PRESS RELEASE

Successful Dynamics Measurement Using Nanosecond Time-resolved X-ray Imaging

--The Beginning of High-Speed Time-resolved Clinical X-ray Imaging Technique—

Presentation Points

◆Using an ultra-compact X-ray source, we achieved high-speed continuous imaging at 900 nanoseconds per image (1 nanosecond is one billionth of a second) and successfully detected the micro-dynamics of polymers within samples through machine learning analysis. We named this measurement method Transmitted X-ray Blinking (TXB).

◆Using a laboratory-scale X-ray source, we have captured, for the first time globally, differences in the structural dynamics of substances at the nanosecond scale – differences that cannot be identified by conventional X-ray (transmitted X-ray) imaging.

◆ Going forward, this technique is anticipated to enable three-dimensional dynamic measurements for all material systems undergoing time-resolved changes and to find application as a clinical testing method.

Abstract

A research group led by Professor Yuji C. Sasaki of the Department of Materials Science, Graduate School of Frontier Sciences, The University of Tokyo, and Lecturer Masahiro Kuramochi of the Department of Materials Science and Engineering, Graduate School of Applied Science and Engineering, Ibaraki University (also Lecturer in the Department of Materials Science, Graduate School of Frontier Sciences, The University of Tokyo) has developed a new dynamic measurement technique called "Transmitted X-ray Blinking" to capture micromolecular motion within polymer resins using time-resolved X-ray v imaging technique. By analyzing slight time-resolved fluctuations in X-ray intensity, this technique successfully detected differences in micromolecular dynamics that were indistinguishable using conventional radiographic (transmission X-ray) imaging (Figure 1).

The research group created an ultra-compact X-ray source and increased the X-ray brightness by shortening the distance between the X-ray source, sample position, and detector to within a few millimeters, enabling them to capture a single image in the extremely short time of 900 nanoseconds. Using this method, machine learning was newly incorporated into X-ray videos of two polymer resins (crystalline polymer resin polyether ether ketone: PEEK and amorphous polymer resin polyetherimide: PEI) that could not be distinguished using conventional X-ray technology. The analysis results showed that the two could be distinguished with an accuracy of over 90%. This result is the world's first attempt to incorporate a time axis into X-ray transmission image information, and in addition to material evaluation, it is expected to be used in clinical testing, where exposure times are short and radiation exposure is reduced. Further development is expected to enable three-dimensional dynamic measurement similar to that of computed tomography (CT). The laboratory TXB technique may enable the identification of cancer cells with slightly different viscosities and amyloid fibrils, which are attracting attention in dementia, without labeling.

Our Manuscript

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Sub-microsecond Molecular Motion Analysis of Polymer Resins via Transmitted X-ray Blinking

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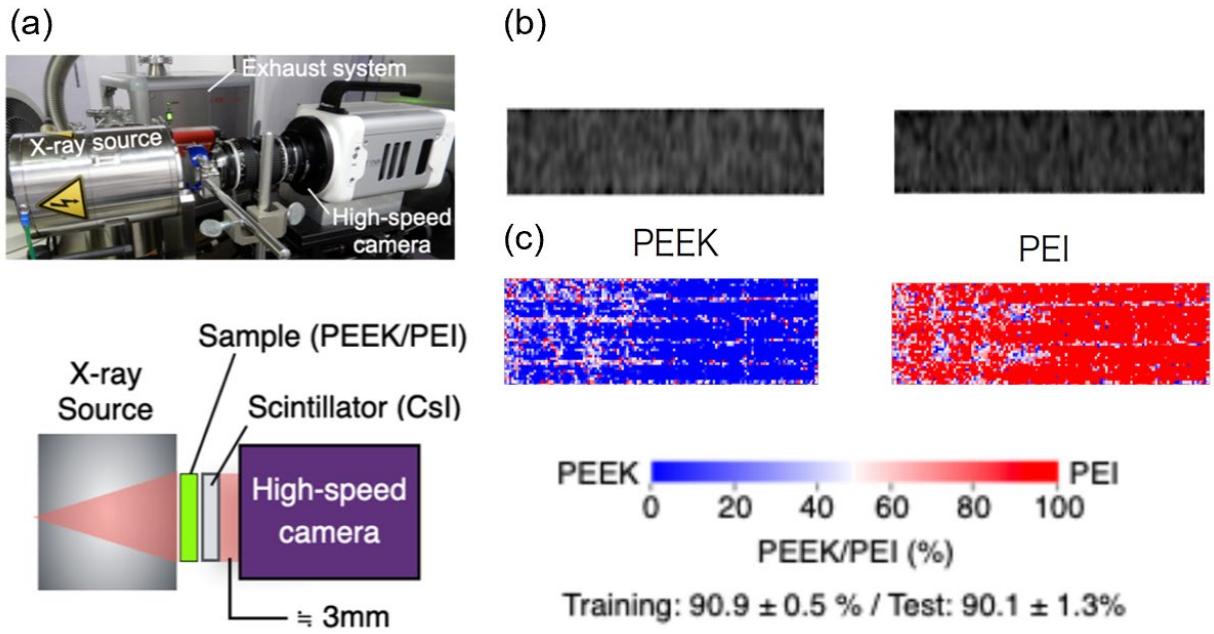

Figure 1: (a) The Transmitted X-ray Blinking (TXB) apparatus developed in this study. The upper panel (b) shows the transmitted X-ray image, while the lower panel (c) displays the kinetic image generated by machine learning. This enables clear differentiation of micro-molecular dynamics that were difficult to distinguish in the upper panel (b).