TOYOTA CENTRAL R&D LABS NEWS

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Toyota Central R&D Labs., Inc.

Development of World's First Measurement Technique for 3D Stress Distribution inside Crystalline Material Grains

Toyota Central Research and Development Laboratories, Inc. (President, Dr. Noboru Kikuchi), a member of the Toyota group of companies, has successfully developed the world's first non-destructive technique capable of measuring the 3-dimentional distribution of stresses inside crystalline material grains.

Assuring the reliability of smaller, lighter, and more functional components is becoming an increasingly important issue. However, although measuring the microscopic distribution of local stresses inside crystalline material grains is a necessary part of improving reliability, no existing techniques were capable of accomplishing this non-destructively.

Therefore, to measure these local stresses, we developed a scanning 3-dimensional X-ray diffraction (3D-XRD) microscopy methodology* that combines a highly transmissive synchrotron X-ray** beam with techniques to extract the internal information of single grains (Fig. 1). We succeeded in non-destructively measuring the 3-dimensional distribution of stresses inside the grains of bulk polycrystalline steel under tensile deformation using a 1 micron X-ray beam (Fig. 2). These measurement results demonstrated for the first time in the world that such local stresses deviate greatly from the average stresses measured by conventional methods.

The developed technique will enable the extraction of weak points inside components and the identification of their degradation and deformation mechanisms. This should contribute to the development of even more reliable components and manufacturing processes for vehicles, home appliances, and information/communications equipment.

Since this technique allows the non-destructive measurement of stresses from the microscopic to the macroscopic scale, it should also facilitate the development of multi-scale material modeling that expresses both fractures and deformation, as well of simulations that predict the life of components.

The results will be published in Science on December 20, 2019 (Eastern Standard Time) by the American Association for the Advancement of Science (AAAS).

Publication Information
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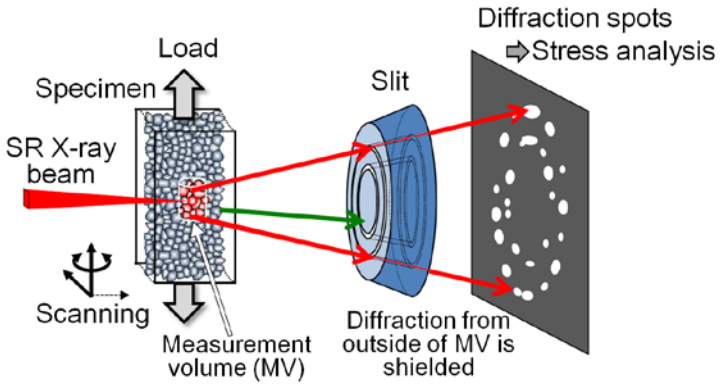

Fig. 1 Schematic of internal stress measurement by scanning 3D-XRD microscopy.

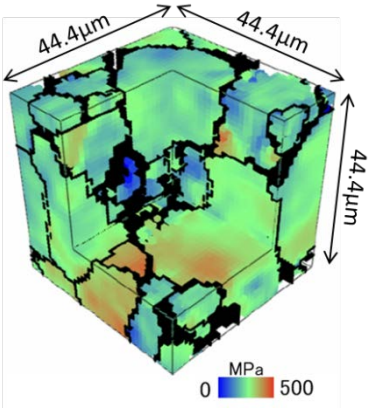

Fig. 2 Measured 3-dimensional distribution of local stresses in grains of steel.

* This technique was developed at the Toyota beamline at SPring-8, a large synchrotron radiation facility in Japan.
** Ultra-brilliant electro-magnetic wave with large permeability.

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