Application Note XRD 613

Texture Analysis with EIGER2 R 500K and DIFFRAC.TEXTURE

Investigation of Rolled and Drawn Aluminum Sheets

The orientation distribution of grains in a polycrystalline material, commonly referred to as its crystallographic texture, has a profound impact on its mechanical, electrical, and thermal behavior. Many manufacturing processes such as machining, rolling, extruding, and drawing lead to changes in texture which can be measured and controlled to enhance functionality or prevent failure.

The EIGER2 R 500K is a versatile hybrid photon counting X-ray detector. Flexible positioning and orientation allows optimization of angular coverage versus resolution. At a short sample-to-detector

Summary

- The large 2θ and γ coverage of the EIGER2 combined with efficient experiment planning in WIZARD results in fast data collection.
- ODF reveals similar texture components in both the rolled foil and drawn sheet, with the latter exhibiting two additional components
- Inverse pole figures reveal an accentuated (100) texture in the rolling direction and (101) texture in the normal direction of the drawn sheet

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distance large sections of multiple Debye rings can be captured in a single frame, significantly reducing measurement time. DIFFRAC.TEXTURE intuitively generates the orientation distribution function (ODF) and inverse pole figures.

In this study, two aluminum sheets produced by different manufacturing processes are examined: a piece of rolled foil, and a drawn sheet from a cut-out section of a soda can.

Experimental

Data were collected on a D8 DISCOVER diffractometer equipped with Cu radiation (40 kV, 40 mA), Goebel mirror, 500 µm UBC collimator, Compact cradle^{plus}, and EIGER2 R 500K detector operating in 2D mode in the gamma-optimized orientation. The same configuration is also available in the D8 ADVANCE.

To obtain pole figures, 2D frames were taken as continuous scans in ϕ (the azimuthal angle) at successive values of ψ (the tilt angle). Due to the large coverage in γ and 2θ the number of required ψ steps is greatly reduced compared to a 0D or 1D method, and there is also the possibility of capturing multiple pole figures in a single frame set. In this experiment (111) and (200) were collected together, in 3 ψ steps; (220) and (311) were collected individually, in 4 ψ steps; and (331) and (420) were collected together, in 5 ψ steps. A thinned algorithm was used with a nominal angular resolution of 8° in ϕ , and 10 s per frame. Collection time was 15 min for (111) and (200), 20 min each for (220) and (311), and 24 min for (331) and (420), resulting in a total collection time of 1 h 19 min for all six pole figures.

Frame data were imported into DIFFRAC.TEXTURE where pole figures were quickly generated and fit using the harmonic method, assuming monoclinic process symmetry.

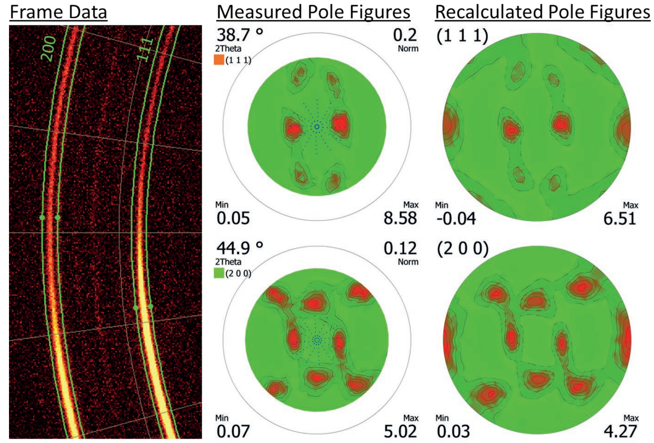


Figure 1: (Left) Stacked 2D frames from the Phi scan at ψ = 15° for the (111) and (200) pole figures. (Middle) Measured pole figures for (111) and (200). Frame coverage at ψ = 15° is shown as blue dotted lines, where the length of the dotted line corresponds to the gamma coverage of the frame. (Right) Recalculated (111) and (200) pole figures after fitting using the harmonic method.

RESULTS

Figure 1 shows the integration from frames to pole figures for (111) and (200) of the drawn sheet, as well as a comparison between the measured and recalculated pole figures after fitting. Excellent fits to the data are obtained for both samples. Figure 2 shows the recalculated pole figures for the rolled foil (upper row) and drawn sheet (lower row). Although they appear similar at first glance, close inspection reveals significant differences. For example, the pole figures for the drawn sheet exhibit sharper features, as well as additional peaks, when compared to the rolled foil.

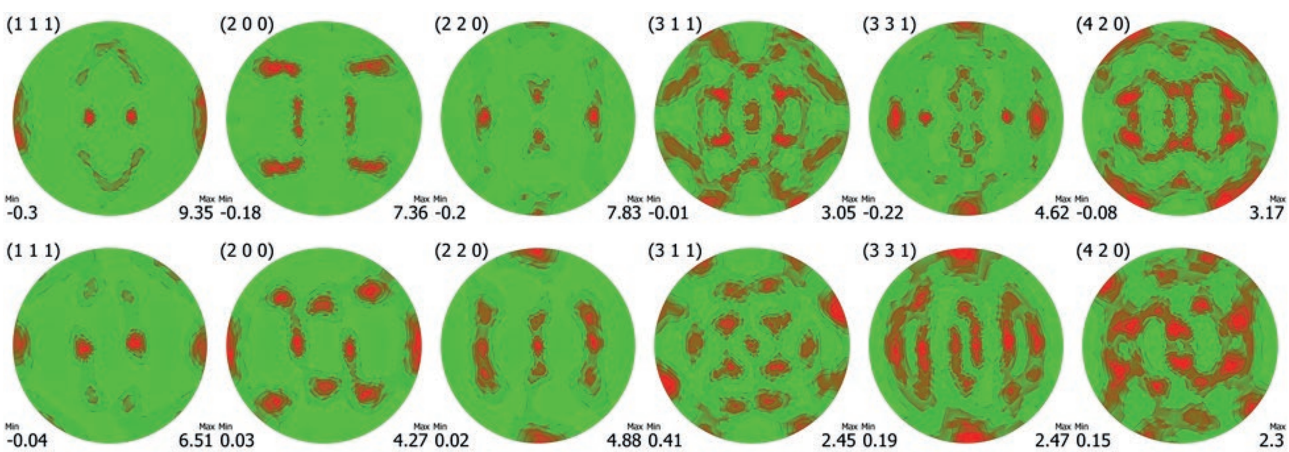


Figure 2: Recalculated pole figures for Al foil (upper row) and drawn sheet (lower row).

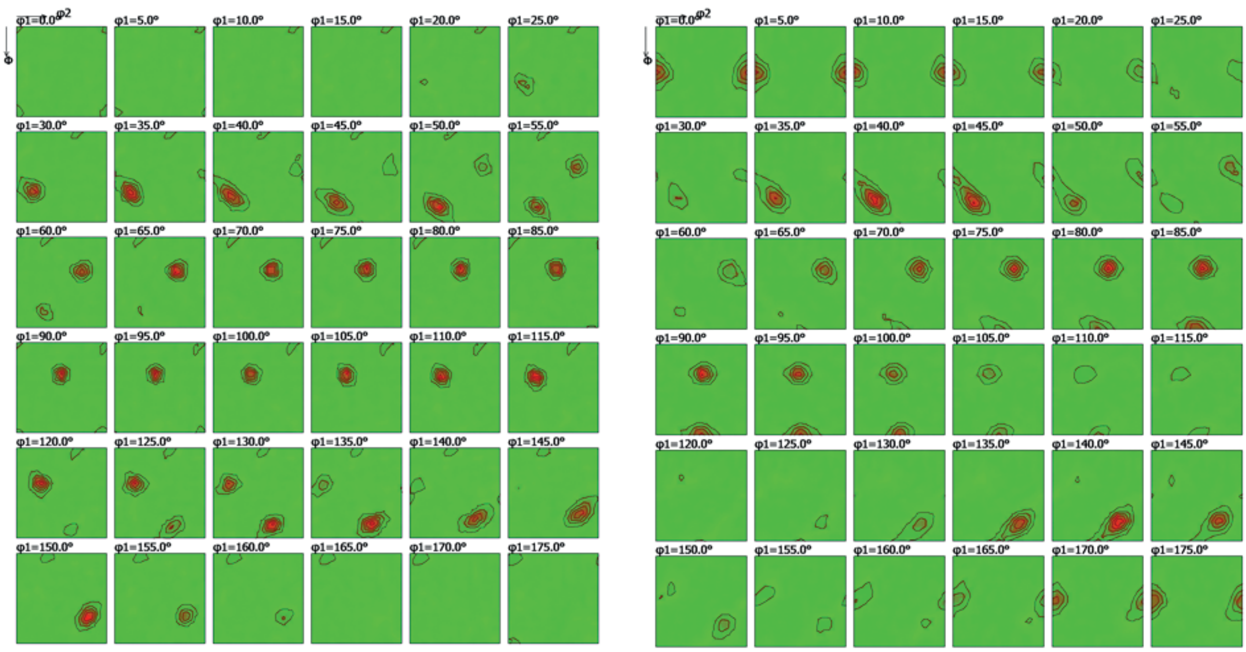


Figure 3: Orientation distribution functions for rolled Al foil (left) and drawn Al sheet (right). The drawn sheet has the same texture components as the rolled foil, but with less broadening in ϕ1. The drawing process also introduces two additional components.

The ODF for both samples are shown in figure 3, plotted in equal slices of the Euler angle ϕ1. Here the reason for the similarity in the pole figures is evident. Three distinct components are identified in the rolled foil, and the same three components are also found in the drawn sheet, differing only in the amount of broadening. For example, a spherical component appears from ϕ1=40° to ϕ1=140° in the rolled foil, while the corresponding component goes from ϕ1=50° to ϕ1=115° in the drawn sheet. The broader texture of the foil is likely a result of it being rolled much thinner than the drawn sheet. In addition, the drawn sheet has two components which do not appear in the rolled foil, one extending from ϕ1=155° to ϕ1=25° and one extending from ϕ1=70° to ϕ1=115°. These were likely introduced as a result of the drawing process.

Inverse pole figures show the density of oriented crystallites in the rolling, transverse and normal directions. Figure 4 clearly shows that the drawing process results in a greater density of (001)-oriented crystallites in the rolling direction, and (101)-oriented crystallites in the normal direction, as compared to the rolled foil. In addition, the foil has a higher density of (112)-oriented crystallites in the normal direction, likely due to the extended rolling process.

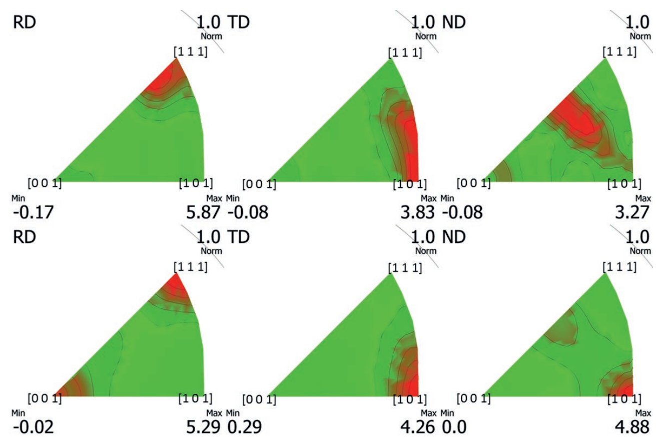


Figure 4: Inverse pole figures showing the density of oriented crystallites in the rolling direction (RD), transverse direction (TD) and normal direction (ND), for Al foil (top row) and drawn Al sheet (bottom row).

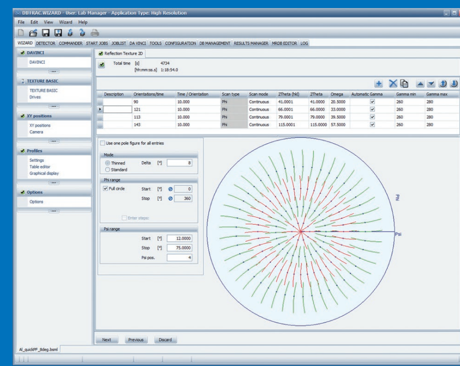
Conclusions

The crystallographic texture of a rolled Al foil and drawn Al sheet were measured using a D8 DISCOVER equipped with an EIGER2 R 500K detector, and analyzed with DIFFRAC.TEXTURE software. As expected, both samples contain similar texture components arising from the rolling process, with the rolled foil exhibiting component broadening due to extended rolling, and the drawn sheet exhibiting additional components resulting from the drawing process.

DIFFRAC.SUITE Workflow for Texture Analysis

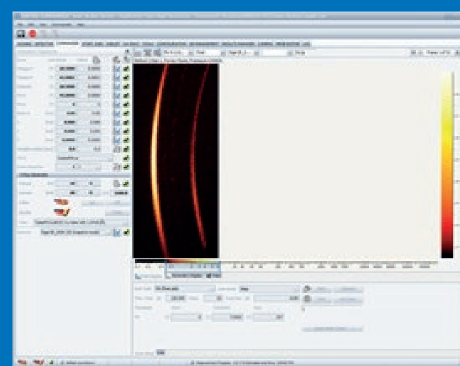
PLAN in DIFFRAC.WIZARD

- Measurement scheme optimization in 0D, 1D, and 2D
- Preview gamma coverage for a given detector distance and 2θ
- Measure at multiple points with XY mapping



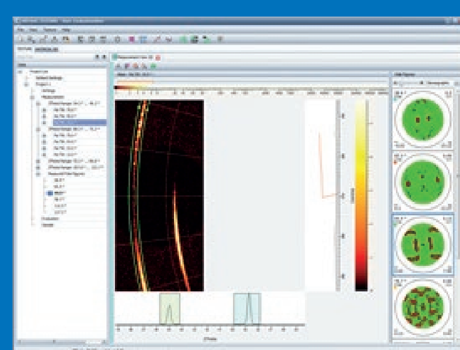
MEASURE in DIFFRAC.COMMANDER

- Direct measurement control or launch predefined experiment methods
- Real-time data monitoring
- Calibrated iso-lines cursor for accurate identification of features



ANALYZE in DIFFRAC.TEXTURE

- One-click pole figure generation
- Supports 0D, 1D, and 2D data
- Harmonic and component method for ODF analysis
- Clear, concise report generation



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