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Time-domain Brillouin scattering for evaluation of materials interface inclination

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Time-domain Brillouin scattering (TDBS) technique uses ultrafast laser pulses to generate and monitor coherent acoustic pulses (CAPs) propagating through transparent materials^[1,2]. The probe light scattered by propagating CAPs interferes with the probe light reflected on stationary interfaces, which leads to a signal with Brillouin oscillations (BOs). If a CAP is reflected from and transmitted through a material interface, the TDBS signal can feature an echo. BOs and echoes can be used for interface profilometry^[3-5] by processing signals from a sample raster scan with co-focused laser beams. We have recently developed a theory for non-collinear sound-light interaction, which allows interface profilometry without the drawback of lateral averaging, by fitting each signal to get an estimation of the local inclination.

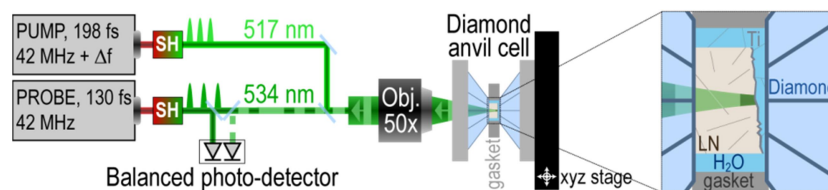


Figure 1: TDBS experimental scheme to evaluate LN single-crystal degradation.

TDBS is here applied to monitor the degradation of a single crystal of lithium niobate (LN) upon non-hydrostatic compression. The plate-like sample was prepared from a 20 μm -thick single-crystal LN disk (x -cut) with the maximum surface inclination of 0.6° at sub- μm scale, averaged down to 0.02° at μm -scale. The crystal, one-side-coated with a 70 nm-thick Ti film, was then loaded in a diamond anvil cell with water and compressed to 10.4 GPa, where water crystallises to cubic ice-VII. The 3D TDBS imaging reveals modifications of the plate thickness profile, initially with plane-parallel surfaces, and of one face profile, caused by non-hydrostatic compression in solid ice. The echo arrival times reveal at least two orders increase in the inclination angles. Using our analytical theory, the inclination angle of the Ti-coated LN surface relative to the diamond anvil surface has been estimated. The local inclination can be revealed either through BOs modifications or CAP echoes arrivals, or both. The zoology of the here-collected signals is very rich and will necessitate further theoretical investigations, accounting for materials optical and/or elastic anisotropy, for example. Performing TDBS experiments by analyzing probe polarization would also complement the analysis.

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Keywords

Time-domain Brillouin scattering, non-collinear beams, inclined interface evaluation

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