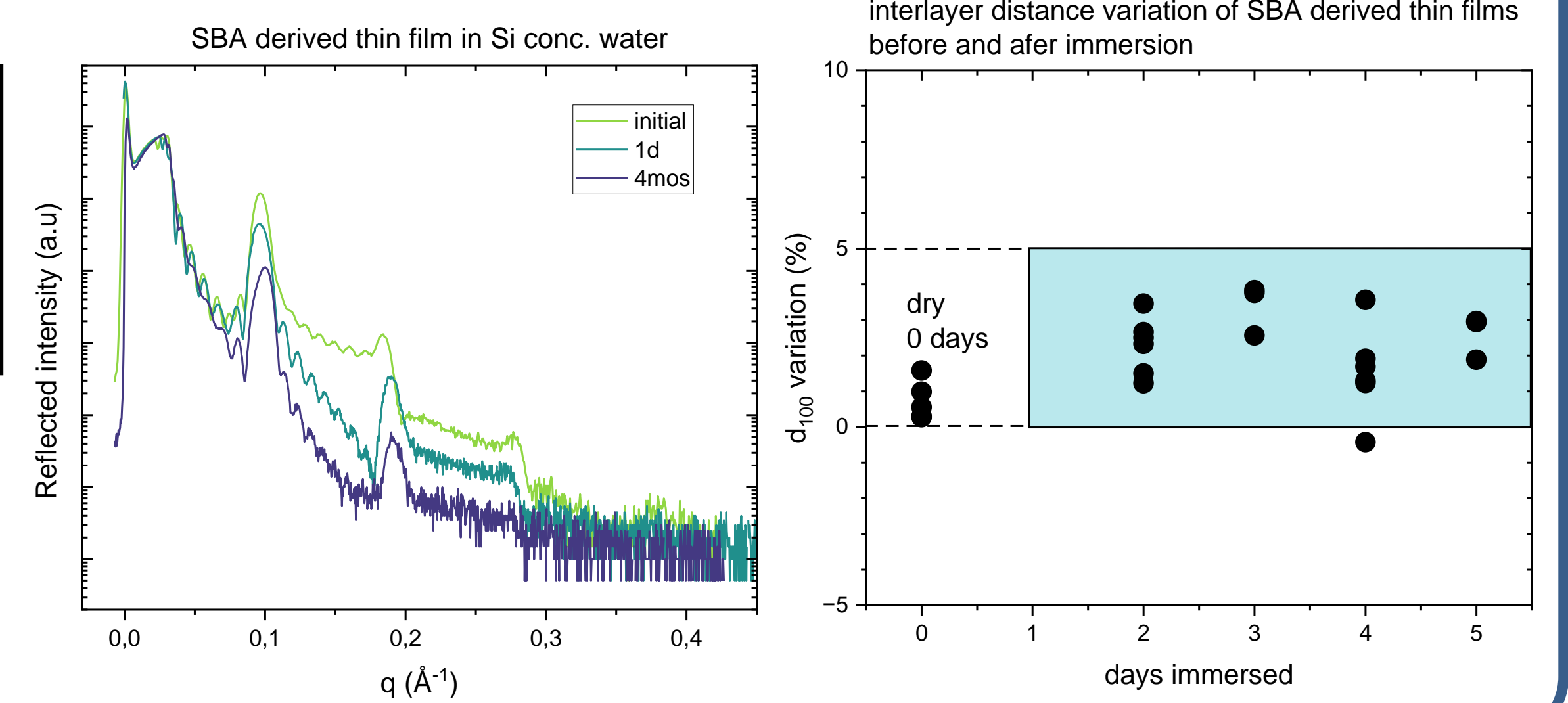
How do wet mesoporous material behave under irradiation?

### Studying the structure of mesoporous materials in coupled aqueous/irradiation conditions.



Mesoporous silica thin films samples were dip-coated and calcinated. Some samples were immersed in water for several days prior to irradiation, then dried in open air before entering the irradiation chamber. Other samples were kept in contact with water throughout irradiation.

- XRR measurements before and after immersion show that immersion induces interlayer ( $d_{100}$ ) and global swelling < 5%
- On the short term, the structure organization is well-preserved.

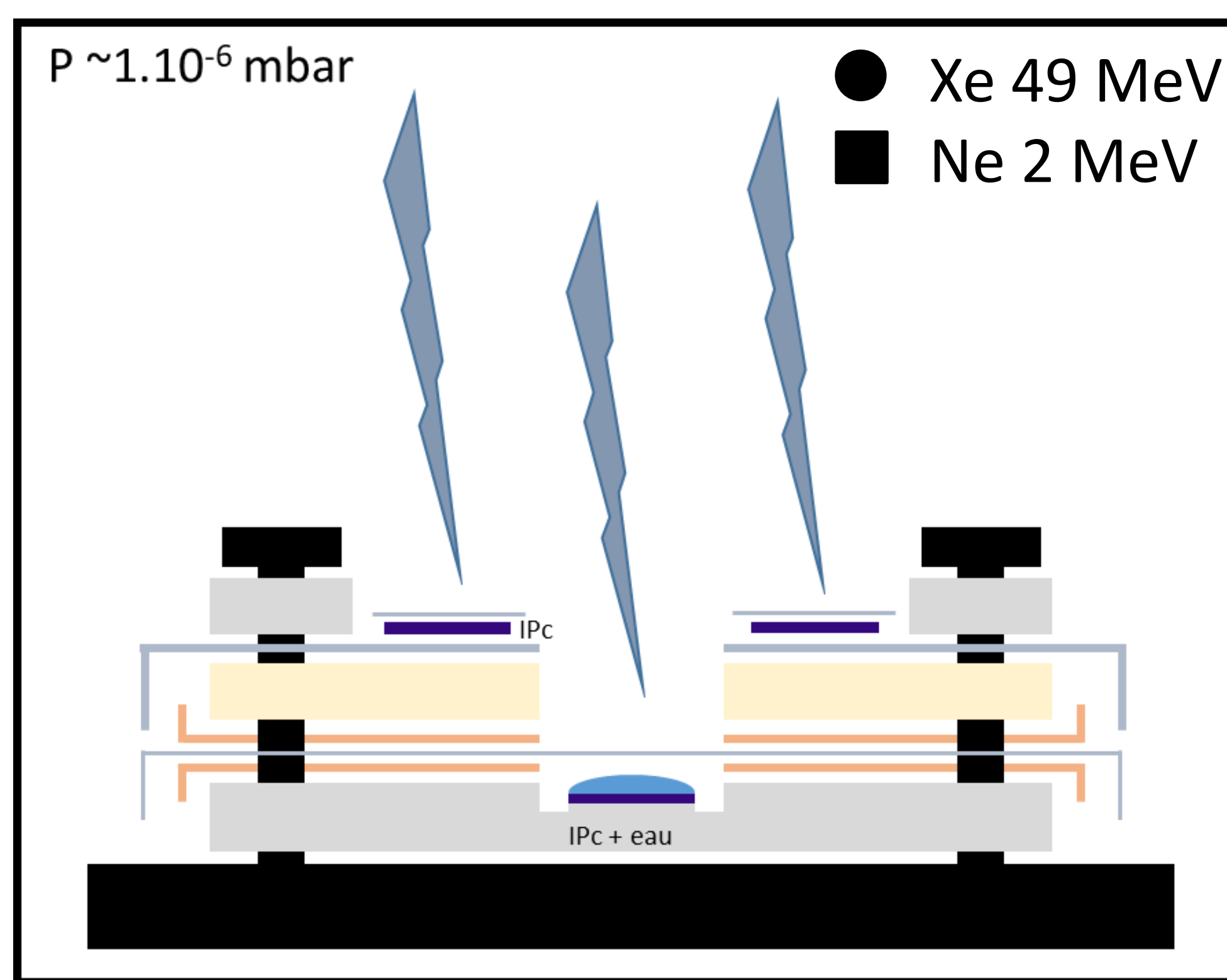
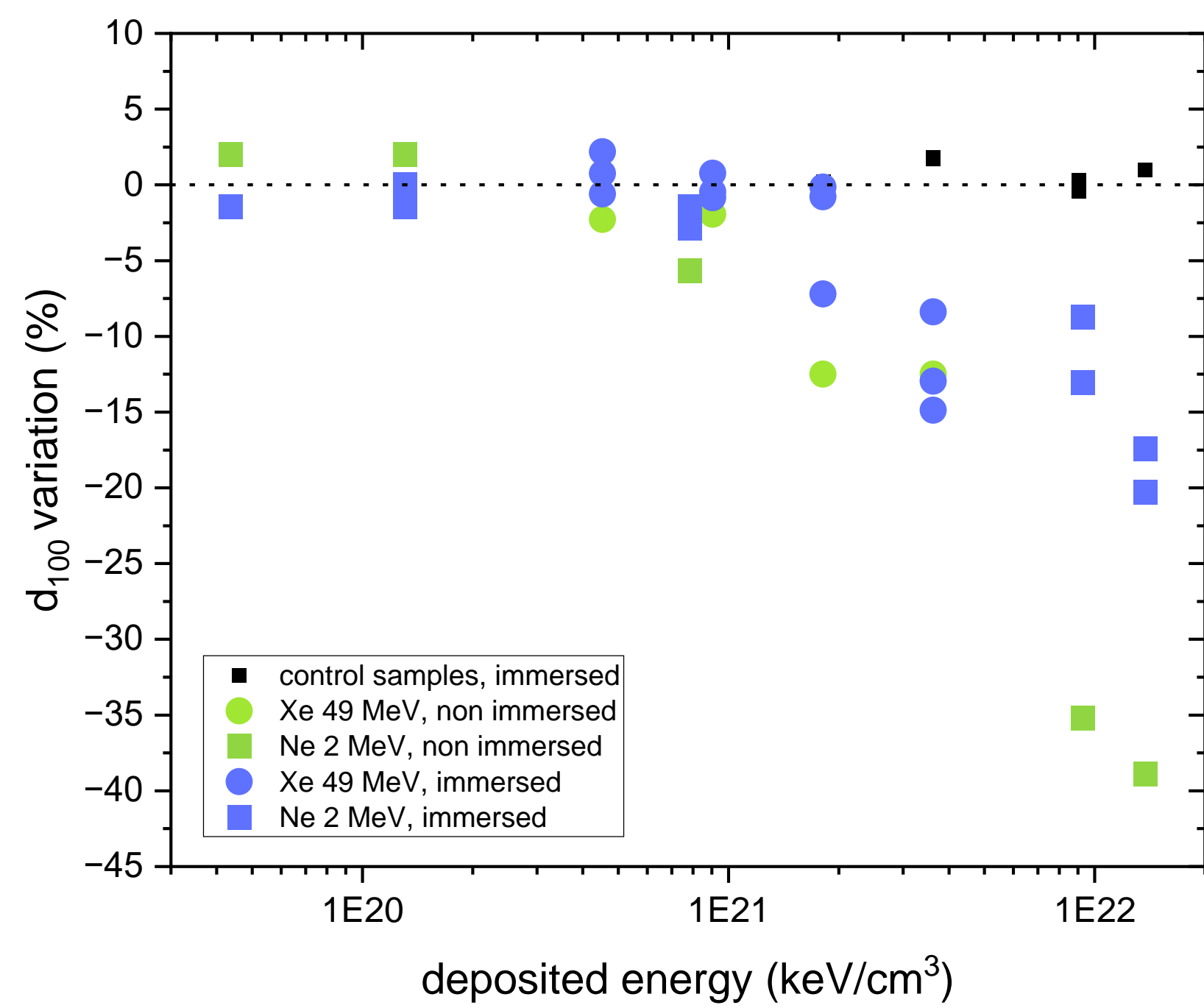


Samples were irradiated with Xe and Ne ion beams at various fluences. From the comparison between sample series:

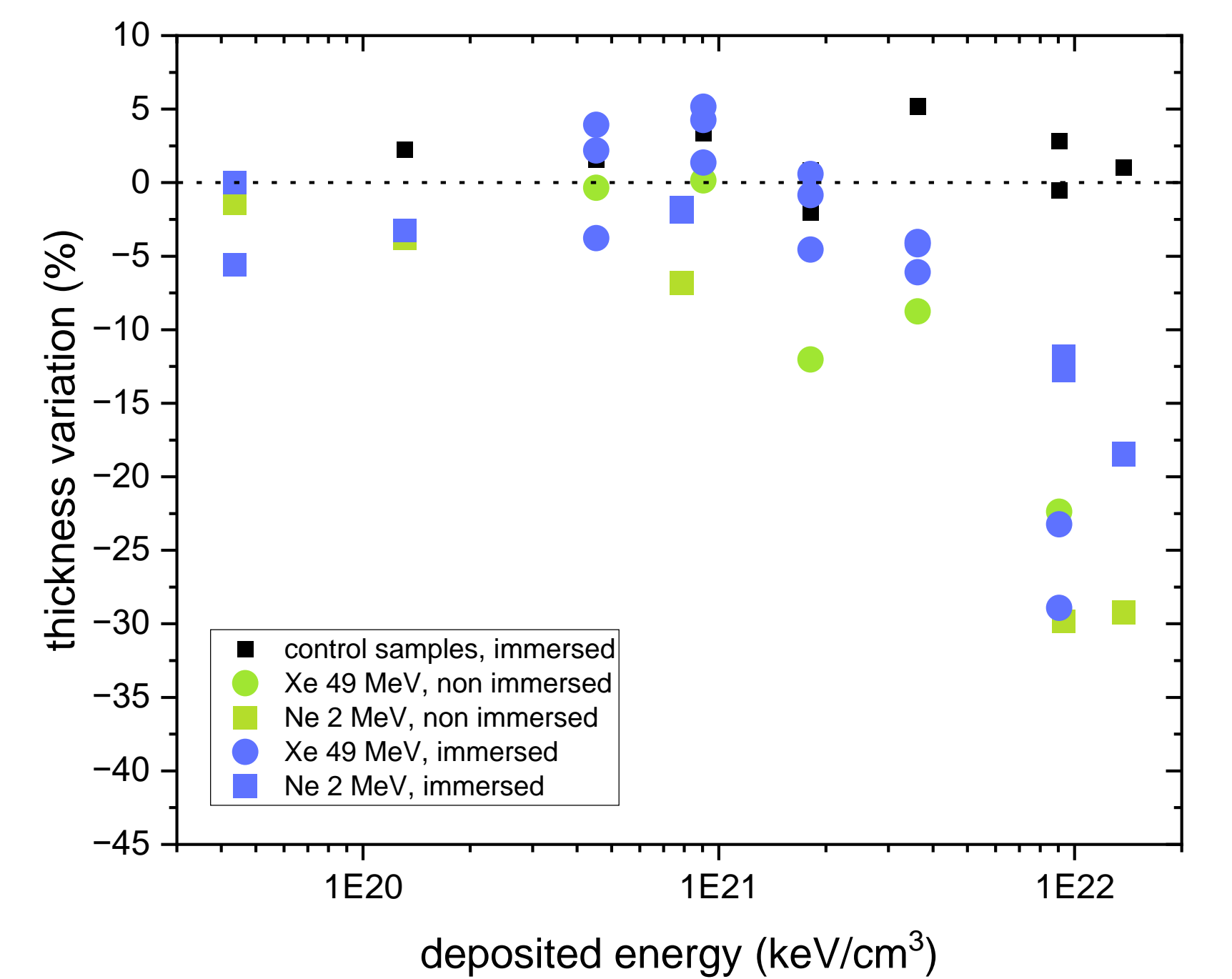
- no significant difference between immersed sample series → simpler distinction
- Immersed samples undergo smaller collapse than dry samples.

- Towards more sophisticated model materials
- Comparison with reference materials
- Molecular modelling<sup>2</sup>

Interlayer distance variation of SBA-15 derived thin films under irradiation



Total thickness variation of SBA-15 derived thin films under irradiation



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