Omega-scan – a measuring technique for the orientation determination of crystals

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Abstract. The X-ray diffractometric Omega-scan method allows the determination of the complete lattice orientation using only one measuring step. It is especially suited for the quick serial and industrial applications. The apparatuses partially combined with other tools and some typical examples are shortly described.

Keywords: Orientation determination, adjustment of crystals, rocking-curve measurement.

INTRODUCTION

The growth and application of single crystals need the determination of the lattice orientation with respect to outer surfaces or other geometric features. Mostly, methods of X-ray diffractometry are used. Using a single measuring step one obtains the orientation of one lattice plane only. Measuring of the complete lattice orientation requires several measuring steps and often manual handling. This procedure takes at least several minutes.

By contrast to that the Omega-scan method [1-4] allows the orientation determination of the complete crystal lattice in a very short time using only one automatic measuring step. Therefore, it is especially suited for serial studies and industrial applications.

DESCRIPTION OF THE METHOD

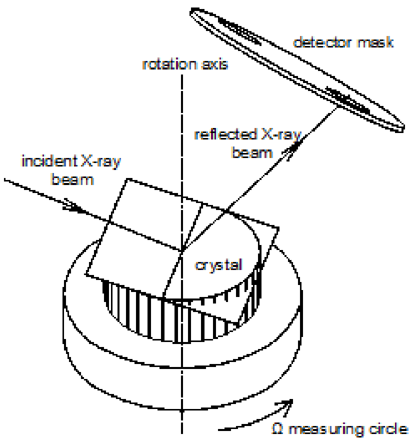

FIGURE 1. Principle of the Omega-scan measuring arrangement.

The principle of the Omega-scan method is shown in Fig. 1. During the measurement the crystal rotates with constant speed around an axis, the reference axis of the system. X-ray tube and detector with mask for the reflected beams are in fixed positions. The X-ray beam is twice reflected from lattice planes inclined to the rotation axis. The reflections are produced in skew geometry. The angular positions of the reflections are measured in the plane perpendicular to the rotation axis (Omega circle). The incidence angle of the primary beam is chosen accordingly and the mask in front of the detector is positioned so that reflections at a sufficient number of lattice planes are obtained and can be evaluated unambiguously. At least the reflections at two lattice planes must be measured. For crystal orientations with a symmetry axis close to the rotation axis, the corresponding number of symmetrically equivalent reflections is registered (Fig. 2). The whole measurement takes only a few seconds.

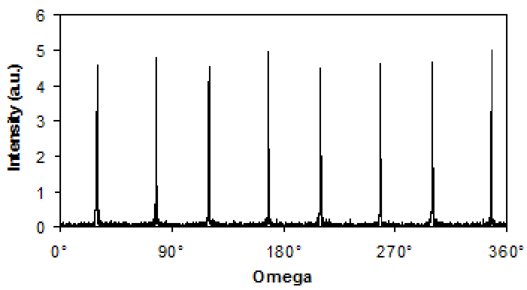

FIGURE 2. Measured Omega-scan diagram of Si, CuKα radiation, reflections of the type 311.

From the angular positions of the reflections the orientation of the crystal lattice is calculated, expressed, e. g., by polar coordinates related to the crystallographic coordinate system. Moreover, also the azimuthal angle of the projection of any lattice direction on the Omega circle yields from the measurement.

A fixed arrangement can be applied to crystals with principally known orientation, but deviations from it in a range up to a few degrees, sometimes also 10 deg. or more. In special cases (cubic crystals), it is applicable also for arbitrary orientations.

The lattice orientation is referred to the rotation axis of the turntable. One possibility to get a reference to a crystal surface is placing it on a measuring table exactly adjusted to the rotation axis and positioning the measuring arrangement under this table. If large crystals are to be studied or they are to be adjusted according to the measured results, the crystals stand on the turntable. The relation of the upper surface may then be obtained by additional optical tools. The azimuthal reference may be realized also by optical or by mechanical tools.

APPARATUSES AND APPLICATIONS

If only one material with one or sometimes a few principal orientations is to be measured, the described simple type of arrangement can be used, with suited masks for different types of reflections. Sometimes two detectors are used in order to enlarge the receiving angular range.

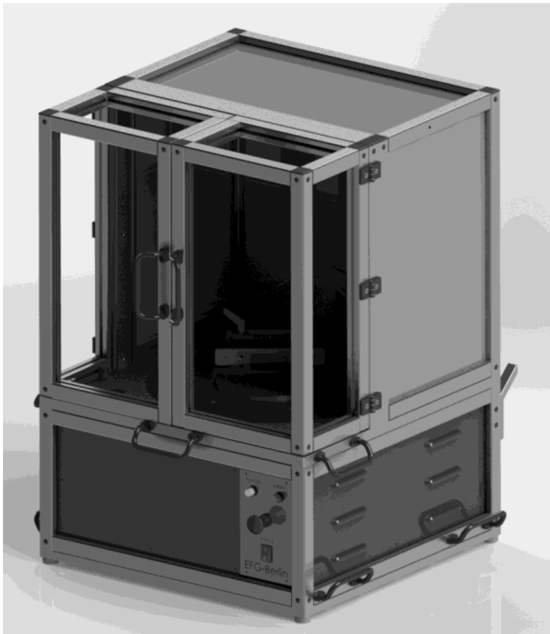

FIGURE 3. Desktop Diffractometer for Omega-scan measurements.

For more universal application, the apparatus is equipped with setting capabilities of the X-ray tube and the detector system.

Fig. 3 shows the Desktop Diffractometer for the study of crystals with even surface placed on the measuring table. It can be applied for a large number of crystal kinds and orientations. Adjustable stops allow the measurement of the azimuthal orientation, e. g. of flats or notches of wafers.

Another type of apparatus is designed for larger crystals and may be equipped with adjustment arrangements for crystal boules of any shape and for ingots (Fig. 4). In order to enable the measurement of different materials and orientations, X-ray tube and detector can be moved using corresponding circles. This allows also conventional diffractometric Theta-scan measurements. So the Omega-scan measurements may be combined with rocking-curve scans for the estimation of the crystal quality. Therefore, the primary-beam collimator is equipped with a channel-cut crystal collimator. Both modes can be simply exchanged.

FIGURE 4. Diffractometer for combined Omega- and Theta-scan measurements; with arrangement for local mapping.

This type of diffractometer can be also equipped with an x-y table for local mapping on the turntable. It can be applied for the orientation determination as well as for rocking-curve measurements.

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