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FOCUS VARIATION MEASUREMENT OF ELECTRON BEAM MELTED PARTS

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Introduction

Focus variation is a promising technique for the measurement of electron beam melted (EBM) surfaces due to its ability to cope with high slope angles, reflective surfaces and, in general, complex topographies. However, many possible FV set-ups could be adopted for measuring an EBM surface: objective lens magnification, illumination and detector parameters are some of the most relevant control variables that can be varied, in the attempt to achieve optimal measurement results. In this work, the sensitivity of FV measurement to some of such parameters is investigated.

Sample surfaces

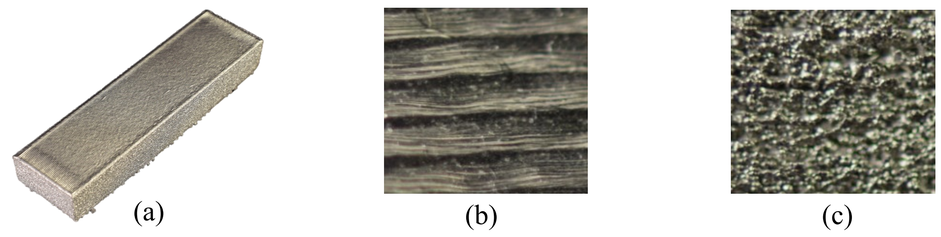

Figure 1. Sample artefact used in the investigation; a) overall view; b) detail of the top surface; c) detail of a side surface. (b and c field of view: (2000 × 2000) µm).

Methods

A (20 × 20 × 75) mm block was made via electron beam melting (EBM) from titanium alloy Ti6Al4V as seen in Figure 1. An Alicona Infinite Focus G5 was used to perform repeated measurements of the same surface regions, whilst varying magnification, type of illumination (coaxial or ring light), light intensity, exposure and contrast at the detector. In this poster, the investigation for the 20× objective (NA 0.4 FoV (0.81 × 0.81) mm) is shown. To reduce the number of combinations, a series of acceptable set-ups (three for coaxial, and three for ring light) were identified through visual inspection of the histogram of pixel intensities as recorded at the detector. Sensitivity was explored by computing a series of areal texture parameters taken from ISO-25178-2 (*Sa*, *Sq*, *Ssk*, *Sku* and *Sz*), and by assessing the significance of their variations through confidence intervals (CIs) on the mean, computed at 95% confidence level. In addition, the percentage of valid points (as opposed to non-measured points) was inspected as a further potential indicator of measurement quality.

Results

The investigated set-ups are illustrated in Figures 2 and 7, for the top and side surface respectively . The corresponding histograms are shown in Figure 3 and 8. The type of illumination was found to be the most influential measurement control parameter, as confirmed by the CIs shown in Figures 6 and 11. FV technology works by detecting local contrast, thus Figures 4, 5, 9 and 10 provide helpful examples to illustrate how different the same surface looks when imaged via coaxial or ring light (RGB maps obtained by focus-stacking). The percentage of non-measured points was also found to be mainly sensitive to illumination type. However, sensitivity was observed only for the more difficult to measure, vertical surface. Instead, for the horizontal surface, the absence of non-measured points was observed with consistency.

Top surface

Measurement	Type of Illumination	Light Intensity	Exposure	Contrast
Coaxial 1	Coaxial	1	30.0 µs	0.65
Coaxial 2	Coaxial	0.5	70.0 µs	0.75
Coaxial 3	Coaxial	0.25	124 µs	0.7
Ring 1	Ring	1	9.0 ms	0.65
Ring 2	Ring	0.5	16.0 ms	0.4
Ring 3	Ring	0.25	32.0 ms	0.5

Figure 2. Set-ups for the top surface, 20× magnification

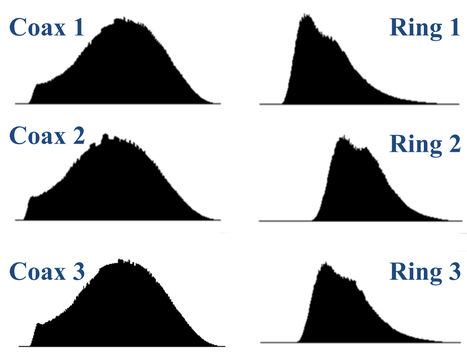

Figure 3. Histograms of pixel intensities corresponding to the set-ups in Figure 2.

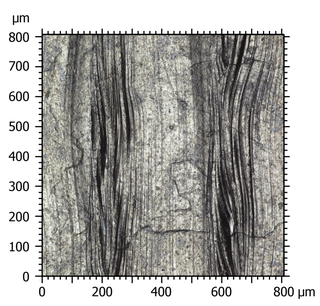

Figure 4. Example RGB map of the top surface using coaxial illumination

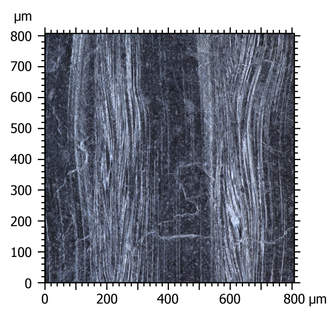

Figure 5. Example RGB map of the top surface using ring light illumination

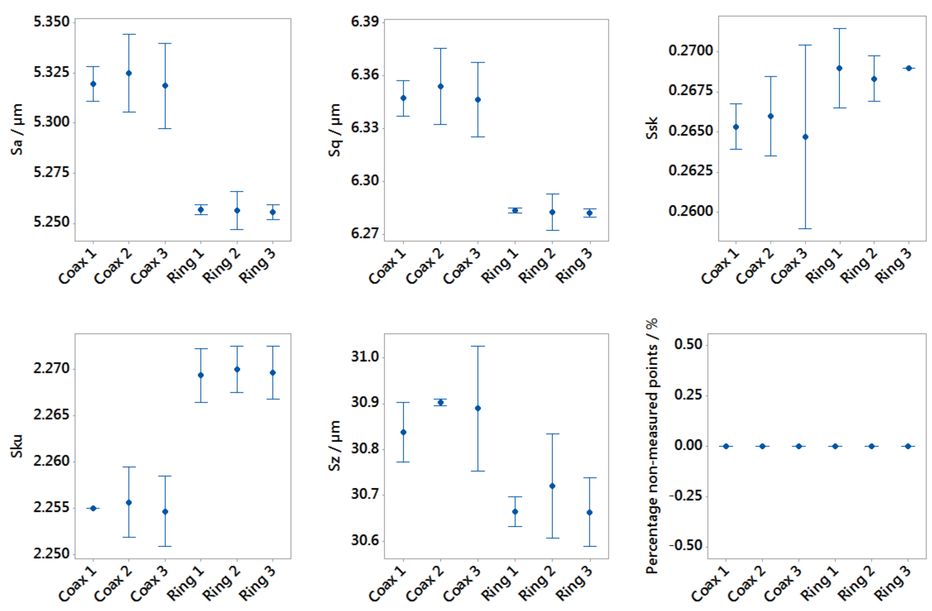

Figure 6. Areal field parameters obtained from the top surface, with the set-ups of Figure 2 (CIs at 95% confidence level)

Side surface

Measurement	Type of Illumination	Light Intensity	Exposure	Contrast
Coaxial 1	Coaxial	1	70.0 µs	0.3
Coaxial 2	Coaxial	0.5	96.0 µs	0.3
Coaxial 3	Coaxial	0.25	188 µs	0.3
Ring 1	Ring	1	9.0 ms	0.65
Ring 2	Ring	0.5	18.0 ms	0.5
Ring 3	Ring	0.25	35.0 ms	0.65

Figure 7. Set-ups for the side surface, 20× magnification

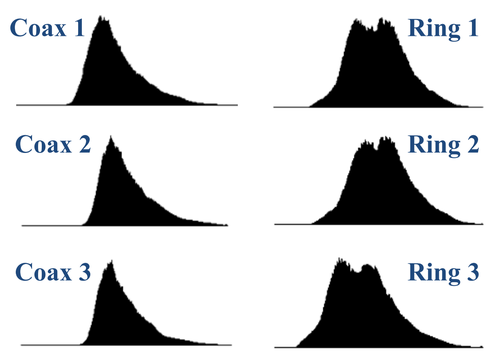

Figure 8. Histograms of pixel intensities corresponding to the set-ups in Figure 7

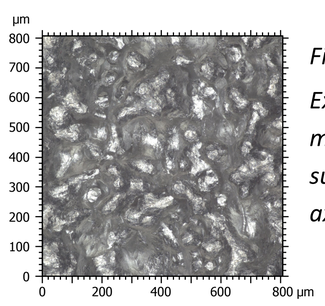

Figure 9. Example RGB map of the side surface using coaxial illumination

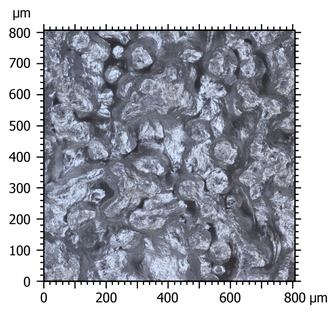

Figure 10. Example RGB map of the side surface using ring light illumination

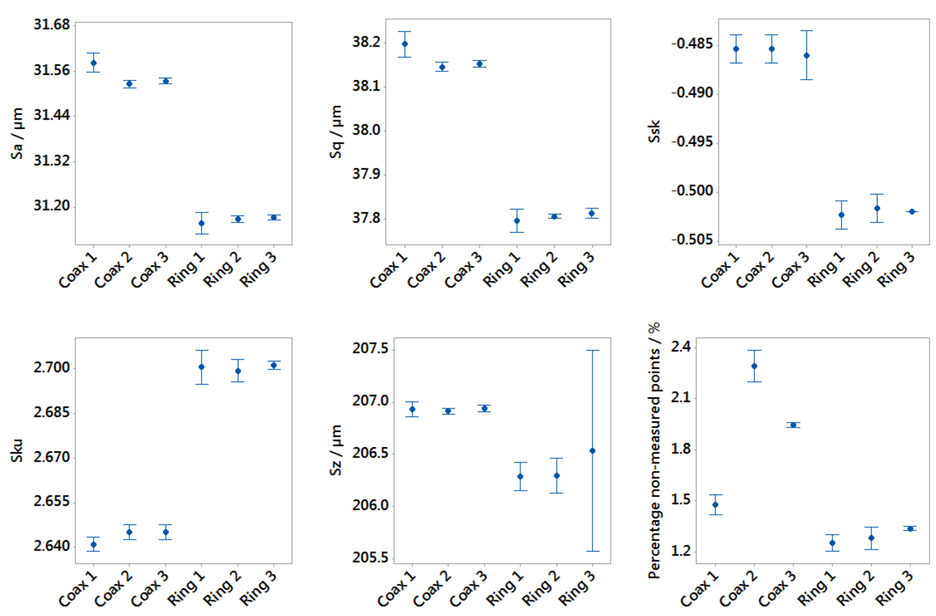

Figure 11. Areal field parameters obtained from the side surface, with the set-ups of Figure 7 (CIs at 95% confidence level)

Conclusions and future work

The selected set of ISO 25178-2 areal field parameters is particularly sensitive to type of illumination (coaxial or ring light) in FV measurement, producing statistically different results in most cases. The percentage of non-measured points is not necessarily a good indicator of performance in the computation of texture parameters. If the surface is not too challenging to measure (e.g. horizontal surface), zero non-measured points are observed in all the set-ups, despite texture parameters being significantly different. When the surface is harder to measure (e.g. vertical surface), the percentage of non-measured points does start to play a role, again primarily sensitive to illumination type . Further investigations are needed to fully understand the reasons for the observed sensitivity of texture parameters. An accurate study of how the actual topographic detail is reconstructed from measurement is ongoing.