CLEMEX
Image Analysis Report

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Characterization of a Thermal Spray Coating

Sample Description

One mounted sample of thermal spray coating.

Purpose of Analysis

Demonstrate the ability of the image analyzer to discriminate and measure the porosity of the coating.

Equipment Used

Image Analysis System: Clemex Vision Software (1024, 640 or ImPak).
Microscope: Nikon Epiphot 200 with 20X objective (Mag.: 200X).
Stage: Marzhauser EK8B-S1 with autofocus drive.
Camera: Sony XC-77CE 1:1 (728X574) B&W

Procedures
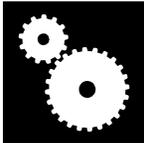
The magnification was set at 200X for a calibration factor of 0.5240 µm/pixel. The pattern used has 2 rows of 10 fields for a total width of 4024 microns and a total amount of 20 fields. The *Three Points Focussing* option was used to perform a perfectly leveled analysis.

The original image (Figure 1a) was improved by a *Delineate* gray transformation before *Gray Thresholding*. It corresponds to the top portion of the coating. The mount and the pores were binarized into blue bitplane while the substrate and the coating were binarized into red bitplane. Figure 1b shows the first detection of these 2 bitplanes overlaid against the modified gray image.

The portion of the red bitplane corresponding to the coating was removed from the red bitplane to isolate the substrate. *Invert*, *Trap*, *Opening* and *Closing* binary operators were used to obtain this result. This lower portion of the coating is not represented here.

Artifacts were removed from the blue bitplane (mount) using *Boolean* binary instructions and pores were isolated from blue bitplane to green bitplane using a *Trap* binary instruction. Figure 2 shows the resulting bitplanes.

Blue bitplane (mount) and red bitplane (substrate) were combined using *Boolean* instructions and *Inverted* into red bitplane to obtain the final coating. Figure 3 shows the outline of the 2 bitplanes that represent the coating (red) and the pores (green) overlaid against the original image.

Figure 4 compares the area percentage of the porosity (green) and the area percentage of the coating without pores (yellow) to the whole coating area.

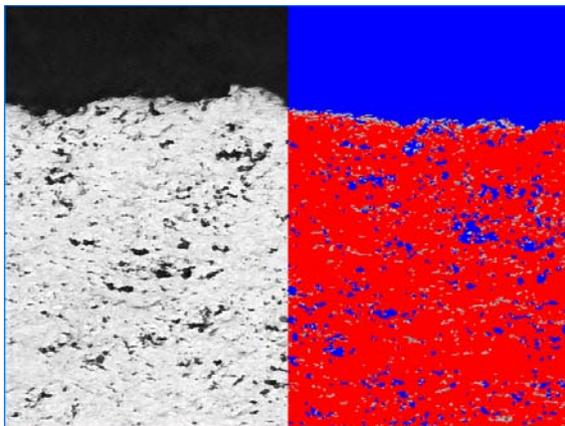The most significant image modifications and final results are as follows:
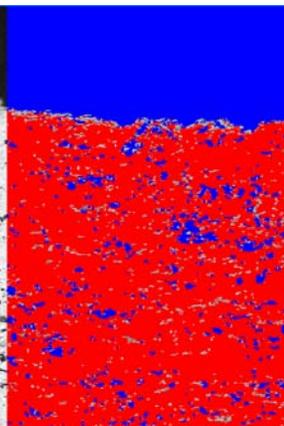

Figure 1a: Original image.

Figure 1b: Binarization by *Gray Thresholding*. Mount and pores are in blue while coating appears in red.
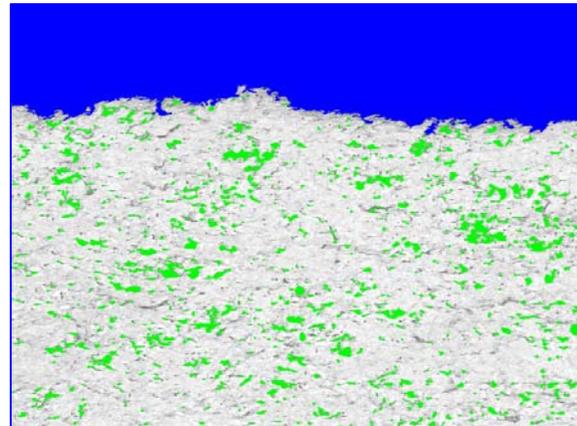

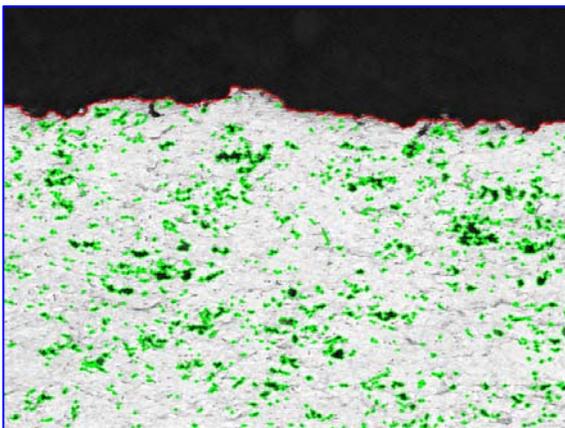**Figure 2:** Pores are isolated from blue bitplane (mount) and transferred into green bitplane.

Figure 3: Green outline of the detected pores and red outline of the coating overlaid against the original image.
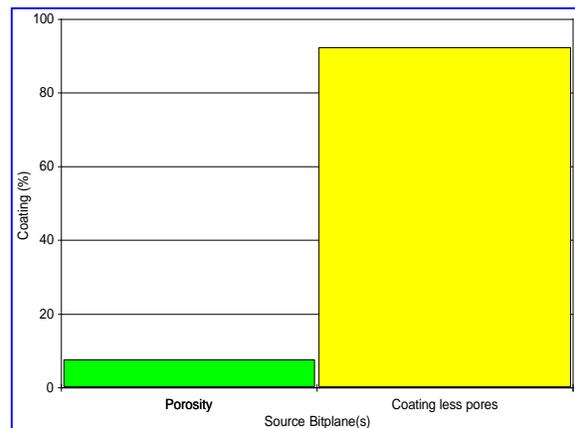

Figure 4: Porosity area percentage (green) and coating without pore area percentage (yellow) compared to the coating (y axis).

Results Summary[1]

Pores:	Area (μm^2)	Length (μm)	Pores / Coating (%)
Minimum	0.3	0.6	
Maximum	375.3	61.8	7.74
Mean	9.3	4.6	
Standard Deviation	15.6	3.7	

Discussion

The image analysis system Clemex Vision can discriminate the pores from the coating and produce area percentage graphic.

At 100x magnification, it was possible to cover the complete coating thickness into a field of view but it was not possible to efficiently isolate pores from the coating. A magnification of 200x allowed performing the analysis with good precision without too many rows of fields. A magnification of 400X would have produce even more precise results but it was then too difficult to properly distinguish the coating form the substrate (lower row of the pattern).

No major problems were encountered through this analysis. It happened that dark spots or scratches from the substrate confused the system such a way that the coating was slightly overestimated. This could be avoided by a refresh of the polishing. It also happened that a portion of the coating was considered as substrate because of its low porosity. The effects of those occasional underestimations tend to counterbalance the effects of the overestimation of the coating surface.

Results are reproducible.

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[1] It is possible to transfer all these results to Microsoft Excel format. Excel offers many valuable statistical tools and substantial graphical versatility.