Testing of Chromium Carbide Overlay

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Report Prepared for
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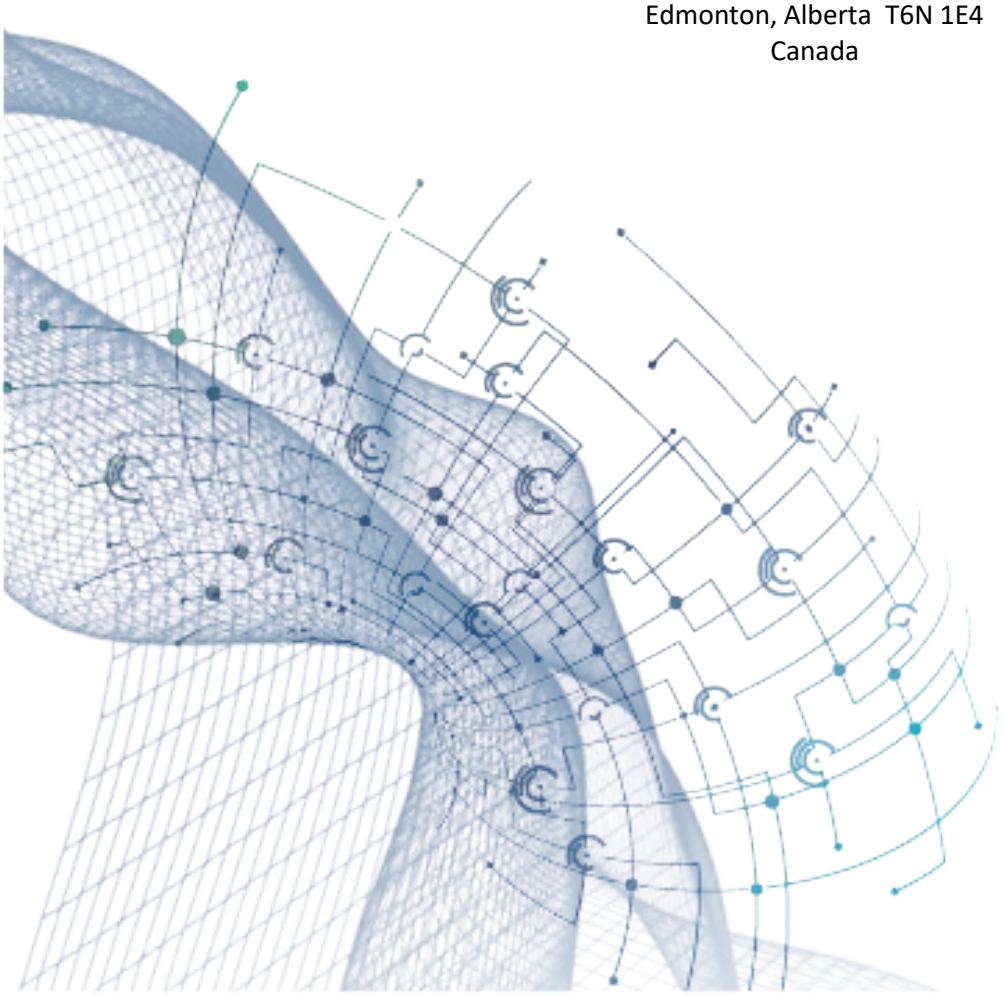

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REPORT REVIEW AND APPROVAL

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TESTING OF CHROMIUM CARBIDE OVERLAY

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HISAN (TIANJIN) CO., LTD supplied InnoTech Alberta (IA) with chromium carbide overlay (CCO) samples for evaluation testing. HISAN (TIANJIN) CO., LTD required the following testing:

- Abrasion testing at the surface and 75% depth location in accordance with ASTM G65-16(2021) Procedure A
- Metallographic preparation and micrographs
- Carbide volume fraction measurements
- Rockwell C surface hardness testing
- Chemical analysis, reporting C, Cr, Mn, and Si in weight percentage.

The sample identification codes and testing requirements are detailed in Table 1

Table 1: Identification codes and testing requirements

IA sample ID	Testing requirements
ML-26-0027-01	ASTM G65-16 (2021) – surface
ML-26-0027-02	ASTM G65-16 (2021) – 75%
ML-26-0029-01	Surface hardness, metallography parent
ML-26-0029-01A	Metallography, micrographs, carbide volume fraction
ML-26-0029-01B	Chemical analysis

Photographs of the as-received samples are provided in Figures 2 and 3.

ASTM G65-16(2021) abrasion testing[1] (Procedure A) was conducted on samples S-26-0027-01 and -02. The results, reported as mass loss[2,3], are detailed in Table 2. A photograph of samples after testing are shown in Figure 3.

Rockwell C hardness testing[4] (150 kg load, 5 s dwell time) was performed on the surfaces of sample S-26-0029-01. The results are reported in Table 3.

Sample S-26-0029-01A was prepared using standard metallurgical techniques. The sample was etched[5] to help reveal the microstructure of the CCO. Micrographs of the sample are shown in Figure 4 through 9.

The area percentage of primary carbides was measured on sample S-26-0029-01A using a VHX 7100 Keyence digital microscope ten random locations, captured at x200 magnification. The results are summarized in Table 4.

[1] The abrasion test equipment was calibrated using AISI Tool Steel D2 material before testing and yielded measurements of 39.58 mm^3.
[2] The mass balance was verified prior to taking measurements using VACS Ltd. standard weights (S/N. A145, Certification #63490, 200 g), and was measured to be 199.999 g.
[3] Testing was conducted according to the ASTM Test Method. However, the results are reported either as adjusted mass loss (g) or adjusted volume loss (mm^3) based on an agreement between InnoTech Alberta and the client. These reported losses were adjusted to account for the actual size of the rubber-lined wheel using a ratio with the original wheel size.
[4] Hardness test equipment was calibrated prior to testing using a standard block (Certificate #33664285) and was measured to 65.1 and 64.9 HRC.
[5] The sample was etched using 2.5 ml HNO_3, 100 ml HCl & 20 g $FeCl_3$, a modified version of etchant #24, ASTM standard E407-07 (2015)$^{\epsilon 1}$.

Sample S-26-0029-01B was sent for chemical analysis[6] to determine the content of C, Cr, Mn, and Si in the overlay. The results are detailed in Table 5.

Table 2: ASTM G65-16(2021) abrasion wear test results

Sample ID	Test location	Initial mass (g)	Final mass (g)	Mass loss (g)
S-26-0027-01	Surface	283.566	283.404	**0.163**
S-26-0027-02	75%	198.733	198.558	**0.176**

Table 3: Area percentage measurement of primary carbides

Measurement #	Carbide volume fraction (%)
1	54
2	50
3	52
4	44
5	52
6	52
7	46
8	45
9	48
10	45
Average	**49**
St Dev	**4**

Table 4: Surface hardness results

Indent #	Hardness (HRC)
1	65.7
2	65.6
3	62.5
4	64.3
5	64.9
Average	**64.6**
St Dev	**1.3**

Table 5: Chemical analysis results

Element	Composition (wt%)	Analysis method
Carbon	4.43	Combustion
Manganese	1.30	ICP AES
Silicon	0.96	
Chromium	42.0	

[6] Chemical analysis was conducted by Element Materials Technology, Cambridge, ON.

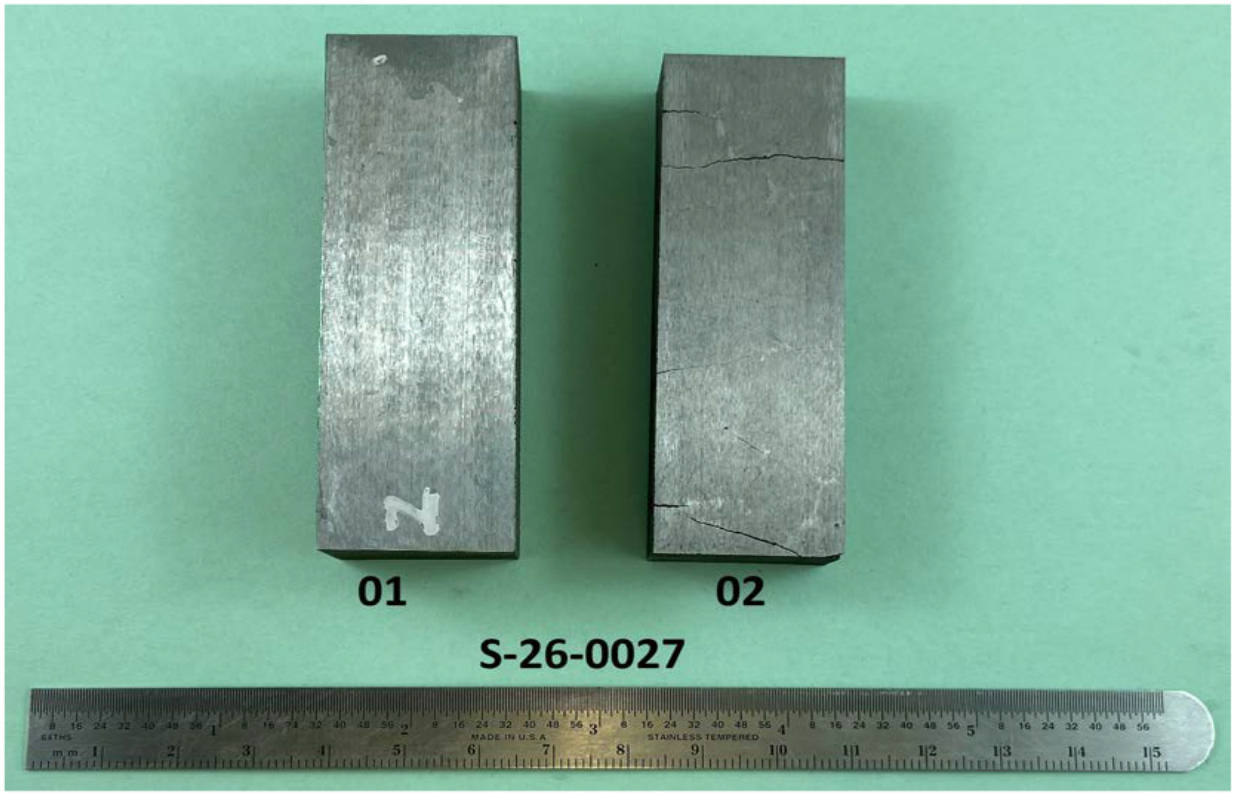

Figure 1: Photograph of the as-received samples S-26-0027-01 and -02.

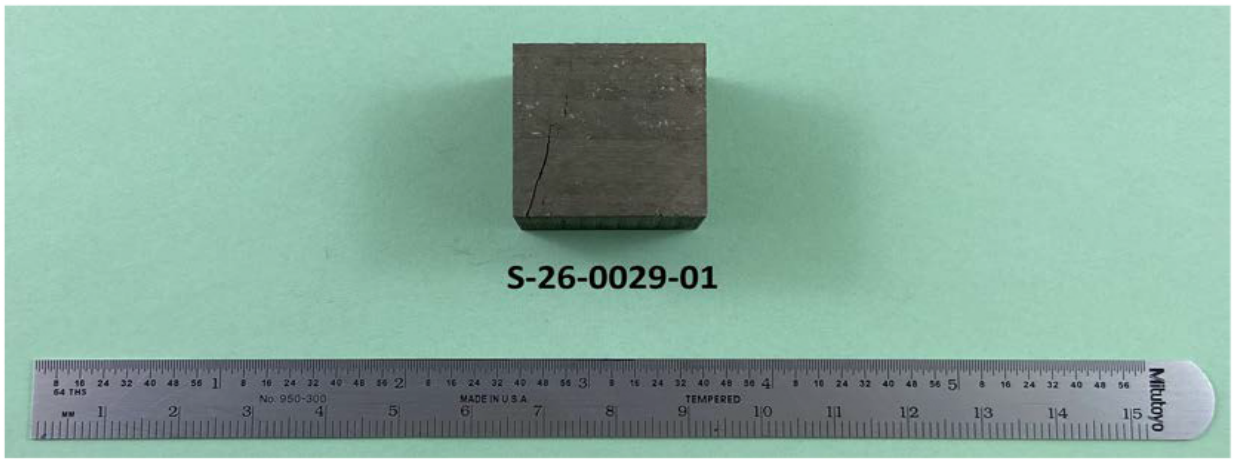

Figure 2: Photograph of the as-received sample S-26-0029-01.

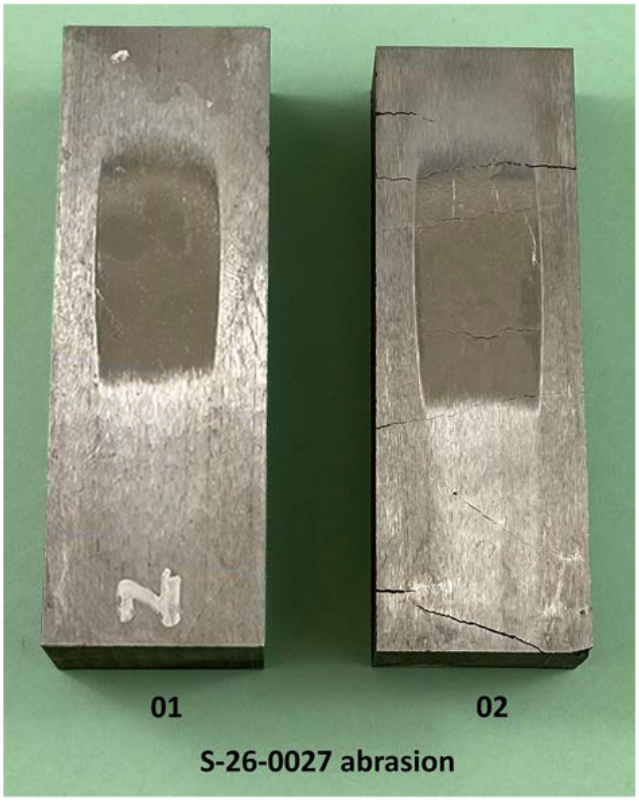

Figure 3: Photograph of samples S-26-0027-01 and -02, after abrasion testing.

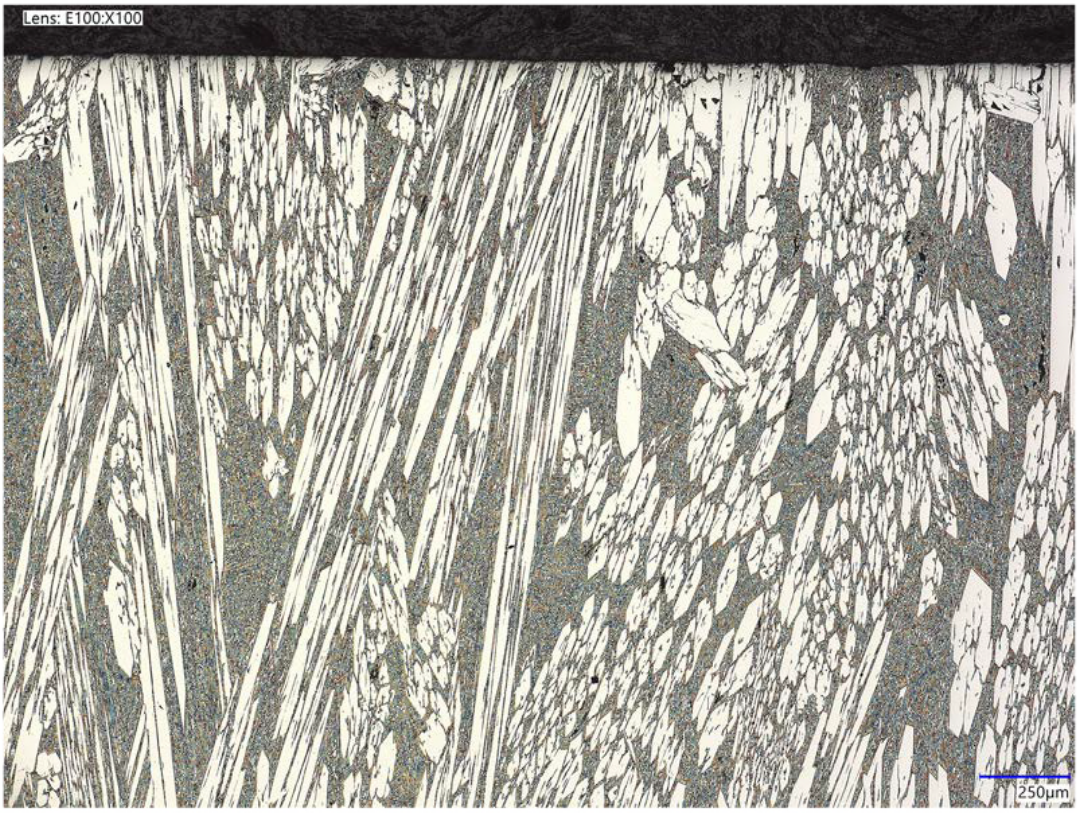

Figure 4: Micrograph of S-26-0029-01A, etched, showing the as-welded surface. Magnification x100.

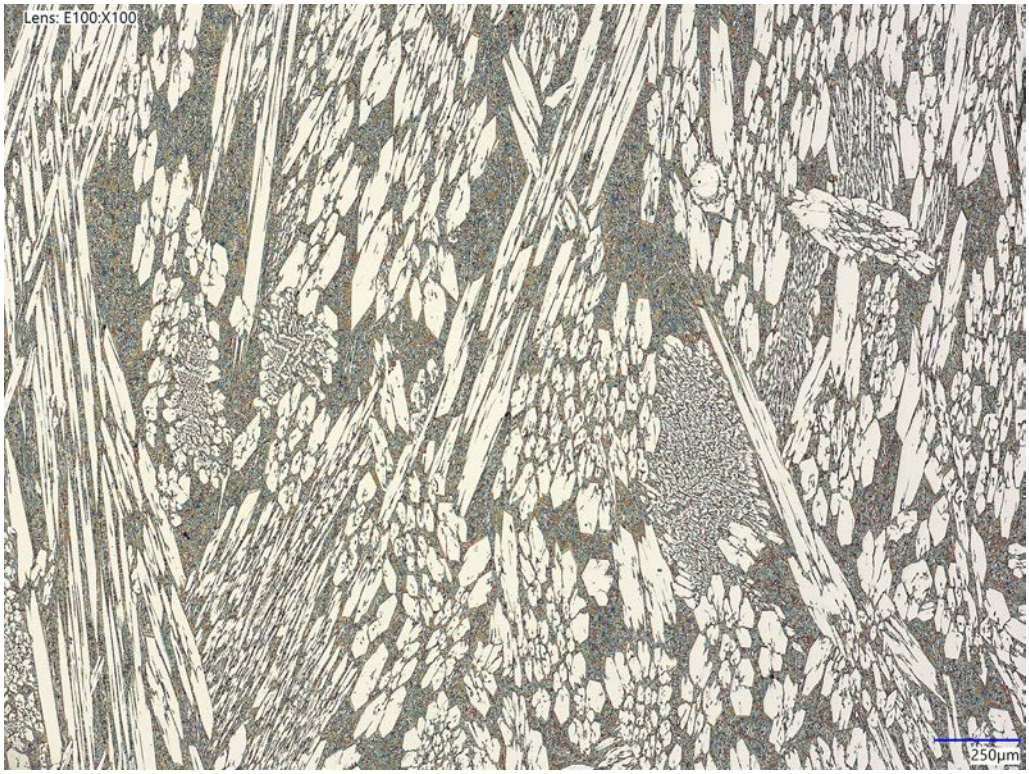

Figure 5: Micrograph of S-26-0029-01A, etched, showing the mid-point of the second pass. Magnification x100.

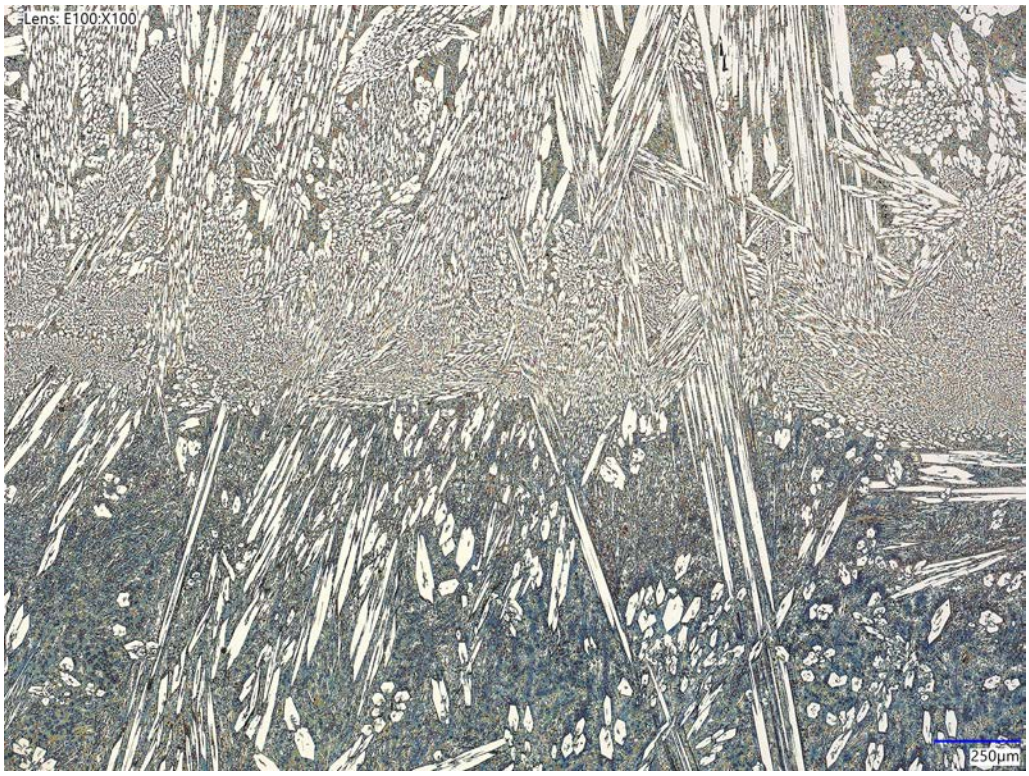

Figure 6: Micrograph of S-26-0029-01A, showing the transition zone between the first and second pass. Magnification x100.

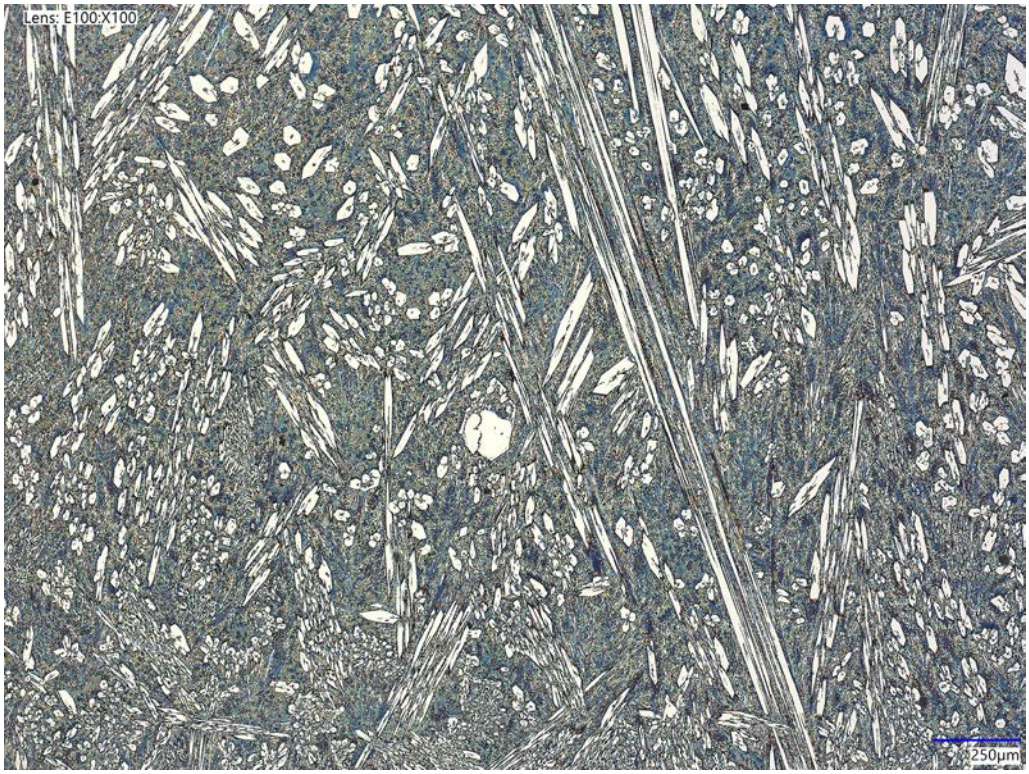

Figure 7: Micrograph of S-26-0029-01A, etched, showing the mid-point of the first pass overlay. Magnification x100.

Figure 8: Micrograph of S-26-0029-01A, etched, showing the overlay/base material interface. Magnification x100.

Figure 9: Composite micrograph of S-26-0029-01A, etched, showing the full cross-section of the sample. Magnification x30.