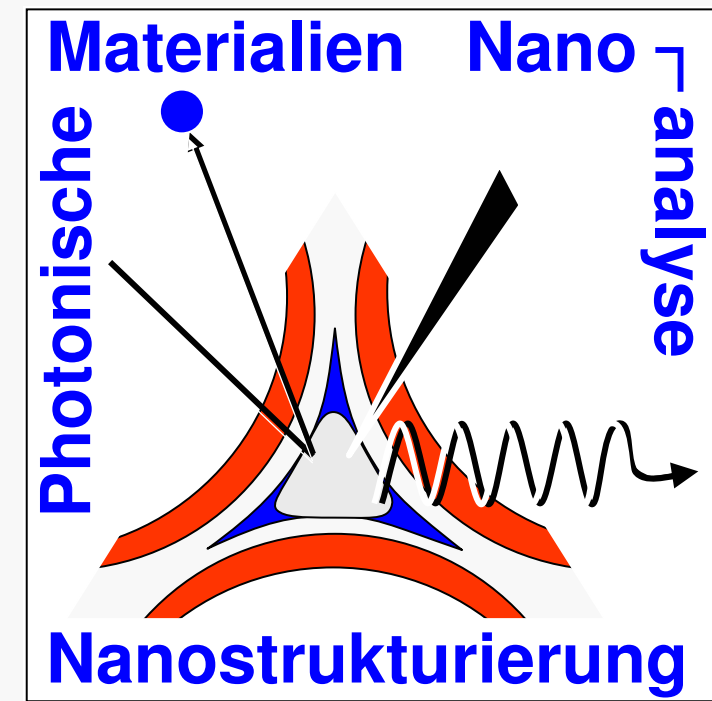


# Correlation between morphology and coordination of nanopores created by block copolymer lithography



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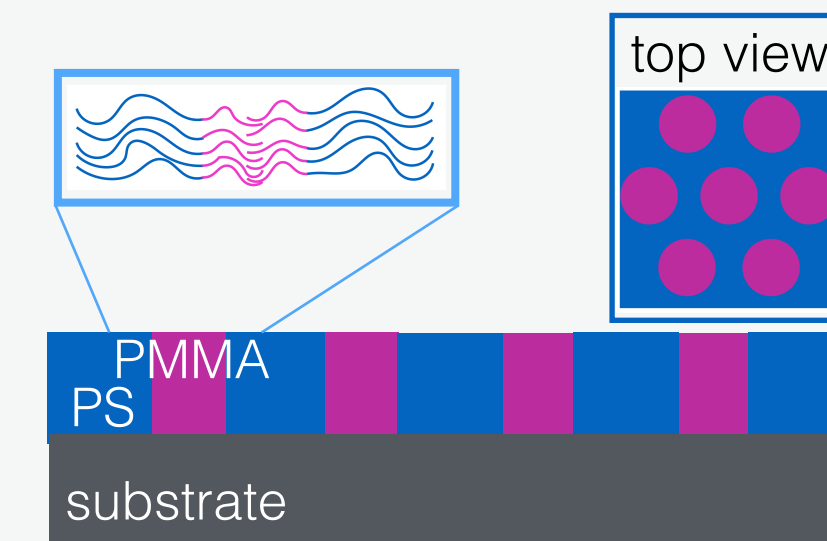


## Motivation

Block copolymer lithography allows for the large-area patterning of surfaces with self-assembled nanoscale features. The created nanostructured polymer films can be applied as masks in common lithography processing steps, such as lift-off and etching for pattern replication and transfer. We present an approach to improve the quality of pattern replication without loss of features, along with a precise tunability of feature sizes using a short mask treatment in an  $O_2/Ar$  plasma. We point out a correlation between nanopore position within the ordered arrays, expressed by its coordination number, the nanopore shape and the replication efficiency. Our experimental strategy to explain these correlations combines the indirect investigation of patterns replicated from the modified polymer masks and direct investigation of the mask top and bottom.

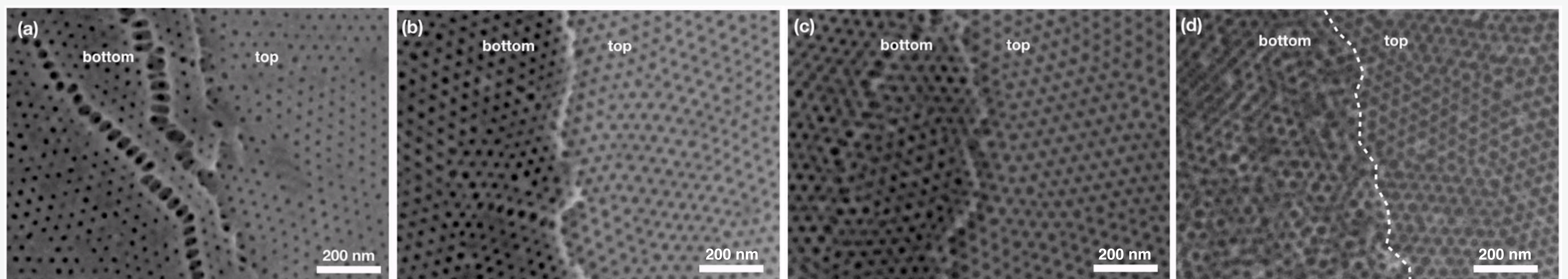
## Block copolymer (BCP) lithography

Polymer thin films are patterned employing microphase separation of BCPs into self-assembled hexagonally arranged PMMA cylinders in a PS matrix.



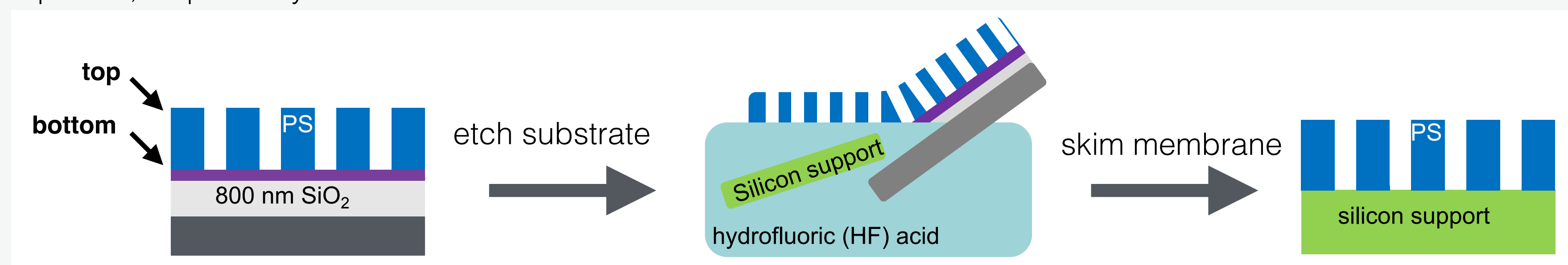
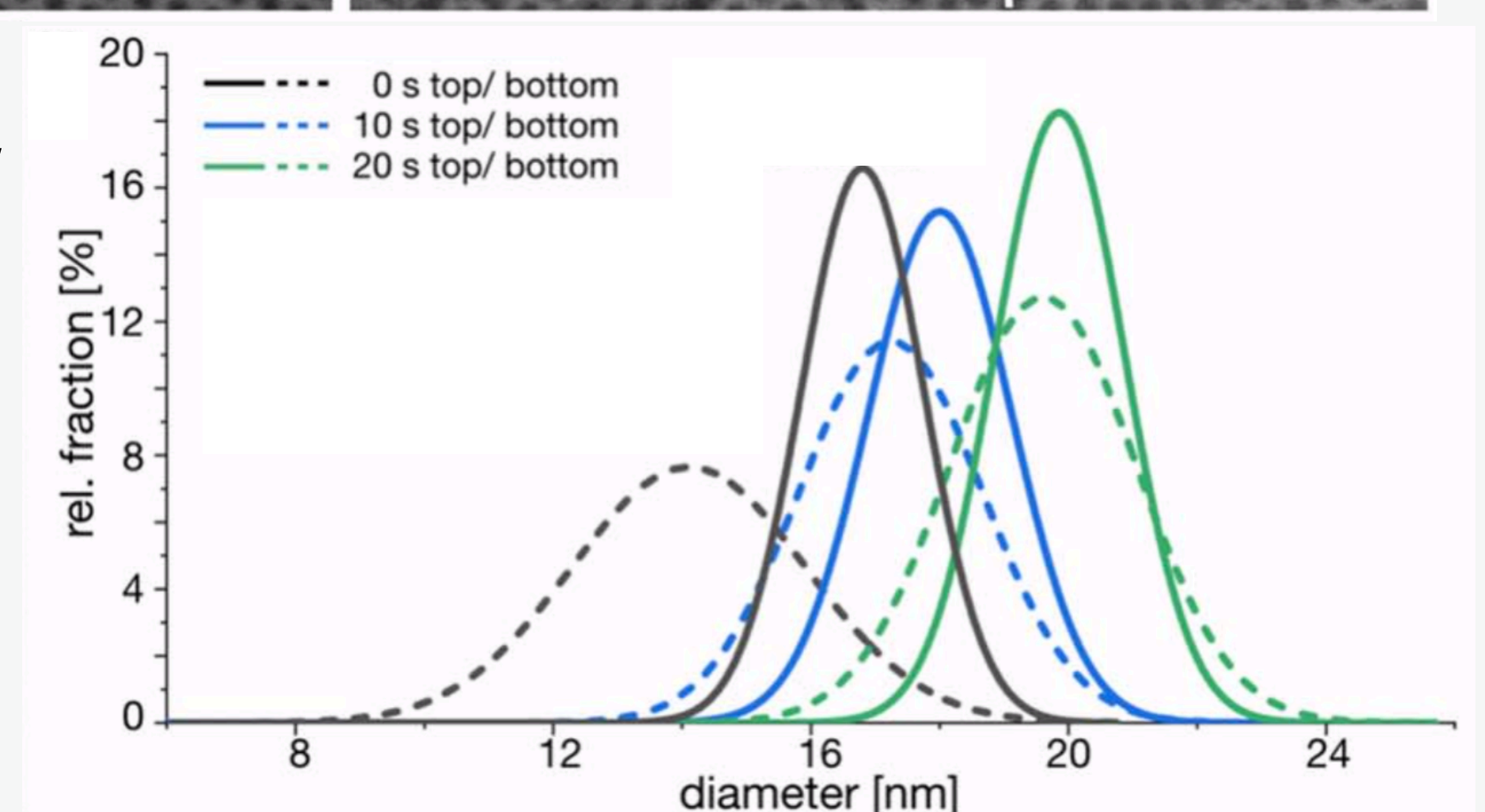
- Polymer: PS-*b*-PMMA, block ratio 70:30,  $M_n = 67$  kg/mol, PDI = 1.09 (Polymer Source Inc.)
- BCP film thickness 35 nm on RCP-functionalized  $SiO_2$
- Microphase separation induced by 24 h annealing at 180 °C at  $10^{-7}$  mbar
- 254 nm UV light exposure and acetic acid to remove PMMA

## Nanopores from top and bottom view

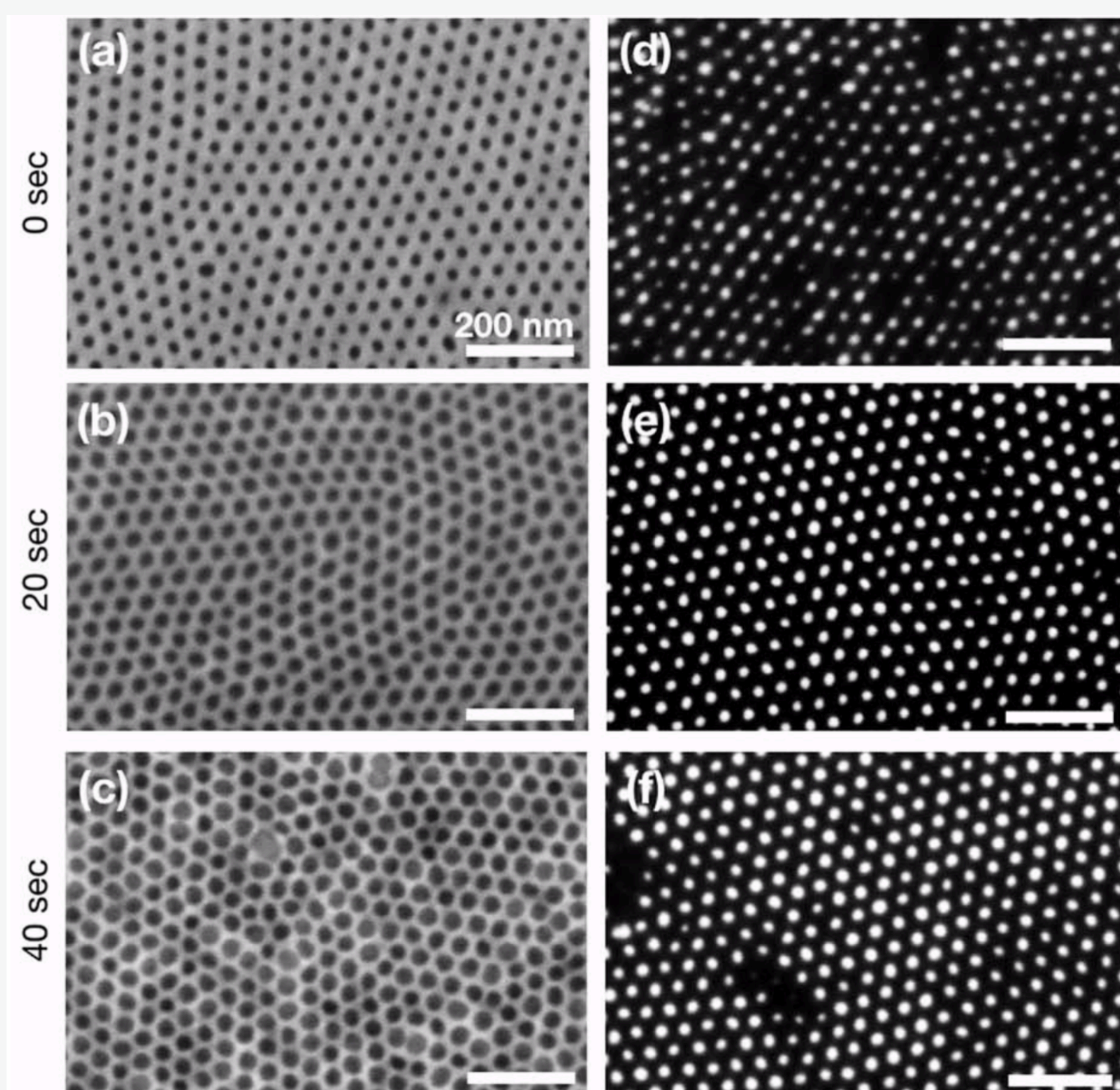


SEM images of free PS membrane after release from a  $SiO_2$  surface by substrate dissolution in  $HF_{aq}$  and membrane skimming with a silicon wafer (sketch below). Images show top and bottom surfaces of the folded membrane. In (a) the PS mask was not exposed to an  $O_2/Ar$  plasma, (b) – (d) show PS masks after 10, 20, 30 s of plasma exposure, respectively.

Size distributions of nanopore diameters at membrane top (solid lines) and bottom (dashed lines) for an untreated PS mask (black) and  $O_2/Ar$  plasma treated PS masks for 10 s (blue) and 20 s (green), respectively.

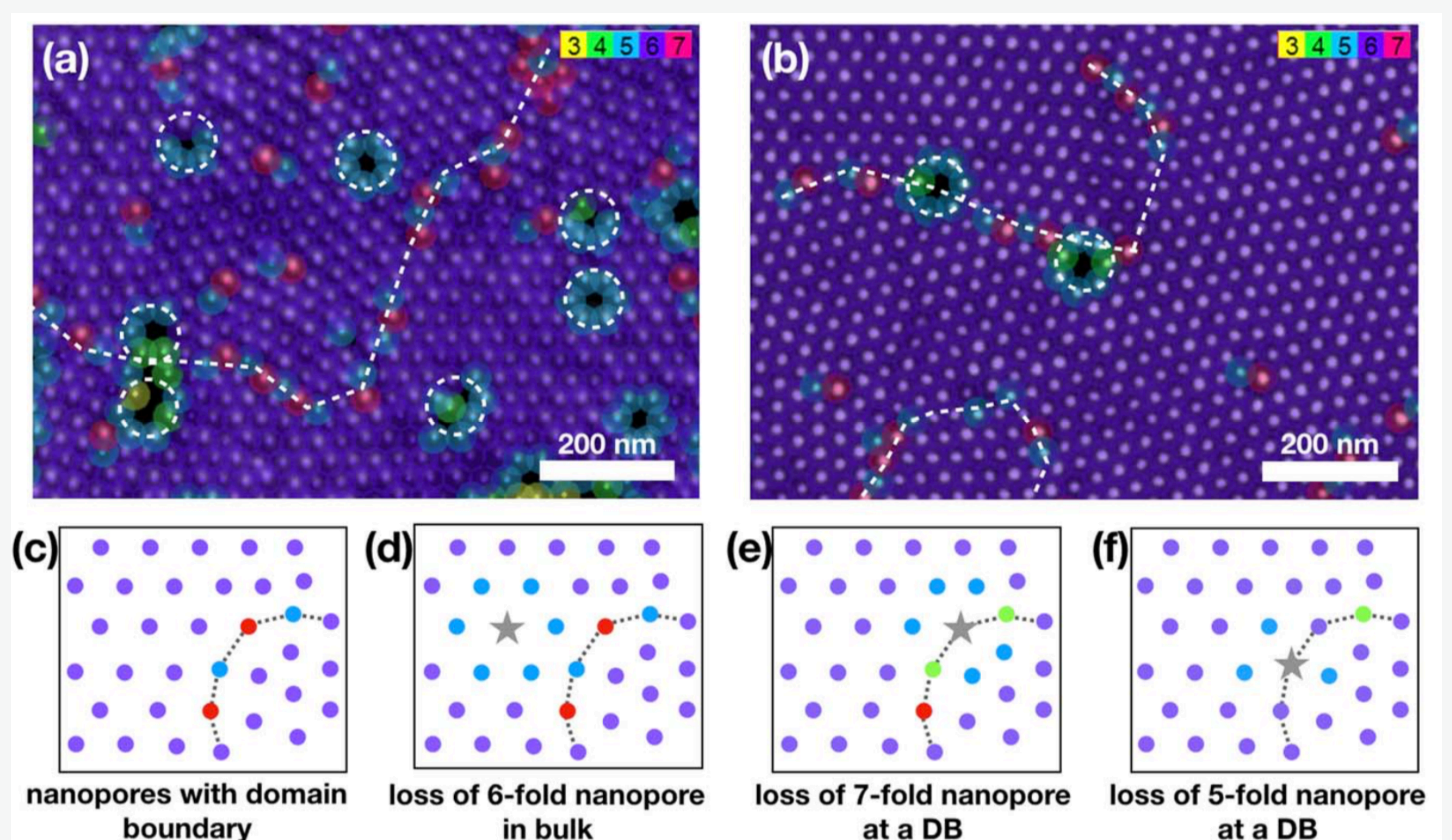


## Nanodot replication efficiency after lift-off



Top-view SEM images of PS masks created by BCP lithography and after  $O_2/Ar$  plasma exposure for 0 – 40 s (a) – (c). These PS films are used as lithography masks to form Au nanodots by Au e-beam evaporation (10 nm) and a lift-off process (d) – (f).

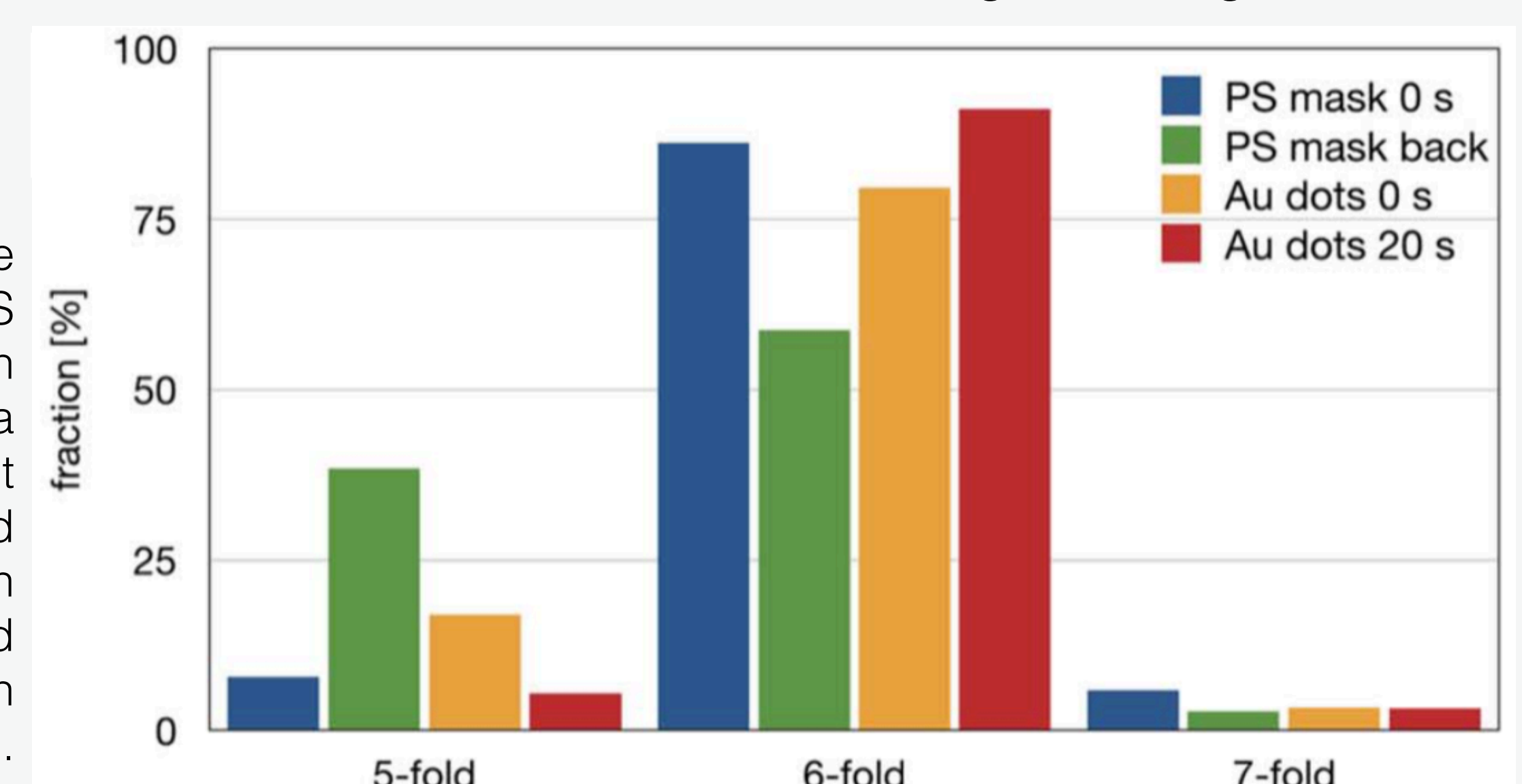
## Coordination numbers of nanopores at defects



Evaluation of the PS nanopore replication by analysis of Au nanodot coordination. (a) Au nanodots formed by lift-off from an untreated PS mask and (b) from a PS mask after 20 s plasma treatment. (a) and (b) display SEM images with an overlay of colour-coded coordination numbers. Orientation domain boundaries (DB) are marked by white dashed lines, point defects by circles. (c) – (f) Sketches of effect of the loss (grey star) of a nanopore during pattern replication on the local coordination of neighboring pores. The colour of dots indicates the coordination number of particles as in (a) and (b).

**Replica of plasma modified masks do not show point defects within domains any more, i.e. these pores get open. 7-fold coord. pores at domain boundaries remain closed leading to missing Au dots.**

Coordination of nanopores visible at the front and backside of PS membranes and Au dots (pattern transfer) of untreated and plasma treated masks. Plasma treatment leads to reduction of 5-fold coordinated nanofeatures (within domain) while the fraction of 7-fold coordinated features (at domain boundaries) is unchanged.



## See our recent publication:

Modification of block copolymer lithography masks by  $O_2/Ar$  plasma treatment: insights from lift-off experiments, nanopore etching and free membranes

K. Brassat et al., Nanotechnology 30, 225302 (2019)

