



HAL
open science

4D X-ray microtomography of vibrating multiscale structures

Antoine Klos, Lucie Bailly, Sabine Rolland Du Roscoat, Laurent Orgéas, Nathalie Henrich Bernardoni, Ludovic Broche, Andrew King, Nicolas Lenoir

► **To cite this version:**

Antoine Klos, Lucie Bailly, Sabine Rolland Du Roscoat, Laurent Orgéas, Nathalie Henrich Bernardoni, et al.. 4D X-ray microtomography of vibrating multiscale structures. ICTMS 2022 - 5th International Conference on Tomography of Materials and Structures, Jun 2022, Grenoble, France. pp.6. <hal-03851516>

HAL Id: hal-03851516

<https://hal.science/hal-03851516v1>

Submitted on 14 Nov 2022

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.



HAL Authorization

4D X-RAY MICROTOMOGRAPHY OF VIBRATING MULTISCALE STRUCTURES

A. KLOS^{1,2,*}, L. BAILLY¹, S. ROLLAND DU ROSCOAT¹, L. ORGEAS¹, N. HENRICH BERNARDONI²,
L. BROCHE³, A. KING⁴, N. LENOIR¹

¹ Univ. Grenoble Alpes, CNRS, Grenoble INP, 3SR, 38000 Grenoble, France

² Univ. Grenoble Alpes, CNRS, Grenoble INP, GIPSA-lab, 38000 Grenoble, France

³ ID19 beamline, ESRF - European Synchrotron Radiation Facility, CS 40220, 38043 Grenoble, France

⁴ PSICHE beamline, Synchrotron SOLEIL, F-91190 Saint-Aubin, France

*Speaker: antoine.klos@3sr-grenoble.fr

1. Introduction

Some pioneer studies have been proposed to image the 3D structural evolutions of biological oscillators using synchrotron X-ray microtomography, allowing to quantify low-frequency motions below 5 Hz [1]. More recently, 3D images of fly muscles during wingbeat at 145 Hz were obtained [2]. However, in order to tackle some current scientific issues in voice biomechanics [3], breakthroughs are still expected in 4D X-ray acquisition and reconstruction procedures to both improve the spatio-temporal resolution and study the vibration of multiscale structures at higher frequencies. Thus, the main objective of this study is to characterize the 4D strain-induced microstructure evolutions of soft fiber-reinforced tissue-like materials subjected to mechanical vibratory loadings up to 400 Hz, as encountered in human phonation.

2. Materials and Methods

Samples and vibration tests – Slender composites strips (10x2x2mm³) made of glass fibers/beads (typical length 50 μm and volume fraction 5 %) embedded in a soft silicone matrix were mounted in a specifically designed vibro-mechanical tensile set-up. They were subjected to sinusoidal oscillations (from 50 to 400 Hz) around different tensile pre-stretches varied from 0 to 0.9 (Fig. 1a).

Imaging process – Samples were imaged with a voxel size of 2³ and 10³ μm^3 at the SOLEIL-Psiché beamline [4]. Scanning and reconstruction parameters (frame rate, angular repartition of projections per cyclic phase...) were optimized to minimize blurring artifacts obtained when imaging a moving structure. To do so, prior numerical simulations were conducted on ideal vibrating (fibrous/spherical) particles of known 3D geometry. Then, 4D X-ray images with retrospectively gated projections were performed using optimal parameters.

3. Results and Conclusion

Typical 4D images are reported in Fig. 1b, illustrating the case of a fibrous composite vibrating at 100 Hz around a tensile pre-stretch of 0.5. The optimal vibratory amplitude to apply (resp. frame rate) was found around 60 μm (resp. 1033 Hz).

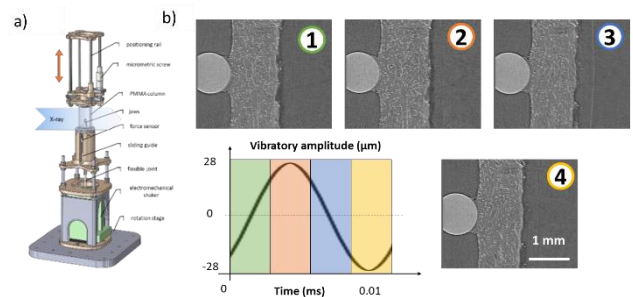


Figure 1. (a) Scheme of the custom vibrating tensile set-up; (b) 4D X-ray tomographic images of a fibrous sample (SOLEIL, mid-vertical slices, 10 $\mu\text{m}/\text{px}$, selection of 4 phases out of 30 of the periodic cycle).

For each case, the optimization procedure allowed a successful reconstruction of 30 phases of the periodic cycle, with promising image quality for quantitative kinematical field analyses (DVC) and particle tracking methods at the fiber scale. The relevance of the methodology will be discussed by comparing the results derived from several (un)optimized scanning and reconstruction procedures.

4. Acknowledgements

This work was supported by the SOLEIL proposal 20210430 and the ANR MicroVoice (ANR-17-CE19-0015-01).

5. References

- [1] G. Lovrić, [10.3929/ethz-a-010587266](https://doi.org/10.3929/ethz-a-010587266)
- [2] S.M. Walker *et al.*, [10.1371/journal.pbio.1001823](https://doi.org/10.1371/journal.pbio.1001823)
- [3] L. Bailly *et al.*, [10.1038/s41598-018-31849-w](https://doi.org/10.1038/s41598-018-31849-w)
- [4] A. King *et al.*, [10.1063/1.4961365](https://doi.org/10.1063/1.4961365)