

Grain Size Analysis

Image Analysis Report # 512

Sample Description

Six prepared copper sheet samples were submitted for analysis. Grains on sample 5 were not sufficiently clear to be analyzed either manually or automatically.

Purpose of Analysis

The goal is to perform automatic grain size measurements on samples containing a large number of twins.

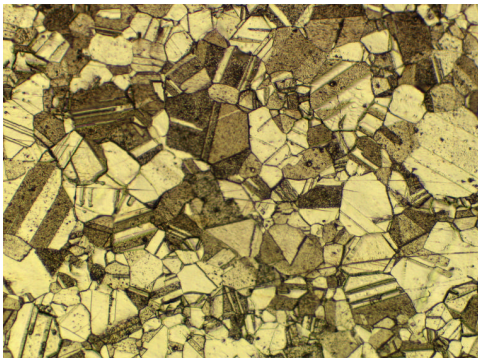


Figure 1: Typical field of sample 3 at 100x (1.27 $\mu\text{m}/\text{pixel}$).

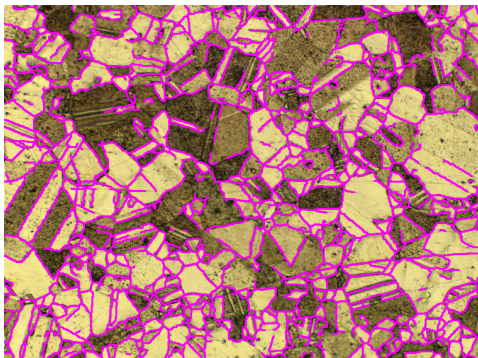


Figure 2: Automatic detection of grains and twins in magenta.

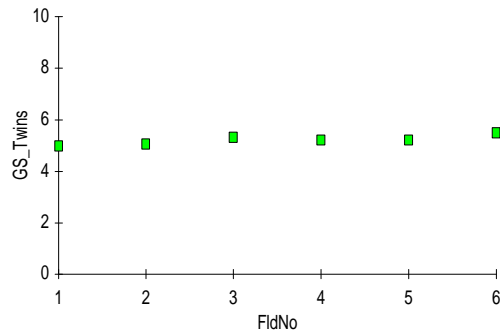
Procedure¹

Several gray filters are applied to the original image to isolate as many grain boundaries as possible including the twins boundaries. Several binarization steps are also performed and all bitplanes are combined together using boolean operations. The resulting network is inverted and cleaned of artifacts prior to automatic measurements.

¹ Images taken during the procedure are available in appendix A.

Results

Automated statistics and graphs are generated and cumulated over all analyzed fields. Final results can be printed directly from Clemex Vision. Raw data can be exported in Excel format.



Minimum: 4.99
Maximum: 5.49
Mean: 5.21
Std Dev.: 0.181

Figure 3: ASTM E 112 grain size measurements and corresponding statistics over 6 fields on sample 3.

Equipment

Image Analysis System: Clemex Vision PE
Microscope: Leica DM LM
Magnification: 100x
Illumination: Reflected Light
Calibration: 1.2658 microns/pixel
Camera: Sony 950P
Motorized Stage: Marzhauser EK32IM
Stage Controller: Clemex ST-2000

Discussion

When dealing with twins in copper or brass, it is always extremely difficult (when not impossible) to distinguish the twin boundaries from the grains. Most of the time, the detected binary grain outlines and the real grain network of the original image do not correspond well. The resulting routine is huge, very difficult to modify, and works only for a few specific samples under specific conditions.

The best way to measure grain size with accuracy on this type of material is to use an intercept method. It is an automatic analysis including a pause for manual editing. Of course, this method implies some user input thus limiting the number of fields that can be analyzed. For those who always work with the same type of material, there is another possibility.

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If we make sure that all measured samples are going to be of the same type, prepared and etched the same way (really similar appearance and contrast), analyzed under a similar light intensity etc, a correlation factor can be found between the manual method and the automatic one. However, as soon as one of these parameters is changed no one can predict the results (see precision and bias section of ASTM E112 standard).

The Heyn intercept method using 3 concentric circles was used to find a correlation factor between the two methods. The next step is to select the correct magnification. The goal is to observe the appropriate quantity of grains per field. A minimum of around 50 grains should be visible inside one field. If this is not the case, we have to decrease the magnification. On the other hand, if too many grains are present, it means that each of them is represented by fewer pixels and that resolution starts to decrease. When this is the case, we have to increase the magnification. It is not uncommon to see people trying to perform automatic analysis on grains that could barely be distinguished by human eyes.

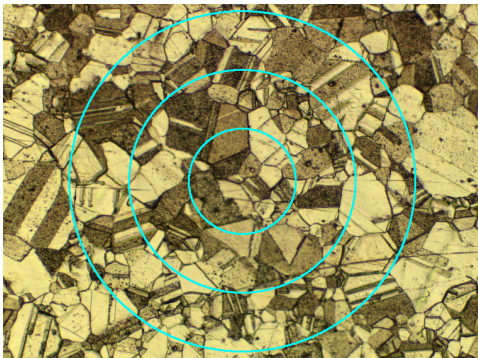


Figure 4: Three concentric circles used for the Heyn intercept method.

Three concentric circles are overlaid against the field being analyzed. The system stops and asks to the user to draw lines where the grain network crosses the circles. When the user is done, the circles are automatically disconnected at the specified intersections. Artifacts are eliminated prior to automatic measurements. ASTM E 112 grain size measurements are performed on each section using Heyn method.

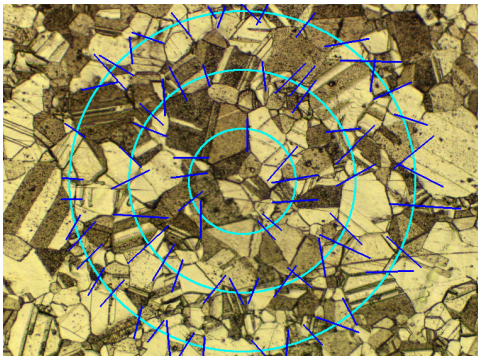


Figure 5: Manually drawn intersections (blue) and automatically deduced intercepts (cyan) as measured.

Note that the manual method can be used as a complete method by itself (Vision Lite plus a Grain Size Application Package).

Several fields must be measured on the same sample to obtain an average grain size. Only 5 to 6 fields over 5 samples were analyzed in this case. More samples and more fields should be analyzed to acquire as many data as possible. Also, each sample must be processed the same way.

In the same routine (where manual intersections are drawn), a second part of processing is added. Gray filters are applied to isolate as many boundaries as possible as was explained in the "Procedure" section. By doing so, each image is analyzed with both methods using a unique routine. Mean chord measurements are then performed over the bitplane representing the inverted boundaries (grains and twins).

Using the average Grain Size and Mean Chord results a correlation factor is deduced. The same process is carried out on all types of samples. Again, if samples are not similar, this will not work.

An overall correlation factor is selected to cover all the different cases. We then create a new custom measurement, a formula using the mean chord size and the correlation factor which will now be available in the Toolbox, just as any other measurement.

Conclusions

Grain size estimation of some materials presenting twins can be done under specific conditions.

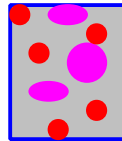
Several samples should be used to deduce a reliable factor. The final value must be validated over another batch of samples with a known grain size value.

The most reliable way of estimating the grain size when twins are present remains the semi automatic intercept method.

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Appendix A: Images



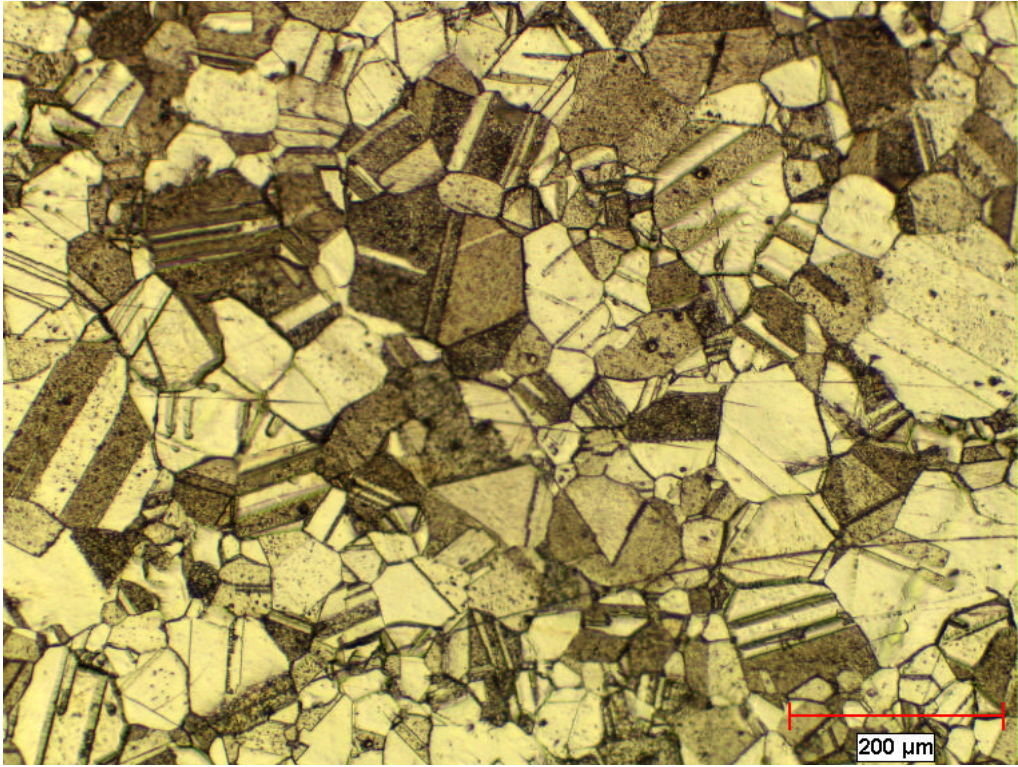


Figure 1: Original image at 100x (1.27 microns/pixel).

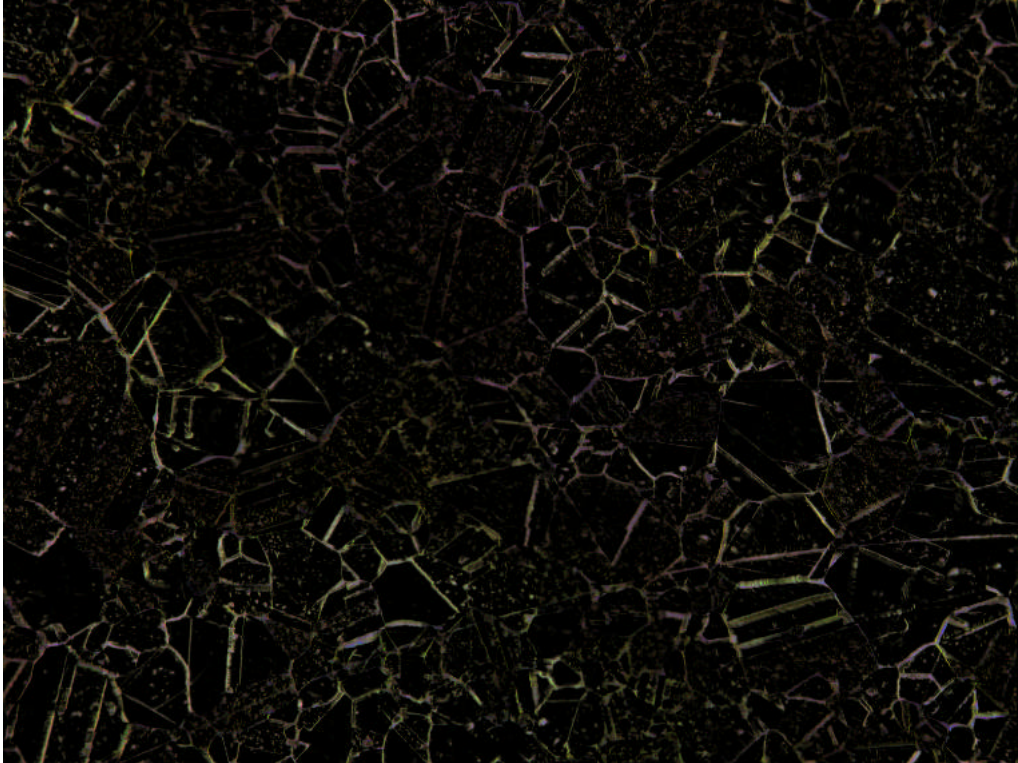


Figure 2: Gray filters are applied to highlight thin dark lines.

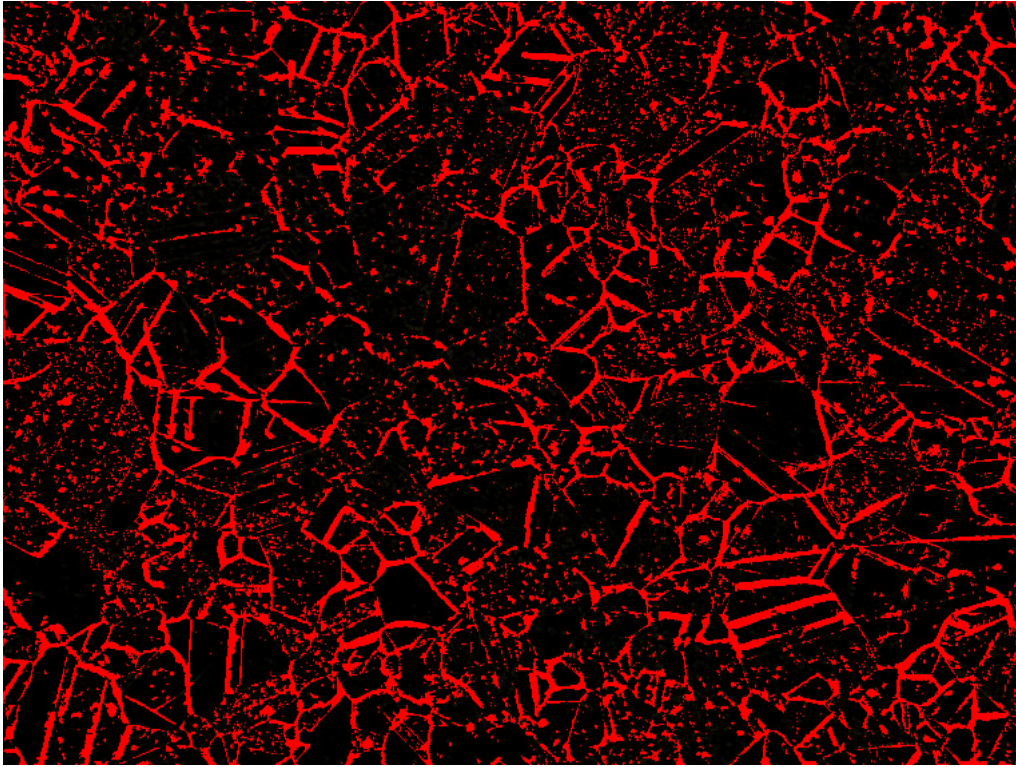


Figure 3: Binarization into the red bitplane of the highlighted boundaries.

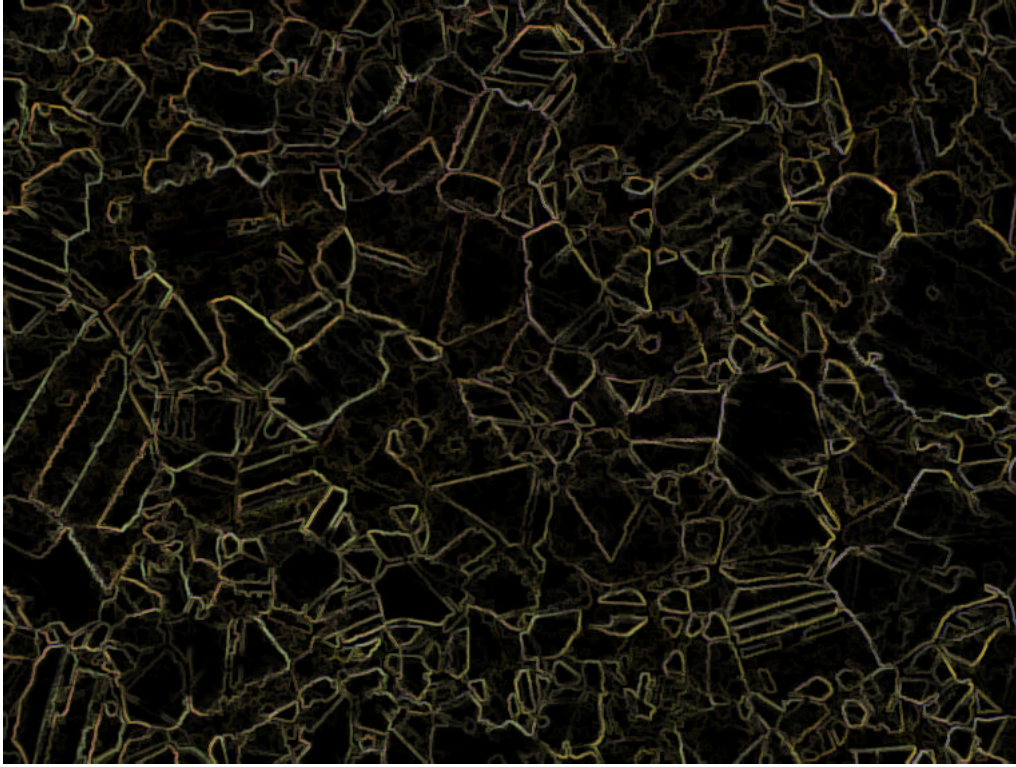


Figure 4: Original image is brought back and other gray filters are applied to highlight any sharp gray transitions.

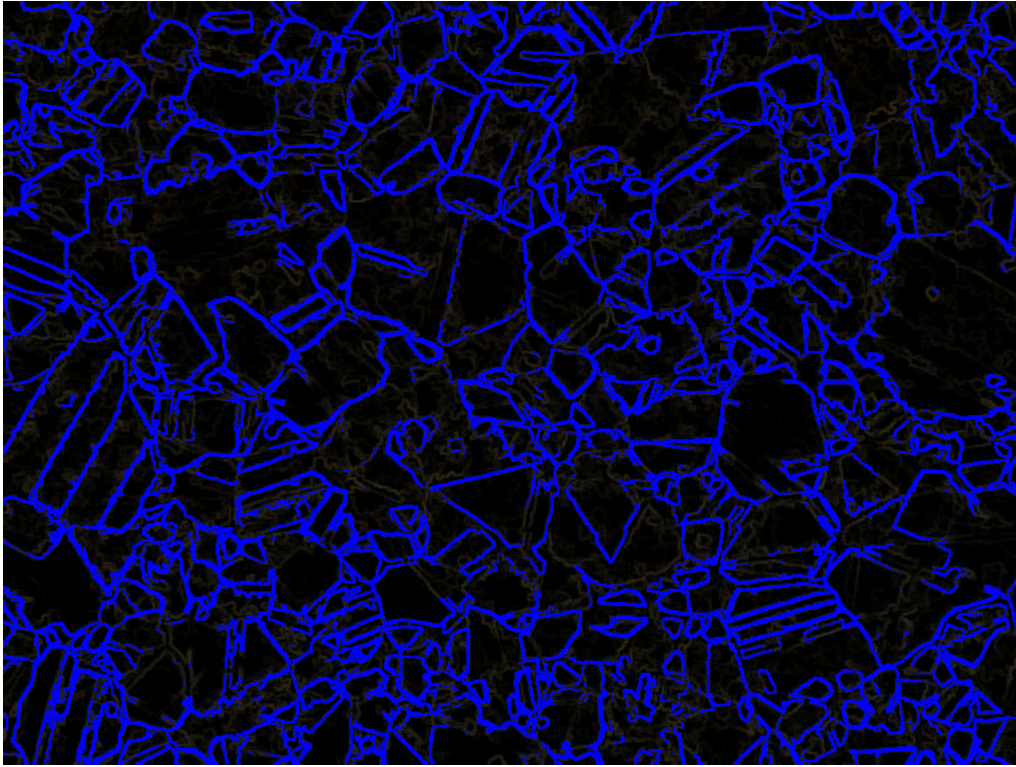


Figure 5: Binarization into the blue bitplane of the highlighted boundaries.

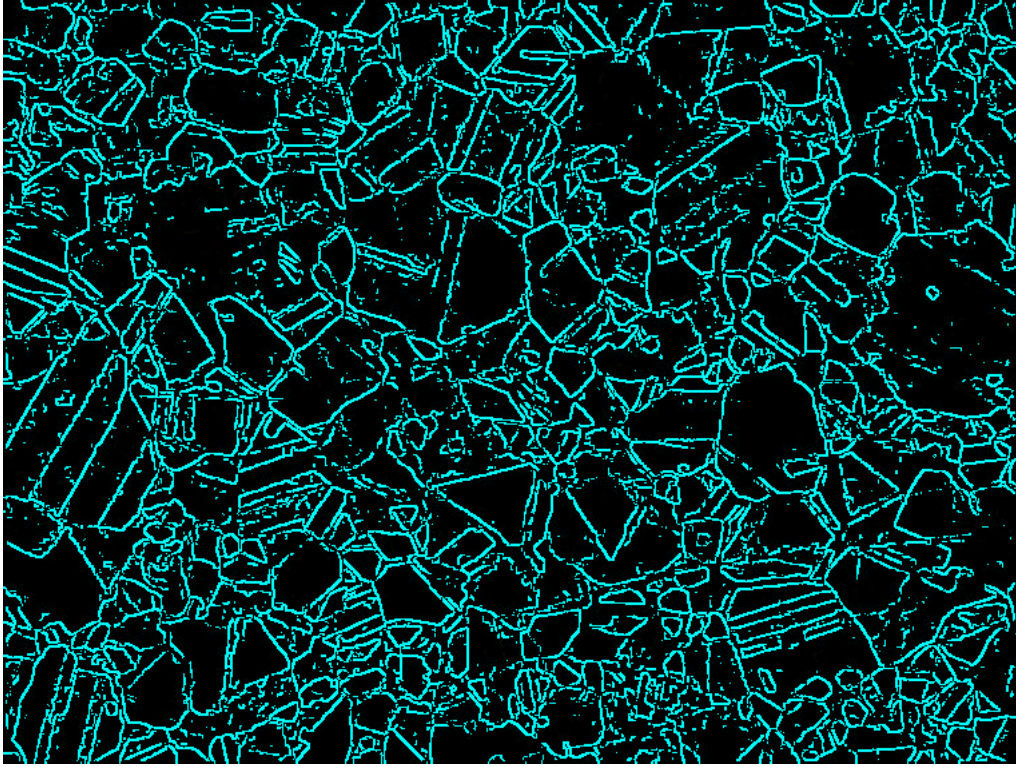


Figure 6: Another filter is applied over the modified image to highlight remaining thin white boundaries. The result is binarized into cyan.

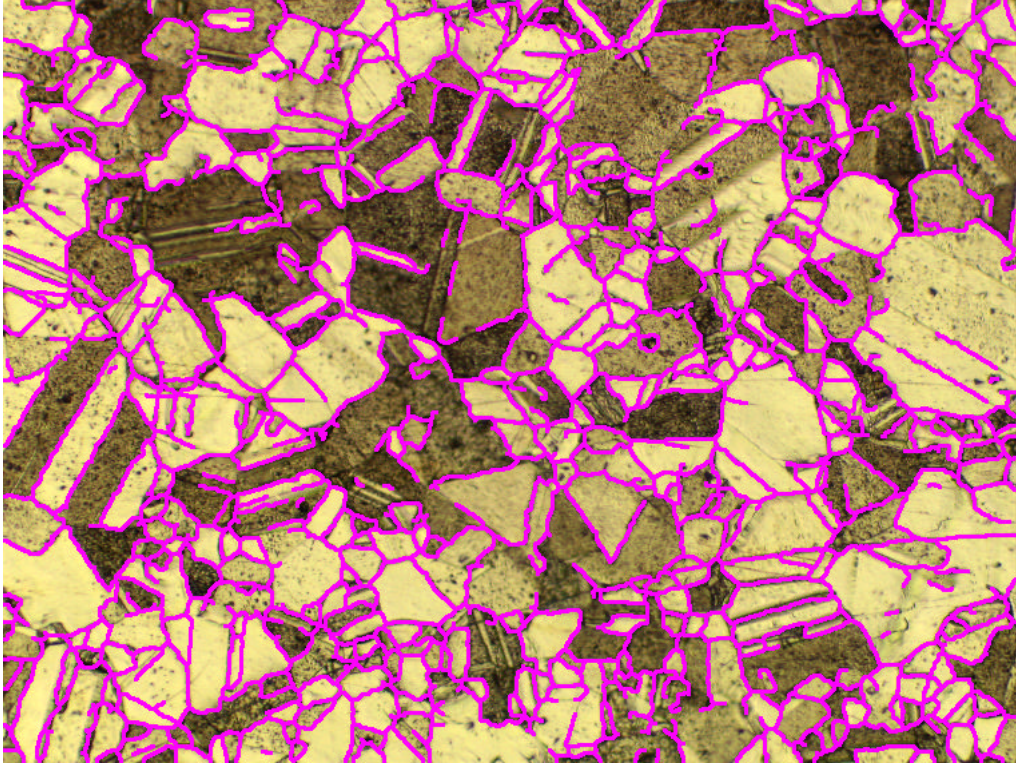


Figure 7: The original image is brought back and all bitplanes are combined together into magenta bitplane and artifacts are eliminated.

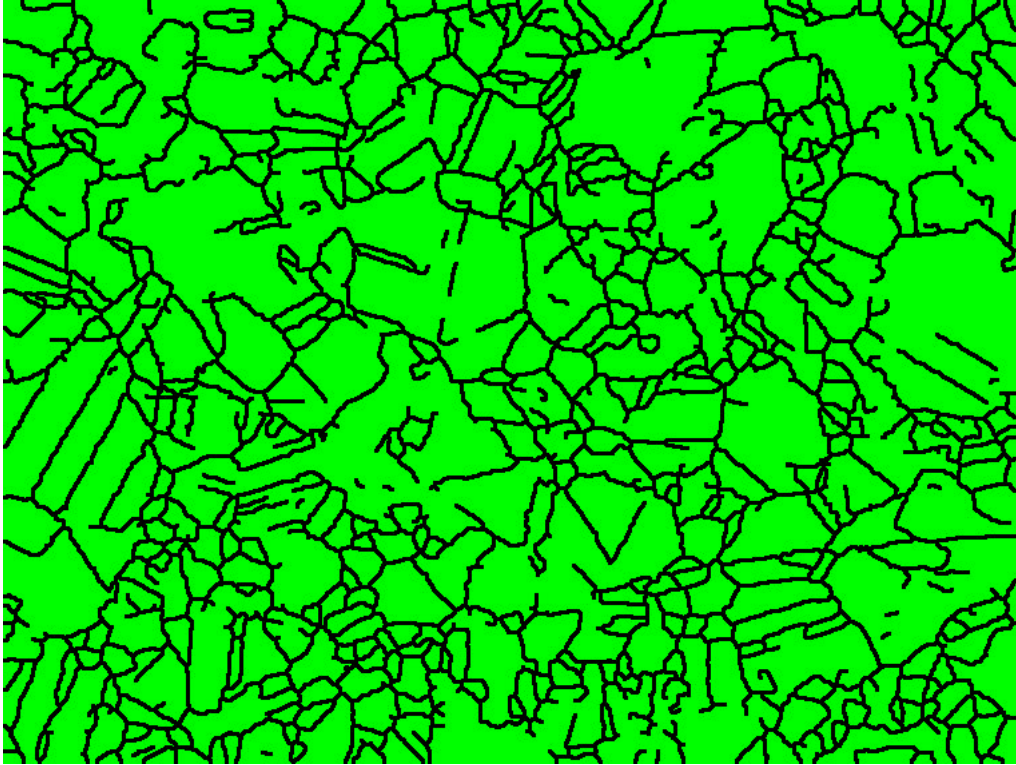


Figure 8: The final grains and twins outlines detection are inverted into green bitplane for automatic measurements (using correlation factor).

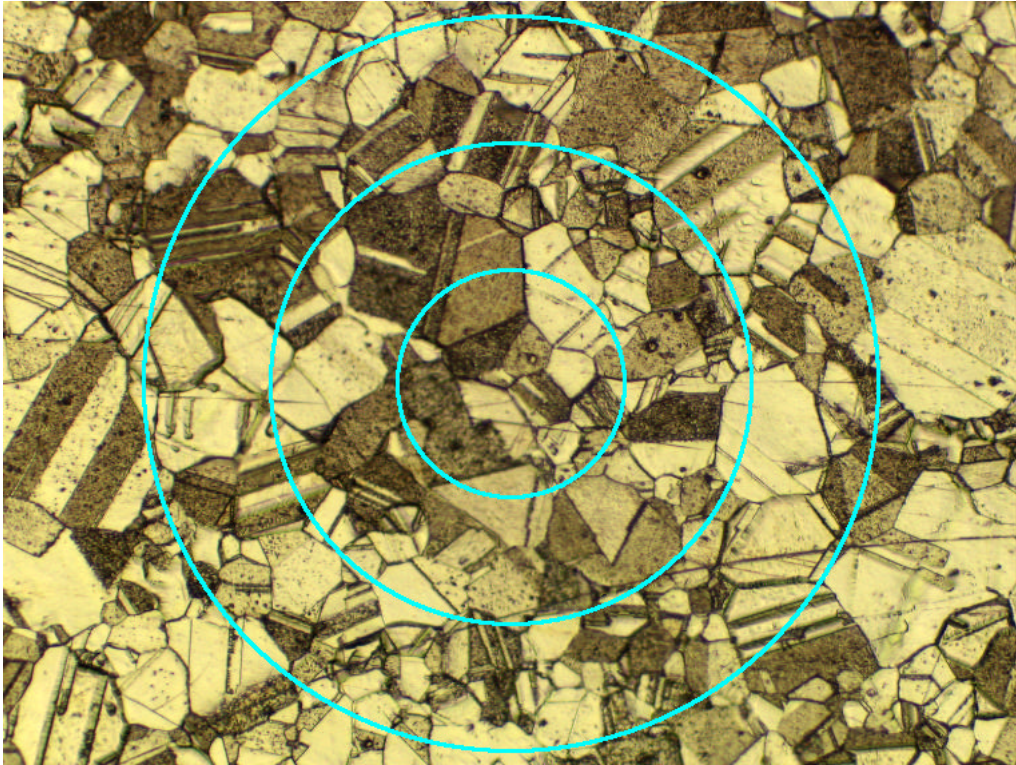


Figure 9: All bitplanes are deleted and concentric circles (cyan) are overlaid against the original image.

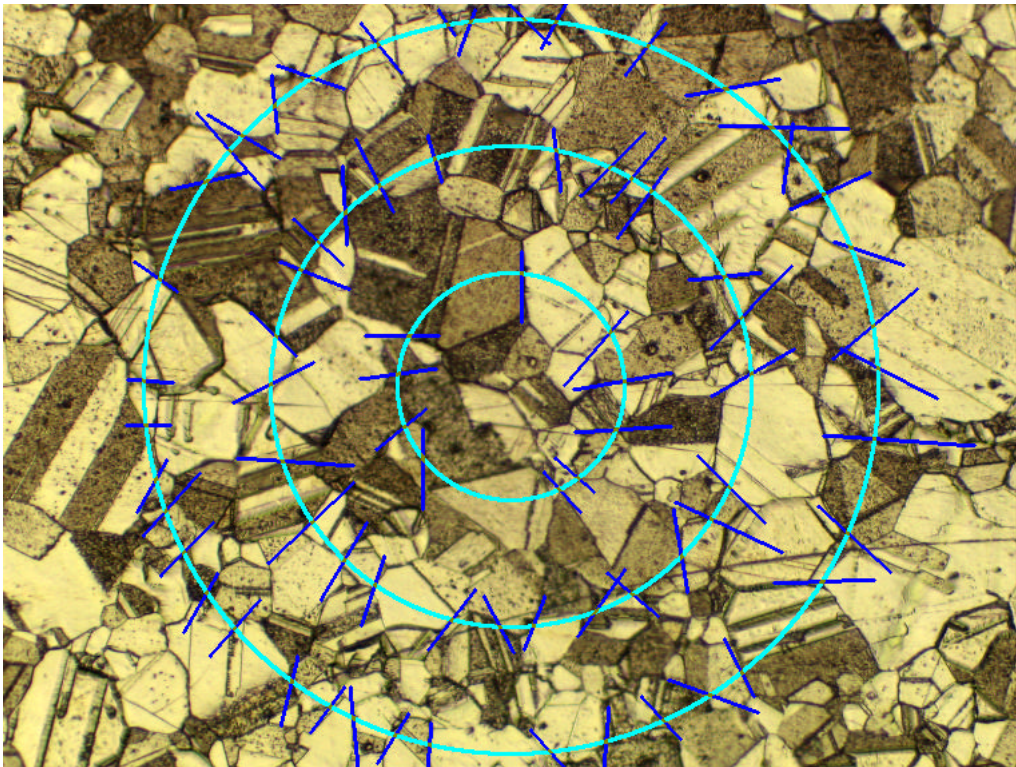


Figure 10: The system Pauses and wait for the user to draw a line everywhere a grain (no twins) intersect a circle.

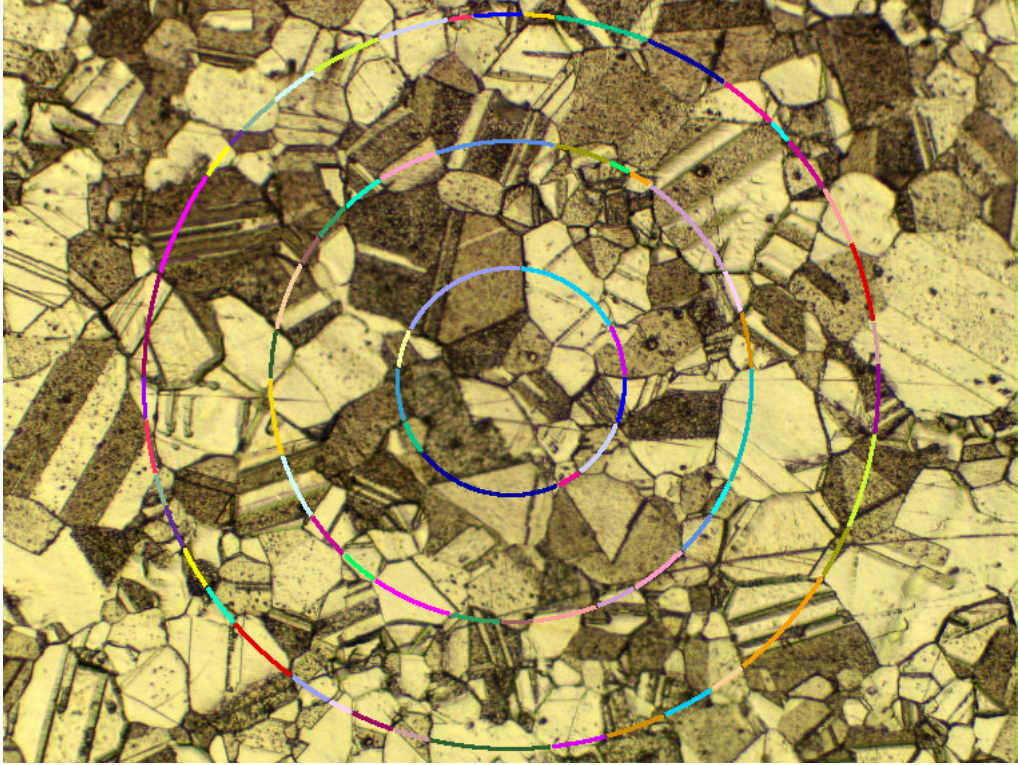


Figure 11: Using the manually drawn line, the circles are disconnected. Sections appears in labelling view to obtain a better view of the segments.

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