



**HAL**  
open science

## **Time-domain Brillouin scattering for evaluation of materials interface inclination**

Sathyan Sandeep, Nicolas Pajusco, Samuel Raetz, Nikolay Chigarev, Théo Thréard, Mathieu E Edely, Alain Bulou, Andreas Zerr, Vitalyi Gusev

► **To cite this version:**

Sathyan Sandeep, Nicolas Pajusco, Samuel Raetz, Nikolay Chigarev, Théo Thréard, et al.. Time-domain Brillouin scattering for evaluation of materials interface inclination. 2023 International Congress on Ultrasonics (ICU 2023), Xiuming Wang; et al., Sep 2023, Beijin, China. hal-04750938

**HAL Id: hal-04750938**

**<https://hal.science/hal-04750938v1>**

Submitted on 24 Oct 2024

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Public Domain

# Time-domain Brillouin scattering for evaluation of materials interface inclination

Sathyan Sandeep<sup>1</sup>, Nicolas Pajusco<sup>1</sup>, Samuel Raetz<sup>1</sup>, Nikolay Chigarev<sup>1</sup>, Théo Thréard<sup>1</sup>,  
Mathieu Edely<sup>2</sup>, Alain Bulou<sup>2</sup>, Andreas Zerr<sup>3</sup>, Vitalyi E. Gusev<sup>1</sup>

<sup>1</sup>Laboratoire d'Acoustique de l'Université du Mans (LAUM), UMR 6613, Institut d'Acoustique – Graduate School (IA-GS), CNRS, Le Mans Université, France.

<sup>2</sup>Institut des Molécules et Matériaux du Mans, UMR 6283, CNRS, Le Mans Université, France.

<sup>3</sup>Laboratoire de Sciences des Procédés et des Matériaux (LSPM-CNRS UPR-3407), Université Sorbonne Paris Nord (USPN), Villetaneuse, France.

Time-domain Brillouin scattering (TDBS) technique uses ultrafast laser pulses to generate and monitor coherent acoustic pulses (CAPs) propagating through transparent materials<sup>[1,2]</sup>. 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<sup>[3-5]</sup> 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.

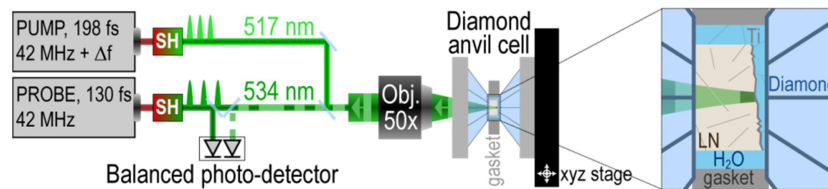


Figure 1: TDBS experimental scheme to evaluate LN single-crystal degradation.

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.

This research is supported by the Agence Nationale de la Recherche (ANR-18-CE42-I2T2M).

## Keywords

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

## References

- <sup>[1]</sup> H. T. Grahn, et al., *IEEE J. Quantum. Electron.*, 25 **1989**, 2562-2569.
- <sup>[2]</sup> V. E Gusev, P. Ruello, *Appl. Phys. Rev.*, 5 **2018**, 031101.
- <sup>[3]</sup> M. Khafizov, et al., *Acta Mater.*, 112 **2016**, 209-215.
- <sup>[4]</sup> T. Thréard, et al., *Photoacoustics*, 23 **2021**, 100286.
- <sup>[5]</sup> S. La Cavera III, et al., *Light Sci. Appl.*, 10 **2021**, 91.