The long memory of glass surfaces

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Abstract

What is the structure of a glass surface ? In the same spirit as the glass bulk structures resembles a snapshot of the liquid frozen at the temperature of glass transition Tg, the structure of a fire polished glass surface resembles a snapshot of the thermal fluctuations of the liquid. The sub-nanometric surface roughness scales as (kTg/gamma)ˆ(1/2) where k is the Boltzmann constant and gamma the interface tension. This results from the superposition of thermal capillary waves frozen at Tg. We discuss this scenario of freezing of capillary waves in the specific context of glass interfaces produced by fibre drawing. We present recent metrological atomic force microscopy and optical profilometry roughness measurements performed on the silica glass inner interfaces of hollow-core photonic band-gap fibers (HC-PBGFs) and hollow capillaries. The freezing of attenuated out-of-equilibrium capillary waves during the drawing process is shown to result in a reduced surface roughness. The roughness attenuation with respect to the expected thermodynamical limit is determined to vary with the drawing stress following a power law. A striking anisotropic character of the height correlation is observed: glass surfaces thus retain a structural record of the direction of the flow to which the liquid was submitted.

References:

B. Bresson et al, Anisotropic super-attenuation of capillary waves on driven glass interfaces, Phys. Rev. Lett. 119, 235501 (2017)

X. Buet et al. Nondestructive measurement of the roughness of the inner surface of hollow core-photonic bandgap fibers, Opt. Letters 41, 5086 (2016)

Keywords: surface, interface, roughness, drawing, capillary waves

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