Analysis of phases and crystal orientations – EBSD

Analysis methods in the Scanning Electron Microscope

Scanning Electron Microscopy (SEM) gives the possibility to image all types of dry surfaces and materials from low to very high magnifications. With different analysis techniques it is also possible to find out what elements and phases are present, as well as crystal structure and crystal orientation. By combining these techniques and, when needed, also other techniques available at RISE, we can help you to get an overall picture of a specimen/material in order to understand what it has been subjected to and/or why it behaves in a certain way during service/loading.

Electron Backscattered Diffraction, EBSD

Electron Backscattered Diffraction (EBSD) gives crystallographic information in each analysed point/pixel, such as crystal structure, crystallographic phase, crystal/grain orientation, etc.

Evaluation of the acquired data can in addition show degree of local deformation (misorientation and pattern quality), average grain size and grain size distribution, grain boundary analysis, etc.

Due to that it is a diffraction-based technique, the material to be analysed must be crystalline (metallic or ceramic). In Figure 1 some examples of EBSD results are shown: EBSD maps of a nitrided steel cross section where the structure of the surface layer can be seen clearly.

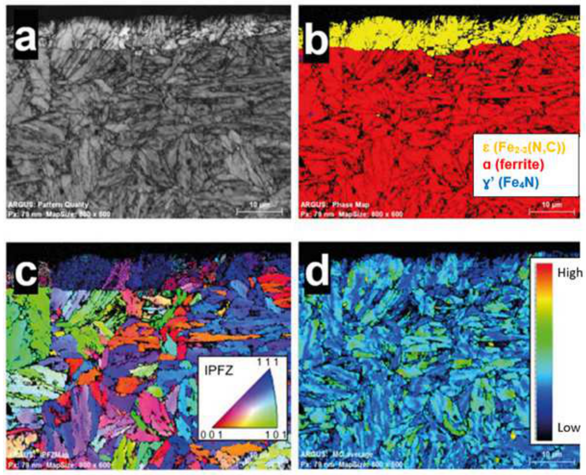

Figure 1. EBSD maps of nitrided steel
a) pattern quality (grain structure)
b) phase identification
c) crystal orientation
d) local deformation (misorientation)

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Analysis of phases

EBSD is a good method to study polymorphic materials and alloys, i.e. materials that can have phases with the same composition but different crystallographic structures.

Grain size and grain morphology

EBSD can produce maps showing the grain morphology of a material and provides statistical average grain size and grain size distribution information. For example, if a material has undergone heat treatment or even recrystallization, the change in grain size and grain shape can be studied with EBSD. In figure 2 an example is given where the EBSD technique is used to study lead-free solder joints. The outer two are monocrystalline (consist of only one crystal/grain) and the middle joint is polycrystalline, which will affect how well they perform under external stresses.

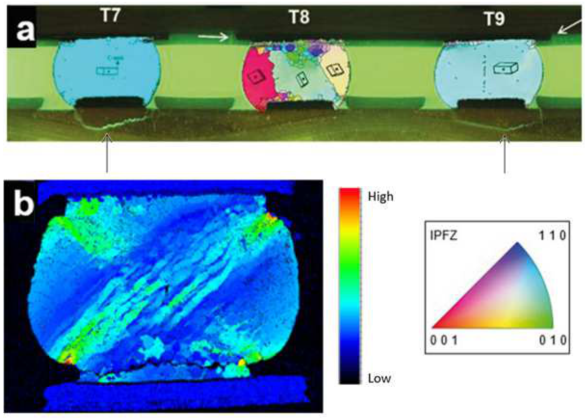

Figure 2. EBSD maps of lead-free solder joints

a) crystal orientation in three joints

b) local deformation (misorientation)

Crystal orientation

EBSD also provides information about crystal orientation (see examples in figures 1c and 2a), which can be of interest when studying texture in a material. For example, a rolled sheet often has a distinct texture, which can be seen by all grains having the same colour in the orientation map. Additive manufactured metals are another example of suitable materials to be investigated with the EBSD technique.

Degree of deformation and combination with other analysis techniques

As the misorientation maps show (figures 1d and 2b), analysis of local deformation can also be performed. In figure 2b stress concentrations are seen in yellow-red colour. Degree of local deformation can be compared/combined with residual stress measurements, where the analysis is done on a much larger area and gives a deformation measure on a macro level.

Figure 3 illustrates an example of how elemental analysis with EDS can be combined with the analysis of phases and crystal orientations by EBSD in an elegant way.

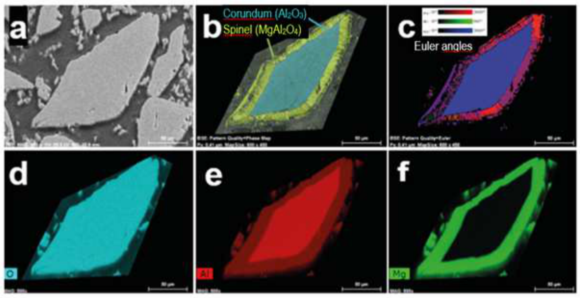

Figure 3. Analysis of steel furnace lining, combination of EDS and EBSD

a) SEM image taken at x500

b) EBSD, phase map

c) EBSD, orientation map (Euler angles)

d) EDS, elemental map of oxygen (O)

e) EDS, elemental map of aluminium (Al)

f) EDS, elemental map of magnesium (Mg)