

GRAIN SIZE CHARACTERIZATION OF TITANIUM

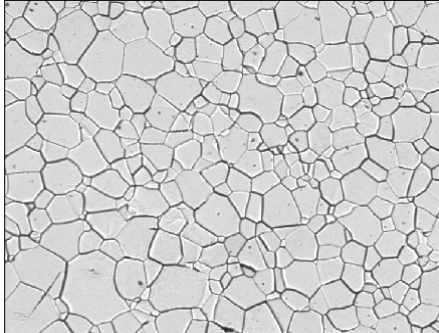


Figure 1: Original image.

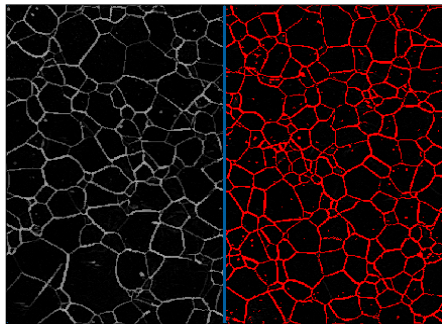


Figure 2a: Black Top Hat of the improved original image.

Figure 2b: Binarization of the preceding gray image.

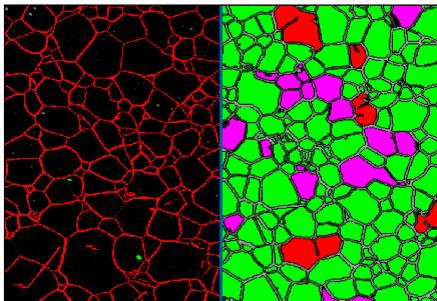


Figure 3a: Artifacts (green) are removed from red bitplane.

Figure 3b: Roughest objects are in red and shall be subdivided according to convexity.

Sample Description

Three unmounted samples of electro-polished titanium.

Purpose of Analysis

Demonstrate the ability of the Clemex Vision image analysis system to discriminate and measure all grains in the field of view.

Procedure

The microstructure of Ti sample (Figure 1) is viewed at 200X. A gray transformation isolates all black and thin objects in it as shown in Figure 2a. Binarization was performed on the transformed gray image results in red bitplane in Figure 2b. Artifacts were removed from the red bitplane using binary operations. Discarded objects were sent to the green bitplane, as shown in Figure 3a. The grain outline was then inverted into the green bitplane to obtain complete grains. Certain binary operations were applied on the green bitplane to separate typical grains. Roughly shaped grains were isolated in red and further separated into the pink bitplane. The remaining red object (the roughest) were then subdivided according to their convexity. Figure 3b shows these three categories. Three types of bitplanes were recombined in red and spread out. The grain boundary network overlaid against the original image as illustrated in Figure 4.

Equipment

Image Analysis System:	Clemex Vision PE
Microscope:	Nikon Epiphot 200
Camera:	Sony XC-77CE B&W
Magnification:	200X
Stage:	Marzhauser EK8B-S1

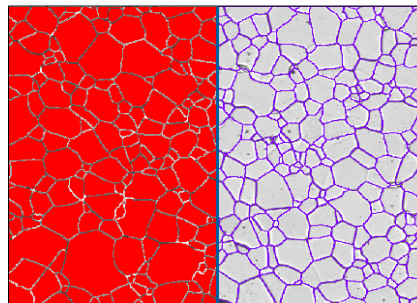


Figure 4a: Recombined bitplanes

Figure 4b: Grain boundary network overlaid against the original image.

Results

Grain size measurements (ASTM E112) by objects and by fields were then performed. A Length measurement was also performed on each object. Figure 5 shows a grain size distribution.

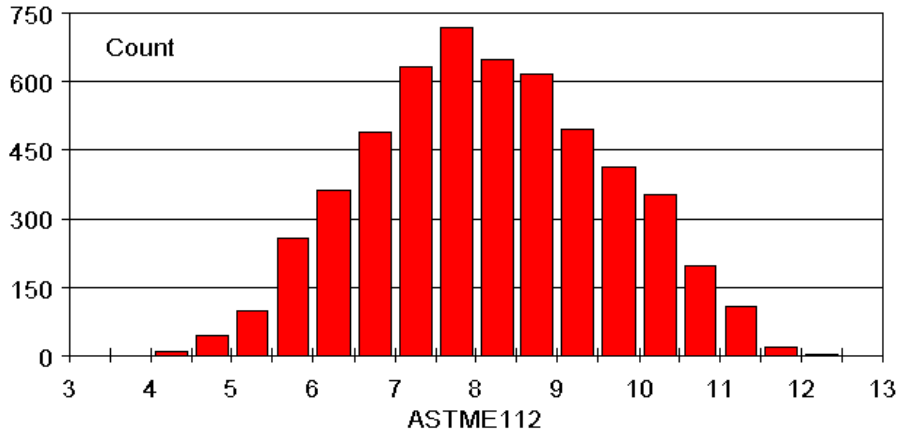


Figure 5: Grain size distribution according to ASTM E112.

	Grain Size by object	Grain Size by field		Length by object (µm)
Minimum	4.13	7.19	Minimum	6.7
Maximum	12.16	7.52	Maximum	122.1
Rating*	7.78	7.37	Average	34.2
			Standard Deviation	17.6

* Rating: The rating is a type of mean. The logarithm is removed before the mean is calculated, and then it is added to the result.