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Microbeam analysis — Guidelines for misorientation analysis to assess mechanical damage of austenitic stainless steel by electron backscatter diffraction (EBSD)

Analyse par microfaisceaux — Lignes directrices relatives à l'analyse des défauts d'orientation pour l'évaluation des dommages mécaniques de l'acier inoxydable austénitique par diffraction d'électrons rétrodiffusés (EBSD)

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Foreword

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This document was prepared by Technical Committee ISO/TC 202, *Microbeam analysis.*

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Mechanical damage such as creep or fatigue, in engineering materials can be assessed by misorientation analysis using electron backscatter diffraction (EBSD) technique. The EBSD technique measures crystal orientation of sample surface by indexing EBSD patterns which are acquired by scanning its surface with electron beam in a scanning electron microscope (SEM). It can give orientation maps and misorientation maps. To determine the degree of damage induced in the materials, the misorientations calculated from the mapping data are qualified by various parameters such as the local misorientation, which is an averaged misorientation between neighbouring measurement points, and intra-grain misorientations, which is an averaged misorientation between the reference orientation assigned to each crystal grain and measurement points inside the grain. These misorientation parameters correlate well with the degree of mechanical damage caused by deformation, fatigue and/or creep. Therefore, the magnitude of the material damage can be estimated using the correlation curve which represents the relationship between the misorientation parameters and the degree of the damage (hereafter called correlation curve).

In the EBSD measurement, the crystal orientation is identified through electron beam illumination to the material surface, acquisition of the EBSD pattern by an image detector, and then crystal orientation identification by indexing of the EBSD patterns. It was shown that the point to point accuracy of the crystal orientation measurement is about 0,05° to 0,5°. The misorientation parameters vary depending on SEM conditions, observation conditions, EBSD pattern acquisition conditions and crystal orientation identification conditions. Several measurement parameters are determined for calculating the misorientation parameters. In particular, the local misorientation greatly depends on the distance between the measurement points (step size). Furthermore, the accuracy of the crystal orientation measurement and the definition of the misorientation parameters may depend on the hardware and software used for the measurement and analysis. There are several venders of commercial EBSD measurement and analysis systems. The correlation curve obtained for a certain condition using a certain measurement system is not always comparable with other master curve obtained with different conditions or systems. Therefore, it is necessary to have a standard to measure comparable master curves to show the degree of mechanical damage by using any EBSD systems.

This document describes measurement procedures and conditions and definitions of misorientation parameters independent on the measurement system in order to assess damage of austenitic stainless steel precisely.

Microbeam analysis — Guidelines for misorientation analysis to assess mechanical damage of austenitic stainless steel by electron backscatter diffraction (EBSD)

1 Scope

This document describes the guidelines for misorientation analysis to assess mechanical damage such as fatigue and creep induced by plastic and/or creep deformation for metallic materials by using electron backscatter diffraction (EBSD) technique. This international standard defines misorientation parameters and specifies measurement conditions for such mechanical damage assessment. This document is recommended to evaluate mechanical damage of austenitic stainless steel, which is widely used for various components of power plants and other facilities.

In this document, the mechanical damage refers to the damage which causes the fracture of structural materials due to external overload, fatigue and creep; excepting the chemical and thermal damages themselves.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 24173:2009, *Microbeam analysis — Guidelines for orientation measurement using electron backscatter diffraction*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
area averaged intra-grain misorientation
average of intra grain misorientation of all pixels in the measurement area

3.2
area averaged local misorientation
average of local misorientation of all pixels in the measurement area

3.3
blank point
non-indexed point (pixel) due to insufficient quality of the EBSD pattern

Note 1 to entry: This can occur for a variety of reasons, such as insufficient specimen surface condition, dust or contamination on the specimen surface, overlapping patterns at the grain boundary, a poor-quality pattern due to the effects of strain, or if the pattern is from an unanticipated phase.

Note 2 to entry: See ISO 13067:2020, 3.4.2 for definition of non-indexing.