Wetting on Nano-Patterned Surfaces&

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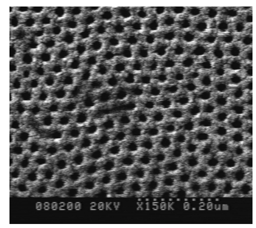
& (Experiments Carried out at NSLS, Beam Line X22B)

Research Summary

- We present here x-ray studies of wetting films on geometrically patterned silicon substrates.
- These "nano-patterned" substrates are characterized with AFM, SEM, &TEM which can be directly compared with X-ray results.
- We demonstrate the strong influence on the structure of wetting layer by the topography of the substrate; and the filling of the "nano-pores."



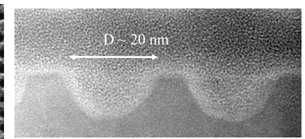


Figure1: SEM image of nano-pattern (Right), Cross-Sectional TEM image of nano-pattern (Left).

Research Motivation

- Fundamental physics associated with wetting on nano-scales is of wide current interest [1] .
- Wetting on nano-patterned surfaces is a crossover between wetting and capillary condensation.
- Depends on both molecular interactions and surface topology.
- Understanding of the phenomena is crucial for any nano-fluid related technology [2], eg., nano-inks, chemical and biological chips

Research Objective

- To study the effects of substrate topology on the evolution of a wetting film
- Gain better understanding of the interplay between surface tension and van der Waals.

Techniques

- Patterned silicon substrates provided by ***IBM*** [3] were characterized with microscopy and X-Ray techniques.
- X-Ray studies were done *in-situ* at the **NSLS, BNL.**
- Studied the evolution of wetting film of hydrocarbon vapor (methyl-cyclohexane, C_7H_{14}) on patterned silicon.
- Film thickness controlled to Angstrom precision by varying ΔT (temperature difference between liquid reservoir and substrate) with mK accuracy.
- X-Ray reflectivity and 2D diffraction were taken at each ΔT to measure thickness of film on flat part of substrate and pore filling.

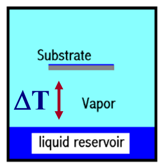
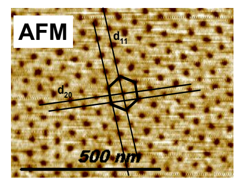
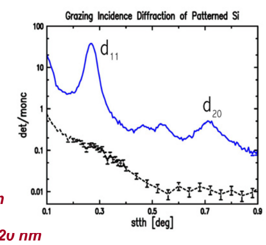


Fig 2: Wetting Cell





Nearly hexagonal nano-pattern with d-spacing: d_{11}=38 nm d_{20}~22 nm (Pore diameter) D ~2υ nm Inter-pore distances ~40 nm Domain size ~ 500 nm

Fig 3: AFM and X-Ray GID (Grazing Incidence Diffraction) of the *dry* sample

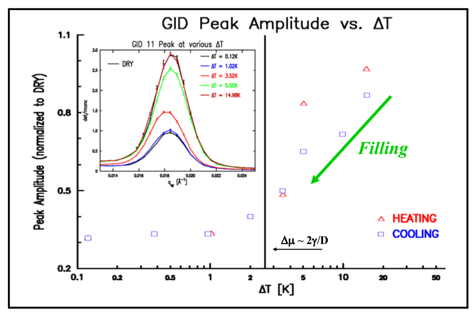


Fig 4: X-Ray GID showing filling of pores, reduction of peak intensity.

Selected Experimental Results

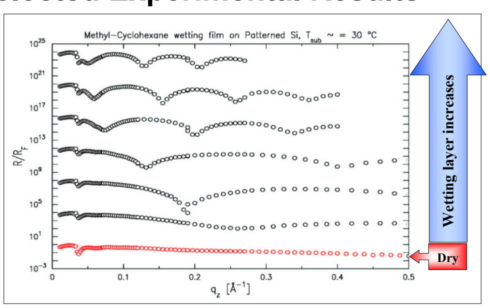


Fig 5: Reflectivities showing the progression of the wetting layer.

- Observed filling of nano-holes with liquid (GID).
- The evolution of the liquid layer development was traced up to thicknesses ~ 8 nm
- Determined that thickness is being "measured" from tops of pits.

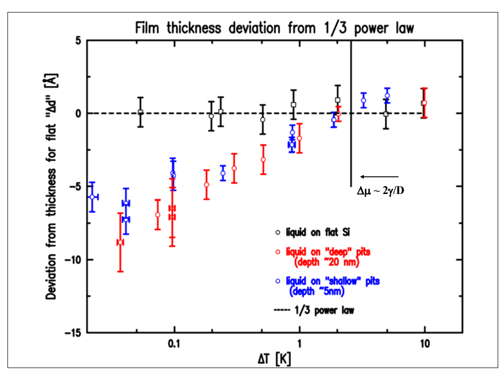


Fig 6: Deviation of the film thickness (above flat part of substrate)from the 1/3 power Law that is predicted for FLAT samples
Both "shallow" and "deep" pores show strong deviation.

Research Summary & Conclusions

- We show well known 1/3 power law for wetting on FLAT sample
- Wetting on pattern sample show strong deviation from simple 1/3 power law!
- Data shows qualitative agreement with theory [1].
- Next step – Chemical patterned samples

References:

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