

# Germanium-based nanostructure synthesis guided by amphiphilic diblock copolymer templating

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## motivation

**Versatility of organic photovoltaics coupled with the stability of inorganic materials**

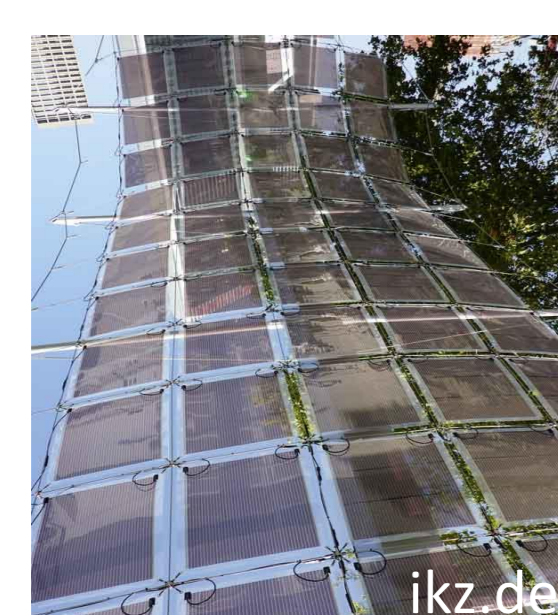
organic

- flexibility
- transparency
- light weight
- cost-efficiency
- large scale

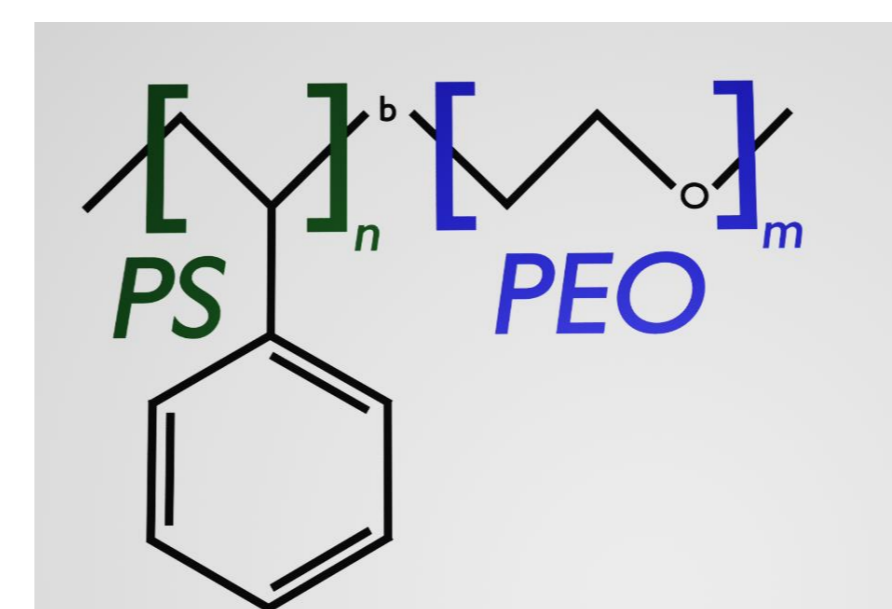
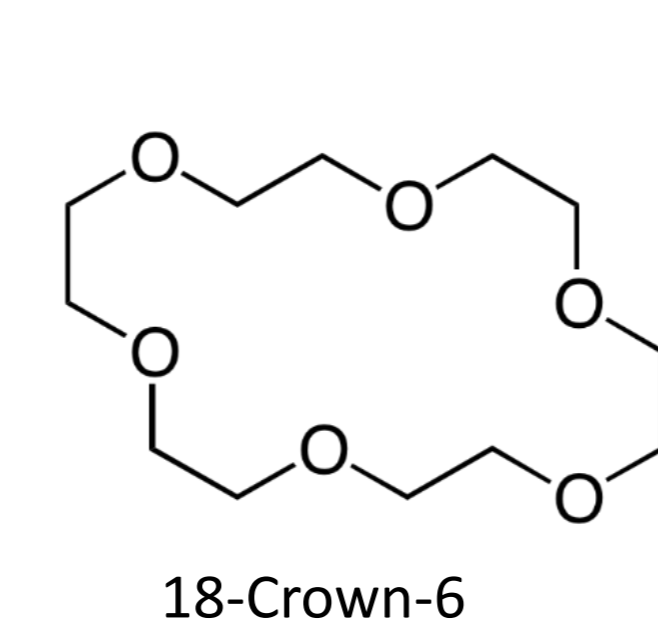


inorganic

- chemical stability
- no expensive dyes
- tailoring of hybrid interface
- tuning of absorption range



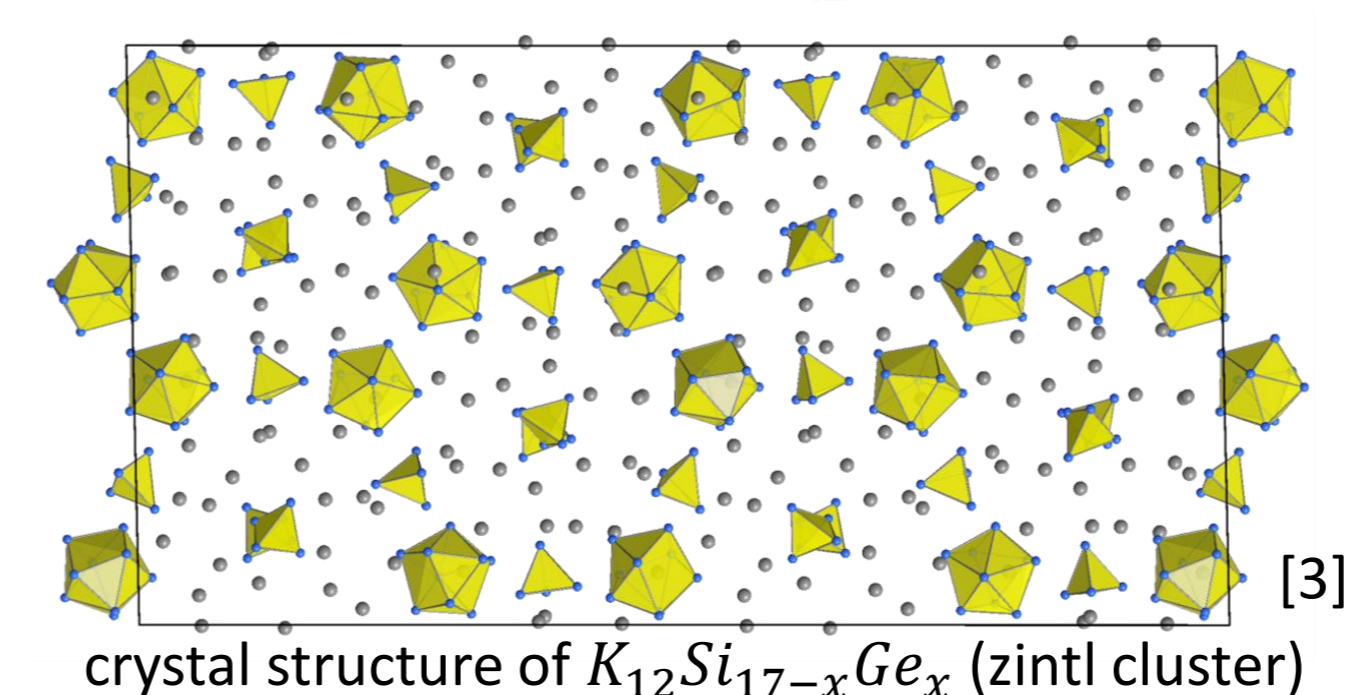
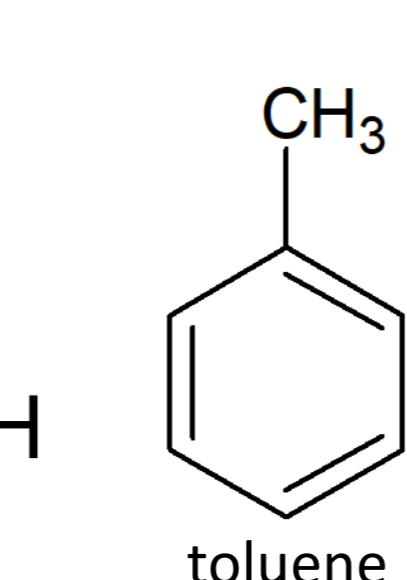
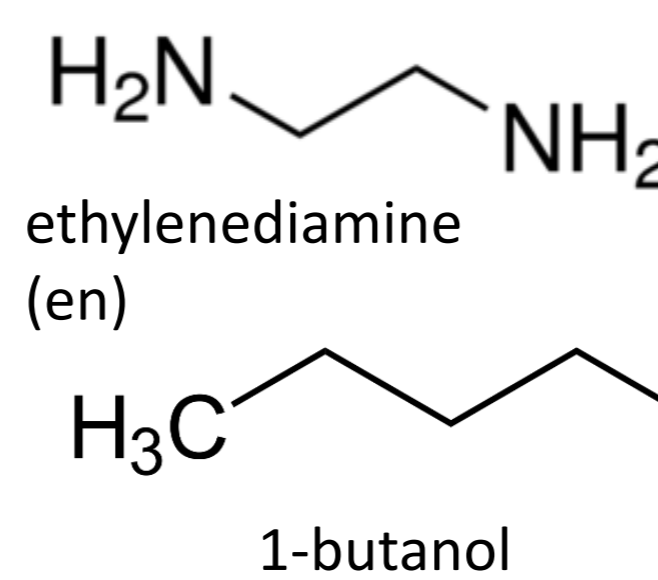
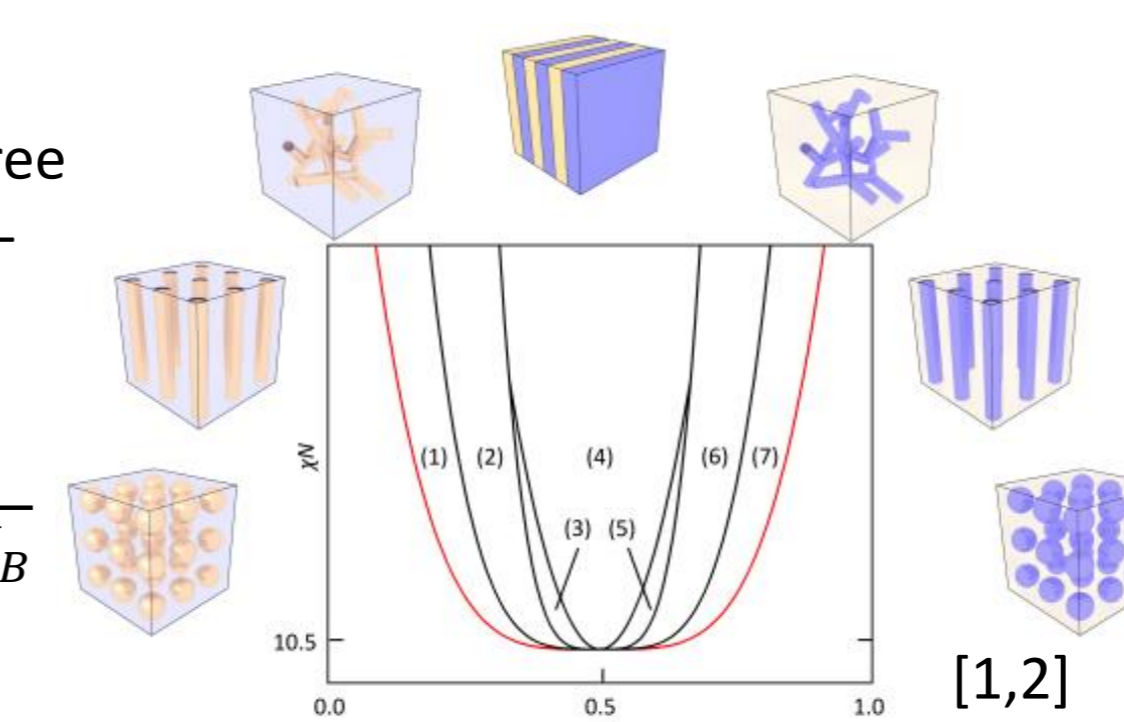
## materials



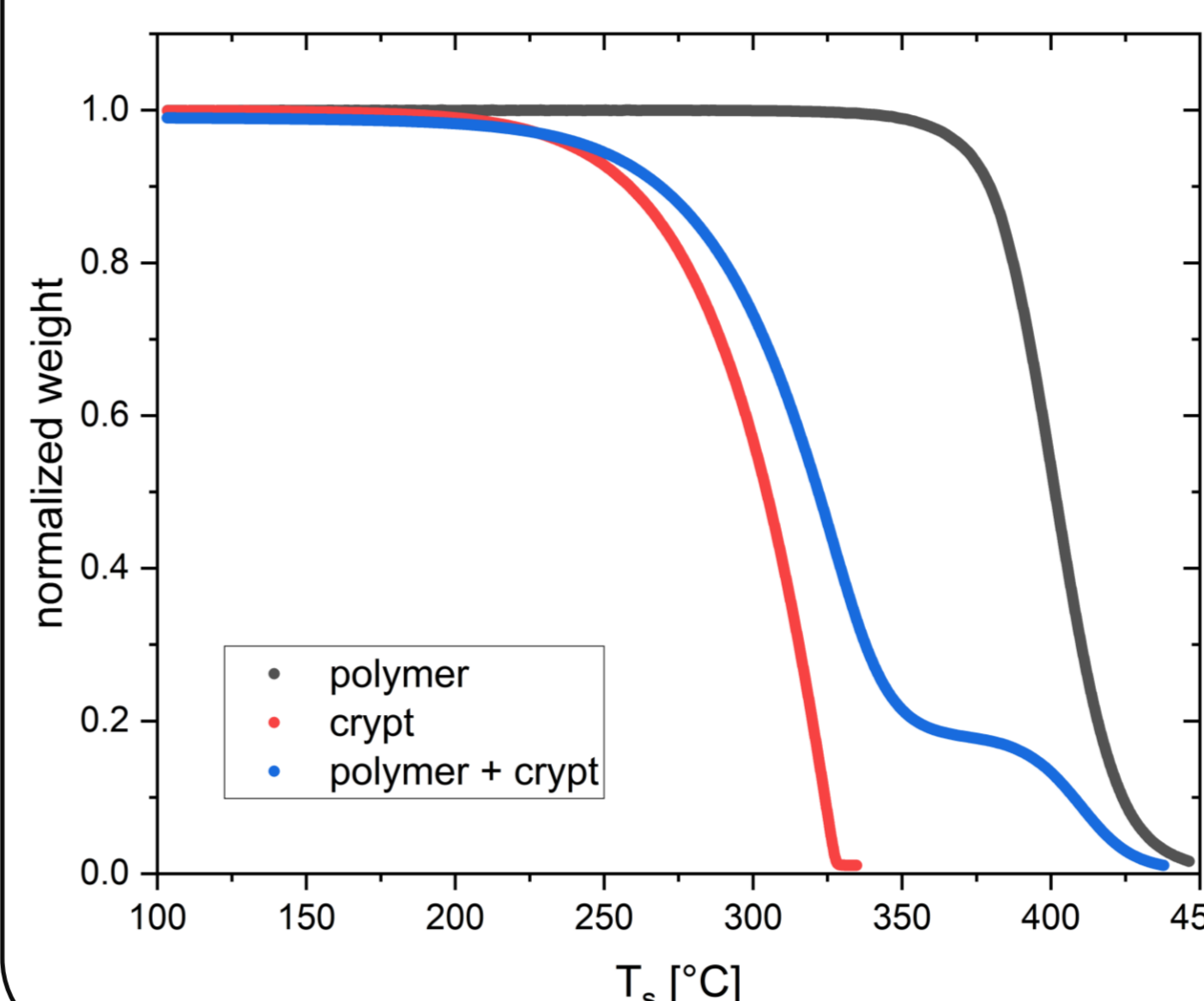
for a high degree of microphase-separation:

$$\chi^N \gg 10.5$$

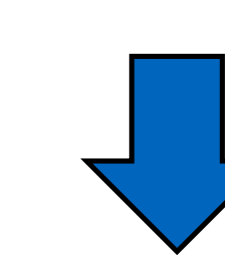
$$f_A = \frac{N_A}{N_A + N_B}$$



## thermogravimetric analysis (TGA)

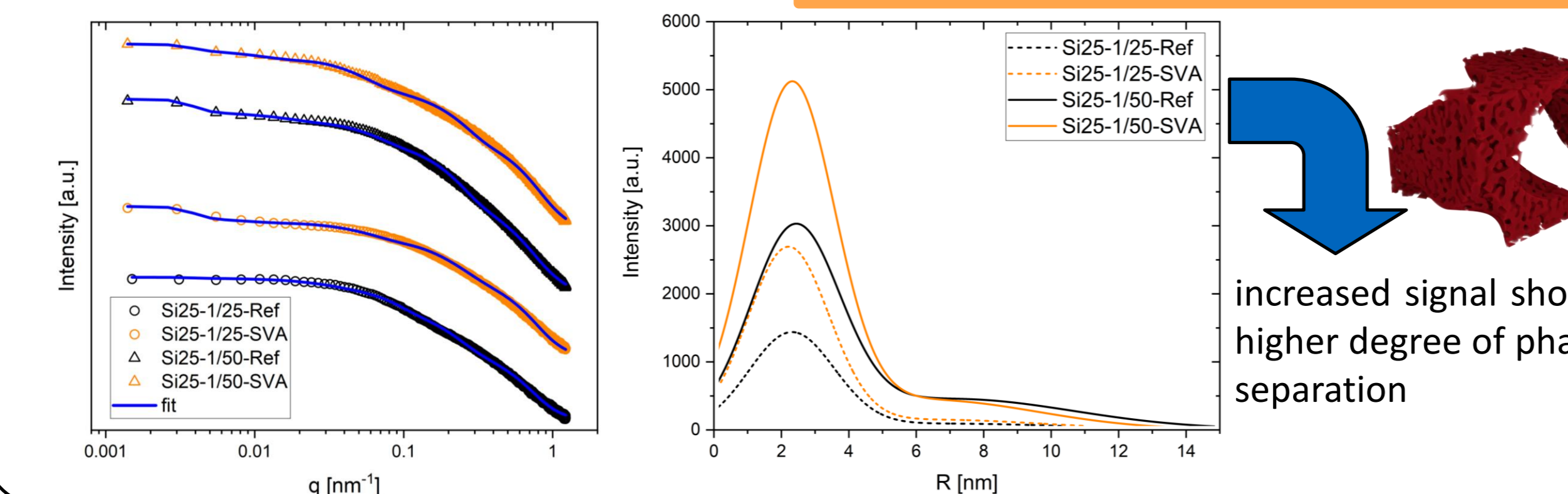
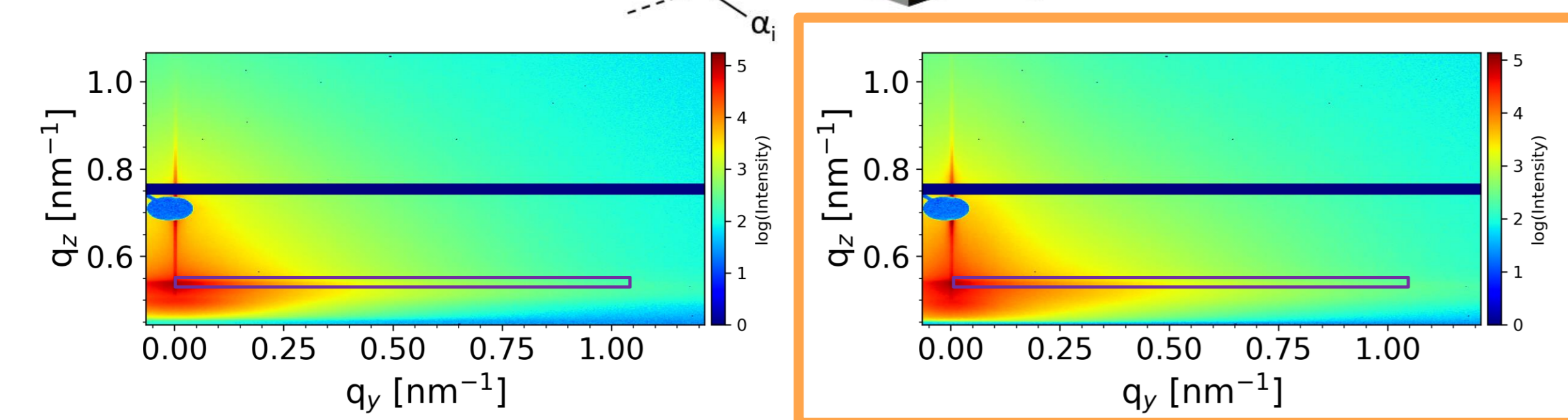
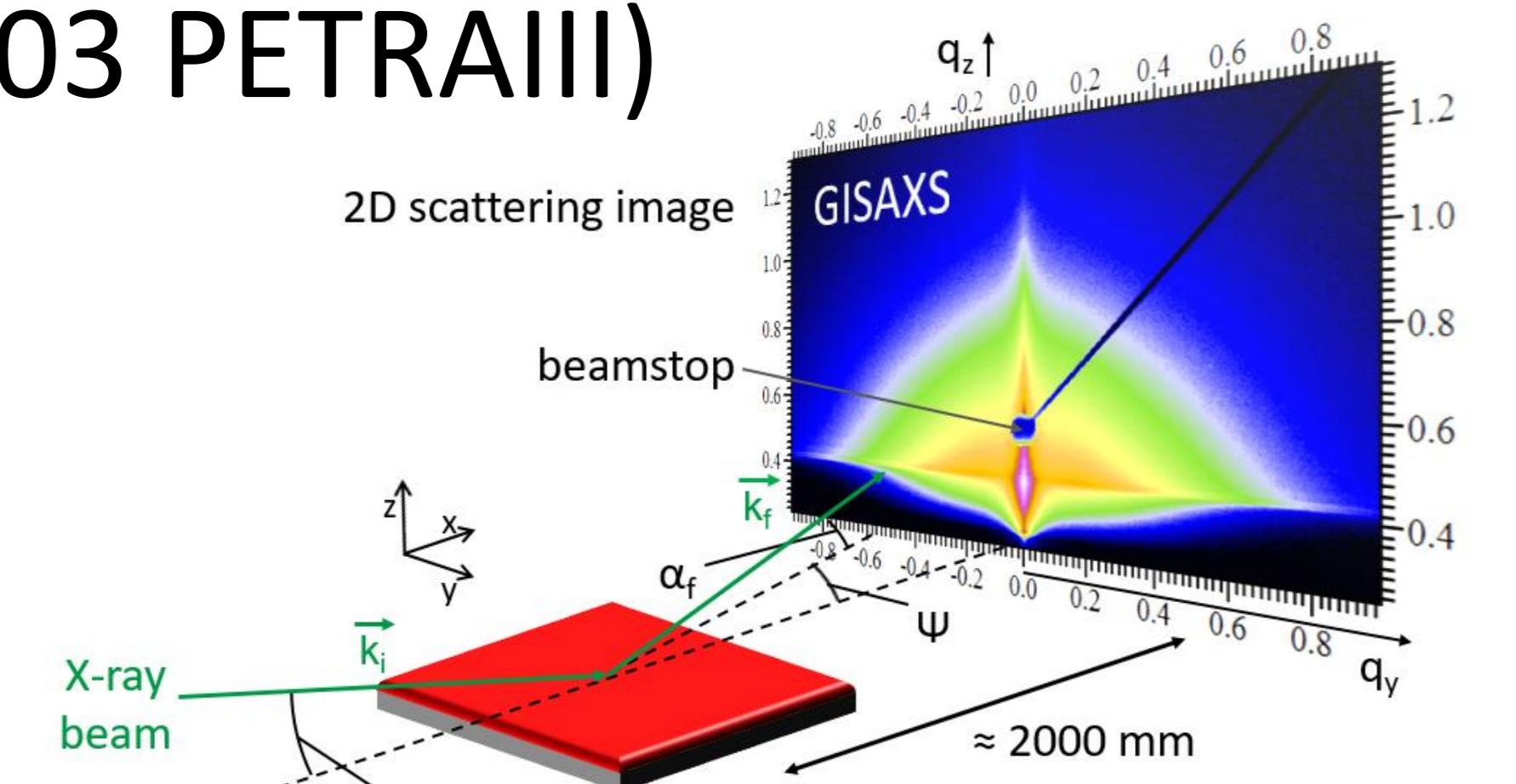


analysis shows the complete removal of the PS-b-PEO, 2,2,2-Crypt and a blend of both



organic residues in the thin film are washed out with DMSO and THF

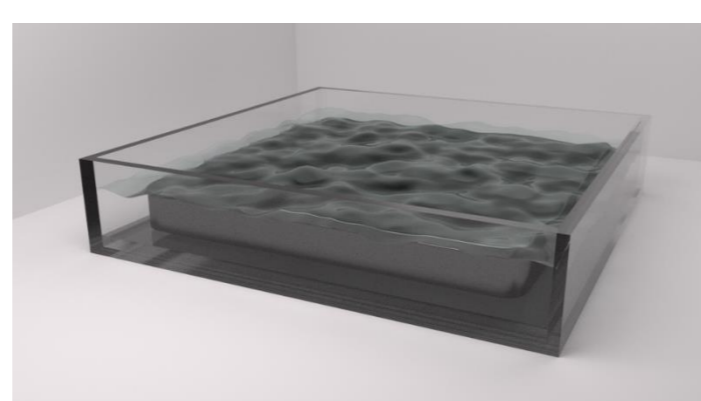
## GISAXS (P03 PETRAIII)



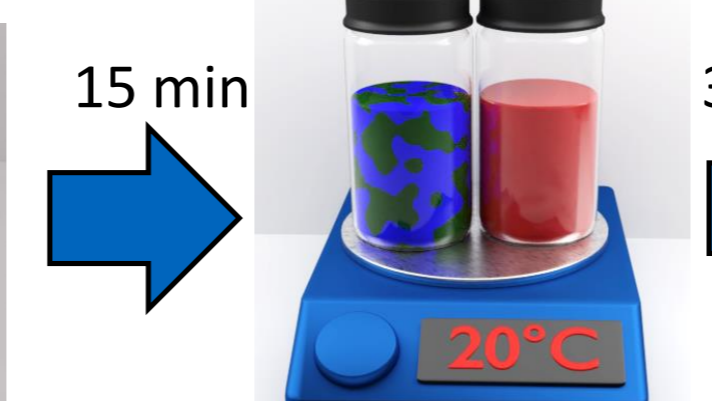
references:  
[1] Hohn et al. *Nanoscale*, 2019, 11, 2048-2055  
[2] Polymer Templated Nanostructures for Application in Hybrid Photovoltaics and Li Ion Batteries, Hohn N., 2019  
[3] Giebel M. A., Inverse Opal Structures of Ge, Presentation, 2017

acknowledgments: This work is based upon experiments at DESY. Special thanks to K. S. Wienhold, S. Yin, T. Tian, M. Gensch, M. Schwartzkopf, S. V. Roth

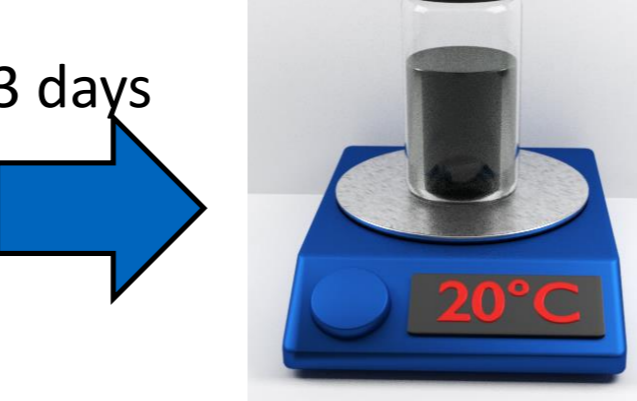
## sample preparation



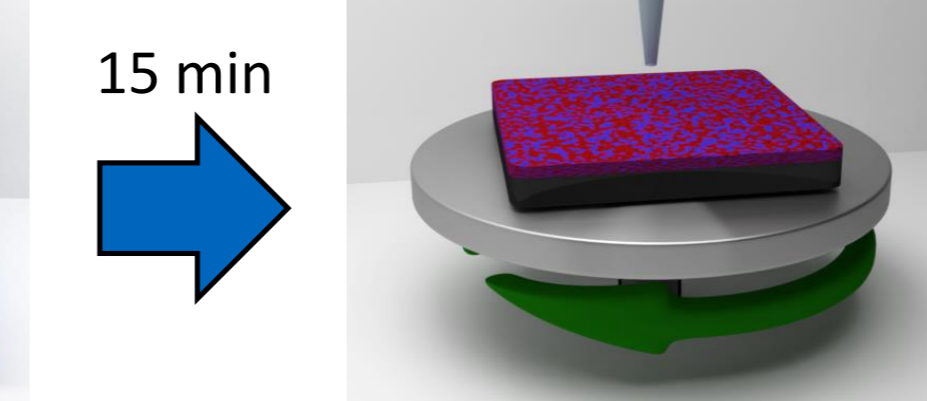
alkaline cleaning to remove inorganic residues on the surface



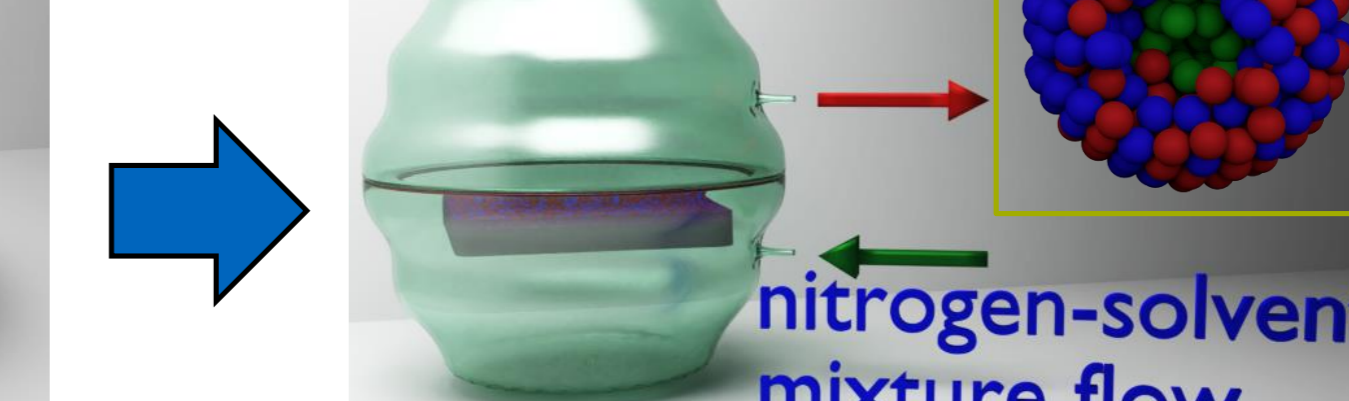
precursor and polymer dissolved in en under  $N_2$  atmosphere, 2,2,2-crypt to precursor



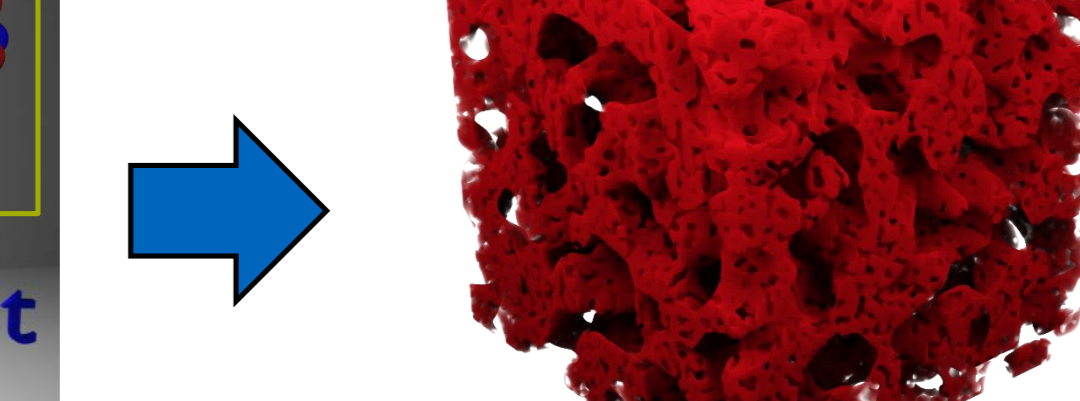
solution intermixing of precursor and polymer



spin coating 30 s, 2000 rpm

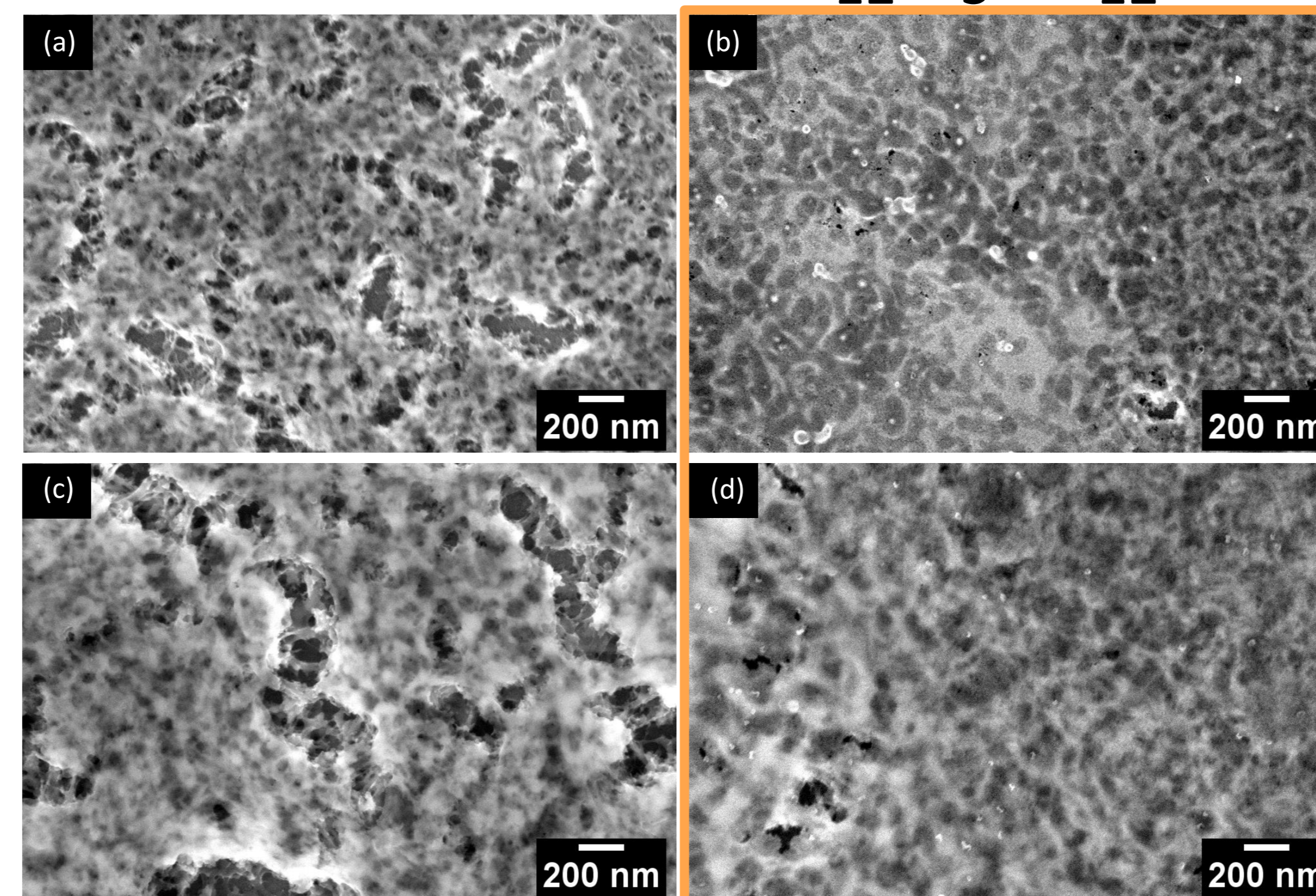


solvent vapor annealing with 1-butanol and toluene enhances micelle formation

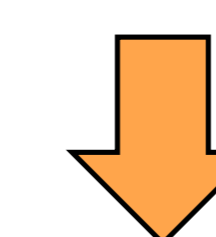


after calcination and immersion bath of DMSO and THF respectively a porous structure is left

## SiGe thin films with $K_{12}Si_5Ge_{12}$



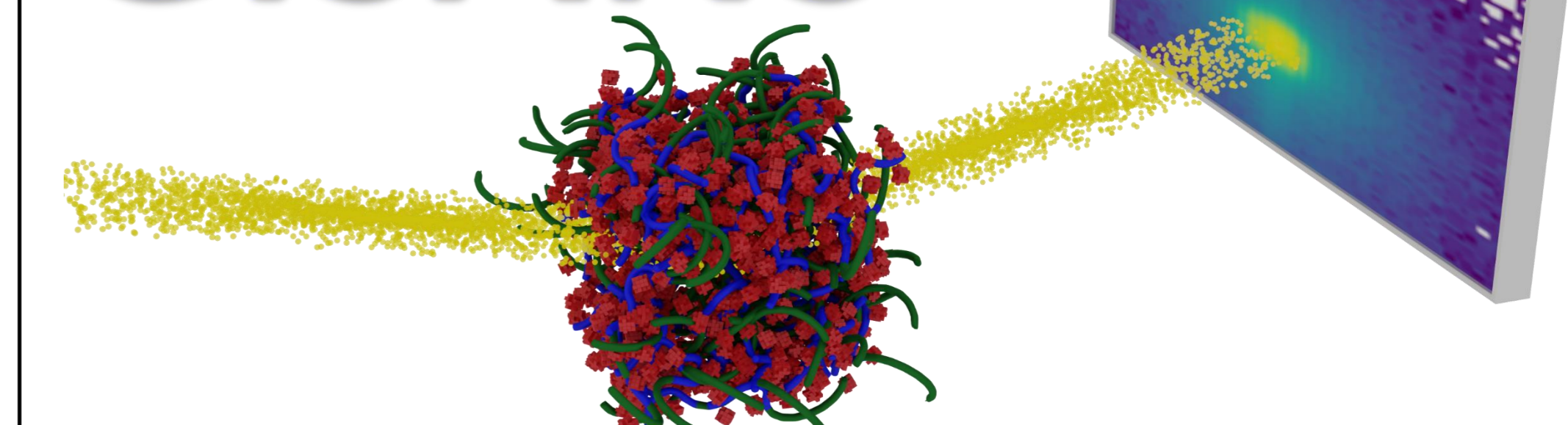
Scanning Electron Microscopy (SEM) images of films with a molar ratio of 1/25 [(a), (b)] and 1/50 [(c), (d)]. Substrates of (b) and (d) were additionally subjected to a solvent vapor annealing post-treatment (good and bad solvent treatment with toluene and 1-butanol).



structural change in the thin film visible  
reduced amount of cracks  
enhanced micro phase separation

## outlook

**GISAXS**



Get information about the structural arrangement of Si and Ge

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