MS067.O03

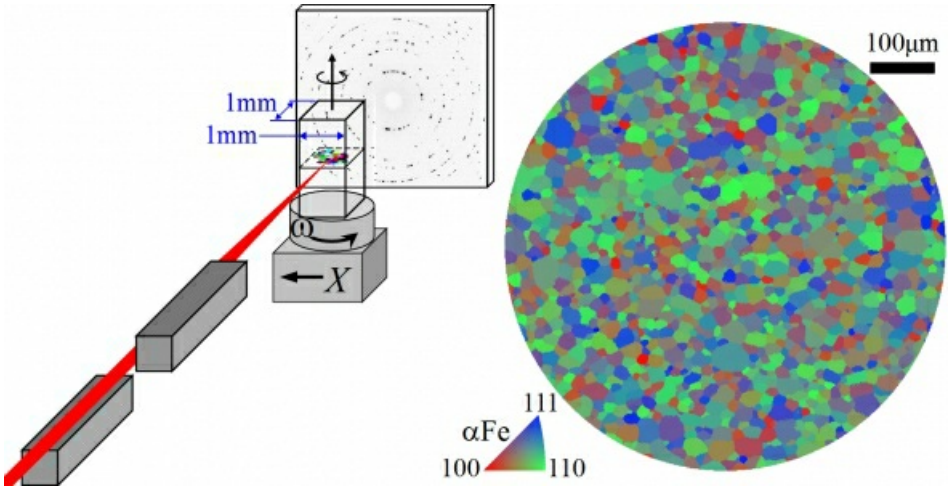
Orientation mapping of steel by scanning three-dimensional x-ray diffraction microscopy

Yujiro Hayashi[1], Yoshiki Seno[1], Tomoyuki Yoshida[1]
[1]*Toyota Central R&D Labs., Inc., Nagakute, Japan*
E-mail: y-hayashi@mosk.tytlabs.co.jp

Three-dimensional x-ray diffraction microscopy (3DXRD) [1] has enabled non-destructive 3D mapping of orientations and stresses in a polycrystal. From practical interests in polycrystalline plasticity of engineering materials such as steel, we have tried to apply 3DXRD to thicker or more deformed specimens. Such specimens tend to give rise to the massive overlaps of diffraction spots due to a large number of grains or mosaic spreads, which prevent us from reconstructing orientation and stress maps. As a solution of the problem, we proposed a scanning type approach termed scanning 3DXRD [2], in which an x-ray pencil beam is employed to reduce the diffraction spot overlaps. A scanning 3DXRD apparatus has been installed at the BL33XU Toyota beamline at SPring-8 [3], at which x-rays with 50 keV photon energy are focused to a spot size of 1–2 μm by 400-mm-long Kirkpatrick-Baez mirrors. In this paper, the scanning 3DXRD with the microbeam is applied to orientation mapping in commercial cold-rolled low-carbon steel, which is economical steel for plastic forming. The typical grain size of 1-mm-thick low-carbon steel sheets is about 20 μm. The scanning 3DXRD experiment was conducted using a specimen with a cross-sectional area of 1 by 1 mm². The corresponding number of grains in the cross section is about 3,000. To our knowledge, orientation mapping for a specimen containing such a large number of grains in a cross section has not yet been achieved by 3DXRD-type methods. By using the microbeam, the significant overlaps of diffraction spots on a far-field detector were not seen. Diffraction images were recorded through the scans of the rotation ω and translation X of the specimen. The range and step of the ω scan were 180° and 0.3°. From the ω–X scan data, the dataset for which the microbeam illuminated the same arbitrary point during the ω scan was extracted. Multi-grain indexing [1] was applied to the dataset, which produced the number N of detected diffraction spots and orientation for the candidates of the grain occupying the arbitrary point. Among the grain candidates, the grain with the highest N/M was selected as the grain occupying the point, where M is the theoretical value of N depending on orientation. The orientation at the point was thus determined. A 2D orientation map was reconstructed by sweeping the arbitrary point. The ω–X scan data with an X step and range of 1 μm and ±340 μm yielded a 2D orientation map with 1 by 1 μm² pixel size and a field of view of 680 μm in diameter. The 2D orientation map containing grains of the order of 1,000 was obtained.

Part of this work was supported by JSPS KAKENHI Grant Numbers JP 22760571 and JP26870932.

[1] Poulsen, H. F. (2012) J. Appl. Cryst. 45, 1084-1097.
[2] Hayashi, Y. et. al. (2015) J. Appl. Cryst. 48, 1094-1101.
[3] Hayashi, Y. et. al. (2016) AIP Conf. Proc. 1741, 050024.



Keywords: three-dimensional x-ray diffraction microscopy (3DXRD), microbeam, orientation mapping