

Island Interface Porosity in PBF-LB 316L: Effects of Island Overlap and Interlayer Shift in Chessboard Scanning

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Abstract

Powder bed fusion – laser beam (PBF-LB) has become one of the most adopted additive manufacturing (AM) technologies for producing complex metallic components. However, porosity remains a critical defect compromising mechanical performance. Island-based scan strategies, such as the chessboard pattern, reduce thermal gradients and residual stresses. Despite these benefits, the chessboard strategy can lead to lack-of-fusion defects at adjacent island interfaces. While interlayer shift (moving the island grid between layers) has been used to mitigate this issue, the influence of island overlap (within the same layer) has received limited attention. This work investigates the isolated and combined effects of island overlap and interlayer shift on the porosity of AISI 316L stainless steel fabricated by PBF-LB. Specimen porosity was quantified by optical microscopy and digital image analysis of metallographic cross-sections parallel to the build direction (Z-axis). The results demonstrate that adding a 1 mm interlayer shift when a very small island overlap was used had little effect on reducing lack-of-fusion voids at the island interfaces. Conversely, increasing island overlap reduced porosity at the island interfaces due to enhanced remelting between adjacent scan regions. An island overlap of 135% without interlayer shift homogenized porosity, reducing the mean porosity to approximately 0.14%. Adding a 1 mm interlayer shift further reduced this value to 0.10%. These findings highlight island overlap as a critical, underexplored parameter in PBF-LB process planning that, combined with interlayer shift, enables enhanced porosity control with negligible impact on manufacturing productivity.

Keywords: Additive manufacturing, Island scanning, Island shift, Interlayer offset, Stainless steel

1 Introduction

Powder bed fusion – laser beam (PBF-LB) is an additive manufacturing (AM) process capable of producing complex metal geometries that are difficult to achieve via conventional methods such as machining, casting, or forging [1]. Owing to its design flexibility, it is widely used in aerospace, medical, and automotive applications. PBF-LB commonly processes AISI 316L stainless steel because of its corrosion resistance, mechanical properties, and thermal stability. However, the steep thermal gradients and high cooling rates inherent to the process promote the formation of internal defects during solidification [1]. Among these, pores are particularly critical because they degrade mechanical strength [2], fatigue resistance [3], and structural reliability [4]. Pores may result from metal evaporation, powder spattering, incomplete melting, and variations in laser absorption [5]. Therefore, minimizing porosity is essential to ensure part integrity. Porosity can be evaluated by gas pycnometry, the Archimedes method, X-ray computed tomography, and metallographic analysis, each having specific limitations [5]. Metallographic analysis provides accurate pore characterization but is limited to two-dimensional sections. Zavala-Arredondo [6] recommended ASTM E2109-01 [7] as a standardized method for porosity quantification in PBF-LB.

The chessboard (island-based) scanning strategy is widely used for 316L because it reduces residual stresses by shortening scan vectors and alternating scan directions [8]. However, inadequate process parameters can promote lack-of-fusion and keyhole defects at island interfaces [9]. Low energy input favors lack of fusion, whereas excessive energy density can promote alloy evaporation and keyhole/gas porosity [10]. High energy input also enlarges the melt pool and intensifies Marangoni convection, which may contribute to gas entrapment [5].

Modifying the island overlap (IO), governed by the island spacing (Is), may reduce interface porosity by promoting local remelting. However, many studies using chessboard scanning set Is equal to the hatch distance (hd) value [8, 11], while others do not explicitly report island overlap parameters [12]. Xiong et al. [10] reduced interface defects in titanium alloys by increasing island spacing (0.15 to - 0.45 mm) and adjusting laser delay time. Nevertheless, the isolated effect of IO on interface porosity remains insufficiently investigated.

An alternative approach is the island shift (Ish), which translates the chessboard pattern between successive layers, distributing defects along the build direction and reducing their local concentration [13]. Holman et al. [14] reported increased porosity in overlapping regions of Inconel chessboard partitions, associating it with short scan vectors and local heat accumulation near partition boundaries. Although Ish can redistribute interface defects, it does not prevent pore formation associated with inadequate IO or necessarily eliminate these pores through subsequent-layer remelting [10].

Therefore, the specific contribution of IO to porosity at island interfaces remains insufficiently explored. This study investigates the effect of IO , both independently and in combination with Ish , on the porosity of AISI 316L processed by PBF-LB. The results provide insight into IO as a relevant but underexplored parameter for optimizing chessboard scanning strategies.

2 Materials and Methods

2.1 Scanning strategy

Before describing the experiments, it is necessary to present the main chessboard parameters and what was assumed in this study in relation to the *IO*. In the chessboard scanning strategy the raster pattern is used and the laser vector direction might be unidirectional (as shown by the arrows in **Fig. 1a**) or bidirectional (alternating direction on each line). The raster angle between the islands is often 90° , and usually, there is an increase of 67° in the laser direction with each new layer (**Fig. 1b**). The interlayer rotation (e.g., 67°) is normally used to improve mechanical performance [15]. An important parameter related to part integrity and pore formation is the hatch distance (*hd*), which is the distance between two consecutive scan tracks (see **Fig. 1a**) [16]. The percentage of overlap between adjacent scan tracks can be calculated as described in [16] and expressed in Equation 1.

$$HO [\%] = (w - hd) / w * 100 \quad \text{Equation 1}$$

where *HO* represents the hatch overlap percentage, *w* is the bead width, and *hd* is the hatch distance between adjacent scan tracks.

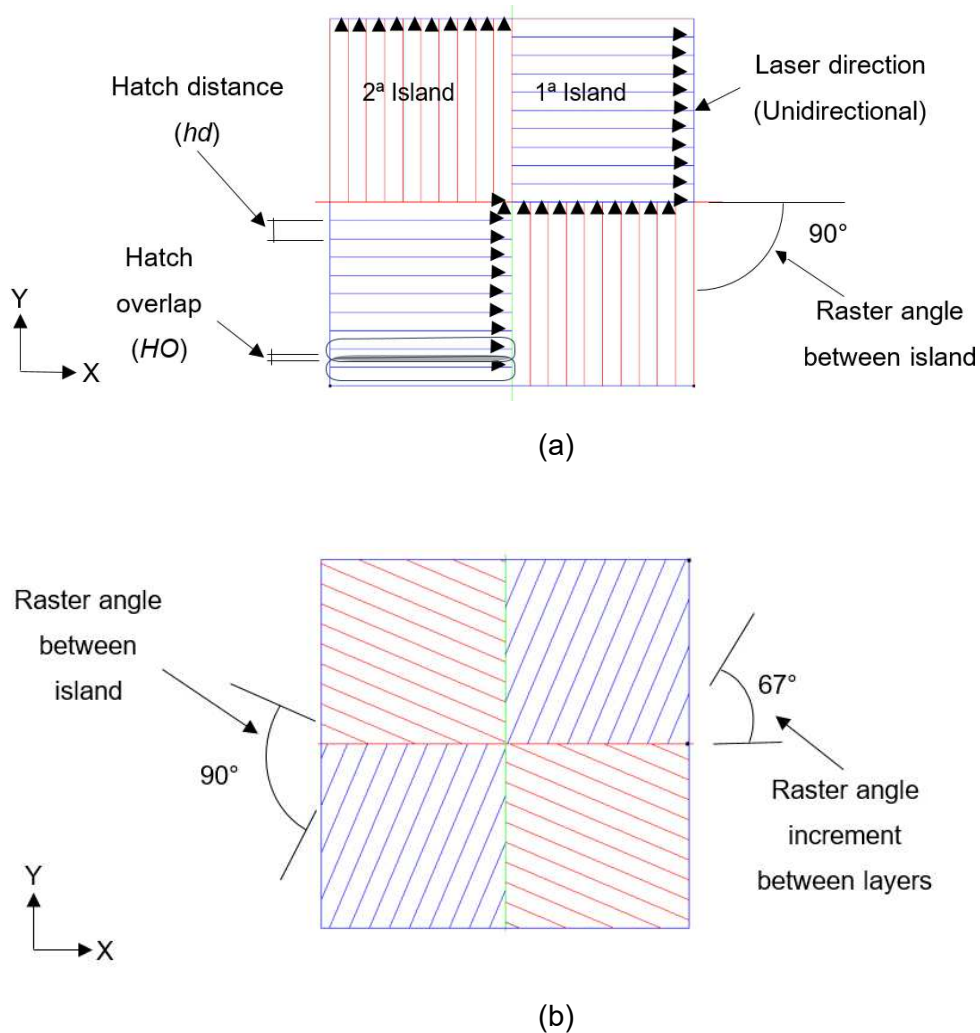


Fig. 1 Basic parameters of the chessboard strategy: layer (n) (a) and layer (n+1) (b)

Another common parameter is the interlayer chessboard shift (Ish), as shown in **Fig. 2**. In this example, a 1 mm shift is applied along the X and Y axes on layer $n+1$ relative to layer n . Finally, it is possible to modify the island overlap (IO) between adjacent islands, inducing local remelting at their interface (**Fig. 3**). Typically, IO is governed by the island space (Is) or island gap (Ig) parameter, which defines the distance from the laser scan line of one island to the endpoint of the adjacent island's scan line, thereby dictating the physical spacing between adjacent island edges (**Fig. 3**). In commercial software such as Autodesk Netfabb, Is is set as half the hatch distance ($0.5hd$) relative to the border of each neighboring island, yielding $Is = 0.5hd + 0.5hd + Ig$, which simplifies to:

$$Is = (hd + Ig) \quad \text{Equation 2}$$

Consequently, Is is directly determined by the user-defined hd and Ig . In this work, knowing the w , the IO was calculated using Equation 3.

$$IO = [w - Is] / w * 100 \quad \text{Equation 3}$$

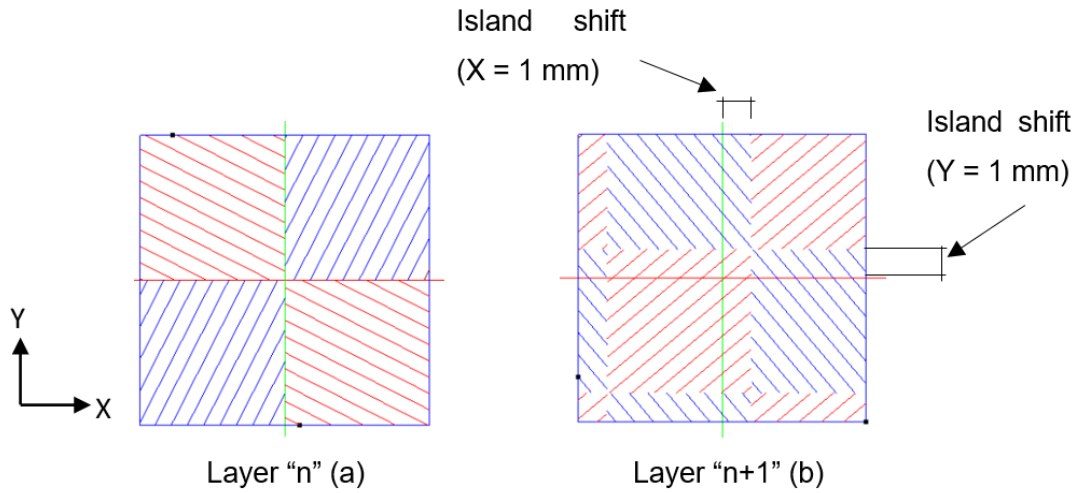


Fig. 2 – Layer shift (Ish) in the X and Y axes (1 mm): layer “n” (a) and layer “n+1” (b)

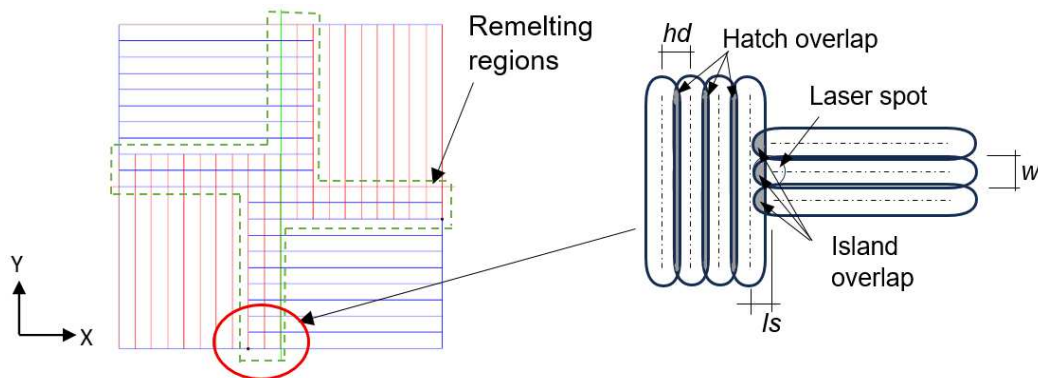


Fig. 3 Remelting between islands in the X-Y plane and the definition of hatch overlap and island overlap

2.2 Material and main manufacturing parameters

The gas-atomized 316L stainless steel powder from Heraeus (data from the Heraeus product certificate 5100948, batch 9005709484, 12/18/2020) was used in this work. The PBF-LB system used was an Alkimat 200, with a build volume of $250 \times 250 \times 280$ mm, equipped with a 200 W fiber laser (1060 nm) and an ~ 80 μm spot size under a nitrogen atmosphere. The chamber and powder reservoir were maintained at 100 °C. The standard process parameters for AISI 316L provided by the machine manufacturer are presented in **Table 1**.

Table 1 Alkimat's PBF-LB process parameters for the 316L material

Parameters	Value
Laser power	165 W
Laser speed (s)	650 mm/s
Layer thickness	0.030 mm
Hatch distance (<i>hd</i>)	0.110 mm
Bead width (<i>w</i>)	0.119 mm
Island gap (<i>Ig</i>) ref.	0.000 mm
Island spacing (<i>Is</i>) ref.	0.110 mm

Using the data presented in **Table 1**, a *HO* of 8% between adjacent scan tracks was obtained. When the *Ig* is equal to zero, the *Is* becomes equal to the *hd*. Under this condition, the *IO* is also 8%, demonstrating the coherence between Equations 1 and 3.

To evaluate the proposed configurations, cubic specimens ($10 \times 10 \times 10$ mm) were manufactured. Machine code was generated in CLI (Common Layer Interface) format using the in-house RP3 software [17]. The chessboard strategy employed 5×5 mm islands, and specimens were built with 333 layers using the parameters listed in **Table 1**. Contour scans were omitted to restrict porosity analysis to the infill region, avoiding the additional contour–infill interface that could influence porosity measurements. Five specimens were produced for each configuration.

At the end, to evaluate the variation in build time as a function of changes in *IO* and *Ish*, a study of build time was conducted using the RP3 software.

2.3 Island overlap study

In this set of experiments, no *Ish* was used, as they were designed to evaluate the isolated effect of *IO* variation on porosity. The *IO* percentage was increased as detailed in **Table 2**. To help identify the configurations, the experiments were coded as OnSn, where O represents the *IO*, in %, and S the *Ish*, in millimeters. Then, O8S0 means 8% of the *IO* without any *Ish* (S0). This particular configuration (O8S0) was included to represent the baseline configuration, with *Is* equal to *hd*. As in this configuration, there is no *Ish*; a concentration of pores is expected right in the middle of the specimens, between the islands.

Table 2 Configurations varying *IO* without *Ish*

N°	Code	<i>Ig</i> (mm)	<i>IO</i> (%)	<i>Ish</i> (mm)
Ref	O8S0	0.00	8	0.00
1	O50S0	-0.05	50	0.00
2	O92S0	-0.10	92	0.00
3	O135S0	-0.15	135	0.00
4	O176S0	-0.20	176	0.00

2.4 Island overlap combined with interlayer shift study

To evaluate the combined effect of *IO* and *Ish*, the configurations summarized in **Table 3** were defined, all incorporating a 1 mm layer shift (S1). Additionally, configuration O8S1 was included as a baseline reference to evaluate the average porosity against a condition typically reported in the literature and used in industrial PBF-LB fabrication [7].

Table 3 Configurations combining *IO* with *Ish*

N°	Code	<i>Ig</i> (mm)	<i>IO</i> (%)	<i>Ish</i> (mm)
Ref.	O8S1	0.00	8	1.00
1	O50S1	-0.05	50	1.00
2	O92S1	-0.10	92	1.00
3	O135S1	-0.15	135	1.00
4	O176S1	-0.20	176	1.00

2.5 Porosity analysis

Specimen porosity was quantified by optical microscopy and digital image analysis of metallographic cross-sections parallel to the build direction (Z-axis). Micrographs were acquired from a grid comprising one central and two lateral columns (**Fig. 4**) to evaluate the spatial distribution of pores. Specimens were sectioned in the XZ plane using an Isomet 4000 precision cutter (3500 rpm, 1.5 mm/min feed rate) [7], [18]. After the initial measurements, approximately 1.0 mm of material was removed by successive grinding to expose two additional planes (faces 3 and 4; **Fig. 4**). For each configuration, four specimens were analyzed in the XZ plane, yielding 240 images, while a fifth specimen was sectioned in the XY plane to evaluate melt tracks and island junction defects.

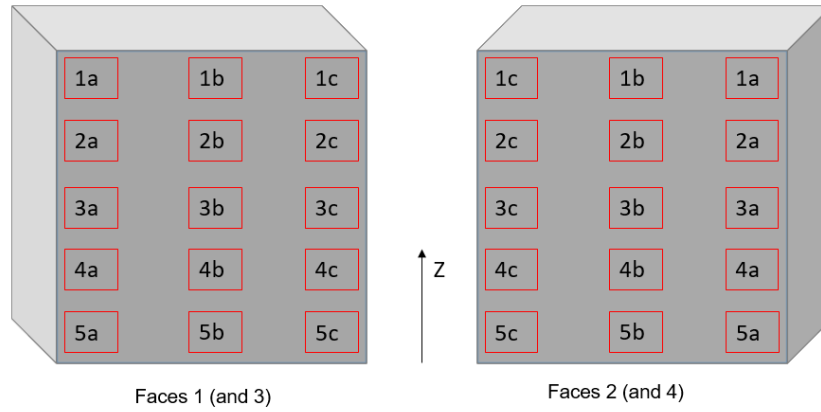


Fig. 4 Position of the micrographs on the sectioned sample

Specimens were embedded using a Struers Predopress system, followed by sequential grinding with SiC papers (120–2400 grit) at 300 rpm and final polishing with a 4 μ m aluminum oxide suspension at 100 rpm, as described in [18].

Porosity was measured using an SC30 optical microscope at 50 $\times$ magnification, and image analysis was performed with analySIS software (v5.1). For microstructural characterization, Adler's reagent (12 mL distilled water, 15 mL HCl, 0.9 g Iron (III) chloride hexahydrate) was applied for 20 s.

The porosity analysis was conducted in accordance with the standard [7], and statistical validation was performed as described in Section 8.2.10. The image capture and analysis methodology proved accurate, yielding a relative accuracy (RA) value of 1.17%.

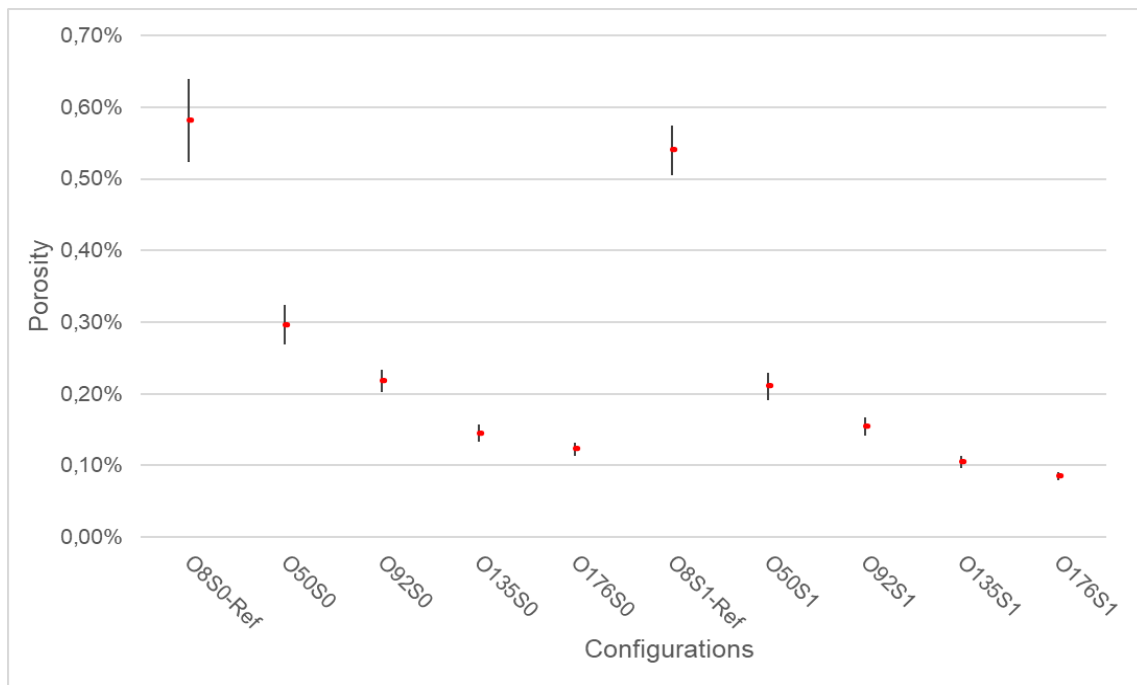
3 Results and Discussions

3.1 Global porosity results

Table 5 summarizes the global mean porosity obtained across all evaluated regions from 240 optical micrographs per configuration. The numerical data were calculated in accordance with Section 8.2 [7] and indicated that all measurements met the acceptance criteria. Additionally, **Fig. 5** illustrates these results to facilitate discussion.

Table 5 – Global average porosity (considering 240 images in each configuration)

Configurations	Global Porosity (%)	Standard Deviation (%)	Dispersion (%)	Statistical Validation RA (%) ($\leq 10\%$)
O8S0-Ref	0.58	0.45	0.06	9.96
O50S0	0.29	0.21	0.03	9.42
O92S0	0.22	0.12	0.02	7.16
O135S0	0.14	0.09	0.01	8.11
O176S0	0.12	0.07	0.01	7.77
O8S1-Ref	0.54	0.27	0.04	6.42
O50S1	0.21	0.15	0.02	9.08
O92S1	0.15	0.10	0.01	8.15
O135S1	0.10	0.07	0.01	8.18
O176S1	0.08	0.04	0.01	6.75

**Fig. 5** The global average porosity for each configuration

Overall, the results show that porosity decreases as *IO* increases, indicating a direct correlation. Furthermore, specimens manufactured with an *Ish* exhibited lower average porosity than those produced without it, aligning with the findings of [13]. However, as shown in **Fig. 5**, keeping the 1 mm shift constant while increasing *IO* leads to a continuous decrease in porosity. This suggests that inadequate *IO* leads to pore formation that cannot be fully mitigated by *Ish* alone. A direct comparison between O8S0 and O8S1 clearly demonstrates this behavior. Consequently, under the specific manufacturing parameters tested, *Ish* alone is insufficient to substantially reduce porosity. This implies that partial

remelting of the underlying layer does not eliminate the majority of pre-existing interisland pores. Accordingly, these findings support the premise that *IO* must be optimized.

3.2 Local porosity analysis of the configurations

As observed in the previous section, the O8S0 configuration exhibited the highest global average porosity and the largest dispersion in results. This behavior can be associated with a central line of pores observed at the interface between islands (**Fig. 6a**), a characteristic of lack-of-fusion defects [12]. With the 1mm shift (O8S1), the pores were scattered throughout the specimen's face (**Fig. 6b**). The numerical results in **Table 6a** confirm that column *b* (which contains the island interface) presents higher porosity than columns *a* and *c*. The wide variation between minimum and maximum values (0.223% and 1.419%) contributes to the high dispersion. This is not observed in **Table 6b**.

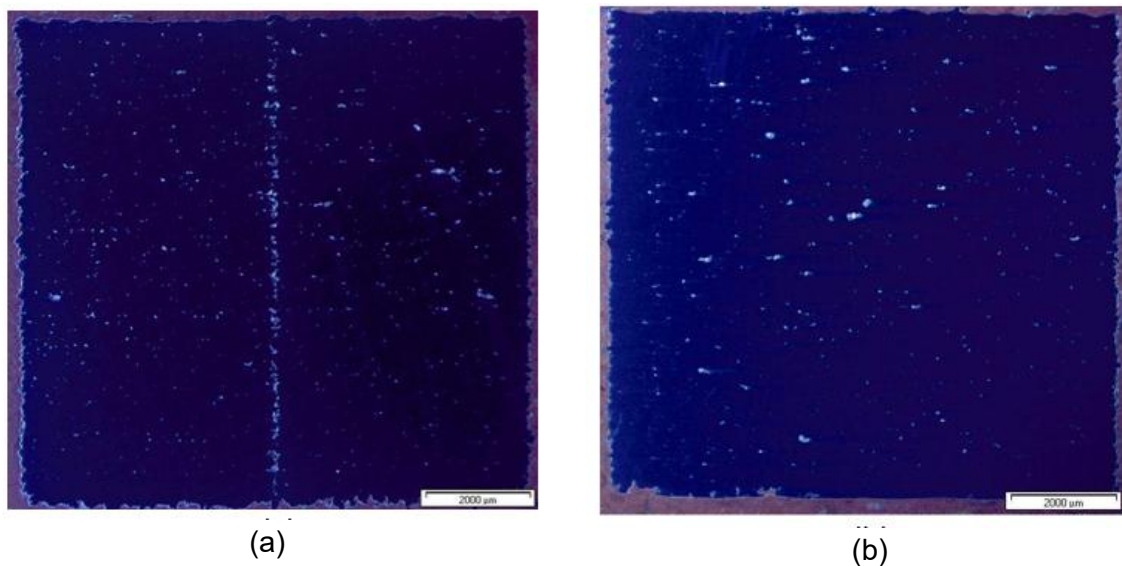


Fig. 6 Examples of micrographs images (ZX Plane) showing pore distribution of the reference configurations: O8S0 (a) and O8S1 (b) (12.5x magnification)

Table 6 – Local average porosity (considering 16 faces) of the reference configurations: O8S0 (a) and O8S1 (b)

O8S0-Ref Local Porosity (%)				O8S1-Ref Local Porosity (%)			
n	a	b	c	n	a	b	c
1	0.505	1.419	0.319	1	0.674	0.734	0.614
2	0.483	1.236	0.326	2	0.630	0.619	0.516
3	0.403	1.359	0.369	3	0.623	0.616	0.477
4	0.293	1.182	0.300	4	0.535	0.571	0.426
5	0.242	1.068	0.223	5	0.353	0.387	0.321

(a)
(b)

As observed in **Table 5**, increasing the *IO* from 8% (O8S0) to 50% (O50S0) the global average porosity decreased from 0.58% to 0.29%; however, the pores remained concentrated at the interface (**Table 7a**), indicating incomplete remelting (**Fig. 7a**). A similar behavior was observed for the O92S0 configuration, where column *b* (**Table 7b**) exhibited higher porosity, confirming that this *IO* level is still insufficient to eliminate lack-of-fusion

defects (**Fig. 7b**). Insufficient overlap limits melt-pool interaction across the interface, leaving regions that may not be fully consolidated. Increasing IO extends this interaction, increasing the remelted volume and reducing the probability of unbonded regions [10]. This was the case with an overlap of 135% (O135S0), where the interface defect was no longer observed (**Fig. 7c**). Porosity became uniformly distributed across columns a , b , and c , indicating a good mitigation of interface defects. For configuration O176S0, lack-of-fusion defects were also absent, but lower porosity in column b (**Table 7d**) suggests effective remelting at the interface. However, because melt-pool dimensions and its thermal conditions depend on laser power, spot size, v , and hd (energy density [8]), the IO value is process-window specific. While lack of fusion can cause porosity, the excessive fusion in this region can also lead to keyhole porosity [13] or even cracking [14].

Island junctions present distinct thermal conditions from the interior of the scan regions because laser vector termination and initiation locally modify energy deposition. Observing the geometry of a single track in the YZ plane, Khairallah et al. [4] highlighted the track-end region, where the laser starts and stops at the ends of transverse vectors. In this region, the melt-pool depth gradually decreases [**Fig. 7(a)**], potentially resulting in an unfused region, if the overlap with neighboring tracks is insufficient.

Furthermore, the overlap between adjacent tracks in the XY plane decreases toward their ends, eventually reaching zero (zero-overlap point, **Fig. 7(b)**). When these tracks meet the neighboring track from the adjacent island at a 90° angle, an uncovered region may remain, becoming susceptible to lack-of-fusion pore formation. When raster rotation between layers is applied (e.g. 0° , 60° , and 80° in **Fig. 7(b)–(d)**, respectively), this uncovered region changes geometry and increases in area. This indicates that, for a given IO , layers with unfavorable raster angles are more prone to pore formation than others. These combined effects demonstrate that IO should be defined with explicit consideration of end-of-track geometry.

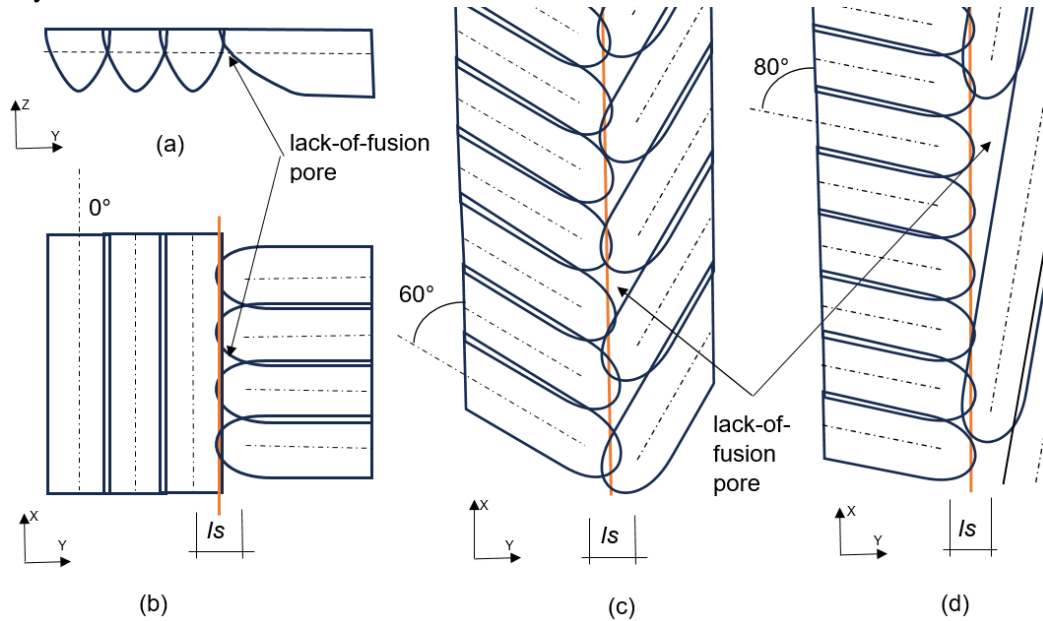
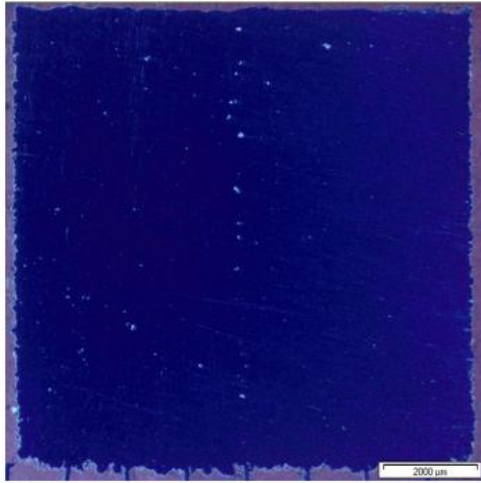
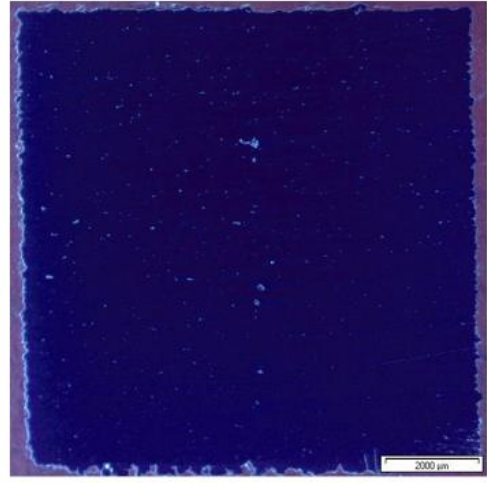


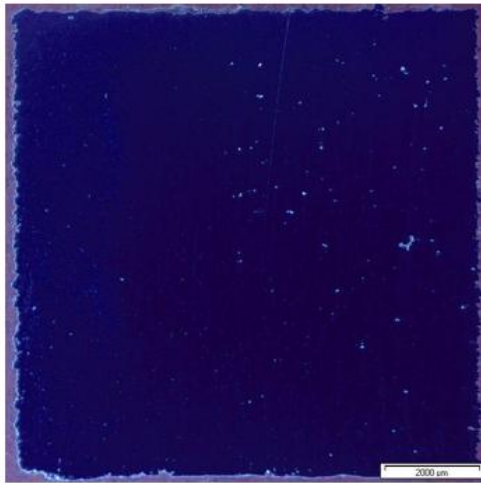
Fig. 7 Schematic of track geometry and laser scanning vector orientation at the island interface: (a) YZ cross-section showing melt pool depth variation, and XY top view with raster rotation relative to the island boundary at (b) 0° , (c) 60° , and (d) 80° .



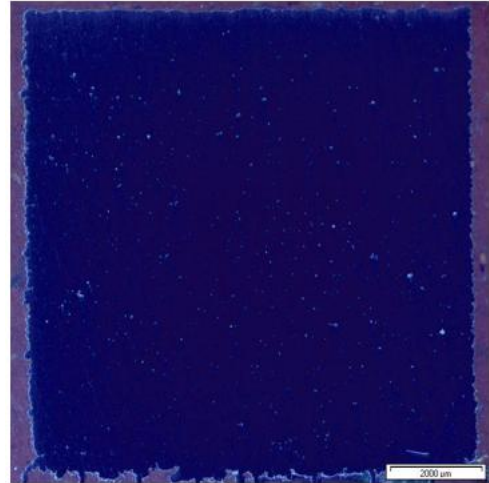
(a)



(b)



(c)



(d)

Fig. 8 Examples of micrographs images (ZX Plane) showing pore distribution of configurations without *Ish*: (a) O50S0, (b) O92S0, (c) O135S0 and (d) O176S0 (12.5x magnification)

Table 7 – Local average porosity (considering 16 faces) of the configurations without layer shift: O50S0 (a), O92S0 (b), O135S0 (c) and O176S0 (d)

O50S0 Porosity (%)			
n	a	b	c
1	0.290	0.619	0.193
2	0.217	0.495	0.199
3	0.197	0.395	0.198
4	0.232	0.458	0.157
5	0.170	0.362	0.153

(a)

O92S0 Porosity (%)			
n	a	b	c
1	0.213	0.348	0.168
2	0.175	0.354	0.194
3	0.166	0.329	0.152
4	0.202	0.325	0.142
5	0.147	0.260	0.105

(b)

O135S0 Porosity (%)			
n	a	b	c
1	0.210	0.222	0.124
2	0.137	0.194	0.111
3	0.141	0.132	0.105
4	0.156	0.150	0.158
5	0.105	0.107	0.123

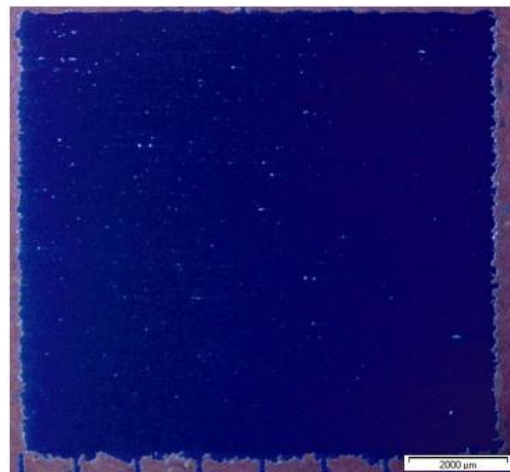
(c)

O176S0 Porosity (%)			
n	a	b	c
1	0.206	0.084	0.133
2	0.132	0.083	0.178
3	0.160	0.082	0.144
4	0.128	0.084	0.139
5	0.119	0.070	0.100

(d)

A particular observation is that for *IO* values $\geq 50\%$ (**Table 7a, b, c, and d**), columns *a* and *c* showed porosity levels from 0.105–0.290%, while the same columns for configuration O8S0 (**Table 6a**) showed higher values (0.223–0.505%). As the *IO* modification was restricted to the interface region *b*, this variation suggests that other factors not detected may be influencing the porosity distribution.

In specimens produced under configurations combining *IO* and *Ish*, a reduction in both mean porosity and data dispersion is observed, as shown in **Fig. 9** and **Table 8**.



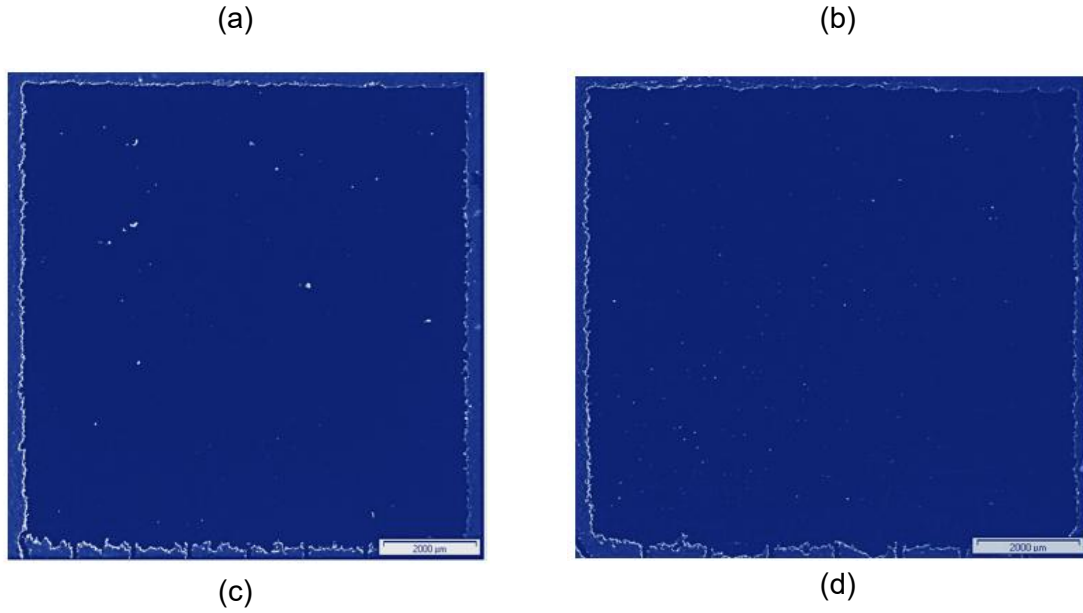


Fig. 9 Examples of micrographs images (ZX Plane) showing pore distribution of configurations with *Ish*: (a) O50S1, (b) O92S1, (c) O135S1 and (d) O176S1 (12.5x magnification)

Table 8 – Local average porosity (considering 16 faces) of the configurations with *Ish*: O50S1 (a), O92S1 (b), O135S1 (c) and O176S1 (d)

O50S1 Porosity (%)			
n	a	b	c
1	0.222	0.242	0.359
2	0.217	0.187	0.223
3	0.237	0.268	0.243
4	0.184	0.153	0.179
5	0.125	0.156	0.166

(a)

O92S1 Porosity (%)			
n	a	b	c
1	0.268	0.190	0.210
2	0.126	0.130	0.195
3	0.184	0.173	0.151
4	0.123	0.148	0.103
5	0.103	0.108	0.106

(b)

O135S1 Porosity (%)			
n	a	b	c
1	0.199	0.155	0.149
2	0.144	0.124	0.096
3	0.087	0.101	0.103
4	0.084	0.075	0.066
5	0.065	0.063	0.063

(c)

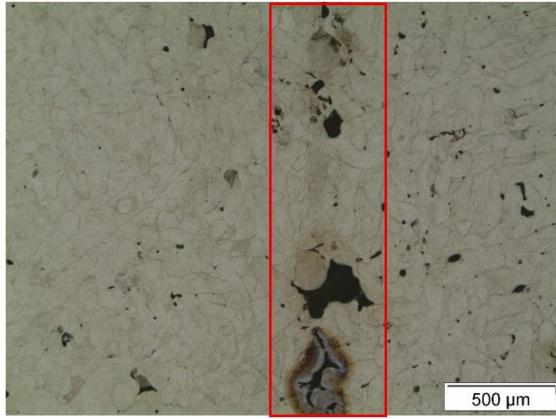
n	a	b	c
1	0.106	0.108	0.119
2	0.075	0.096	0.095
3	0.089	0.088	0.097
4	0.078	0.067	0.064
5	0.067	0.064	0.063

(d)

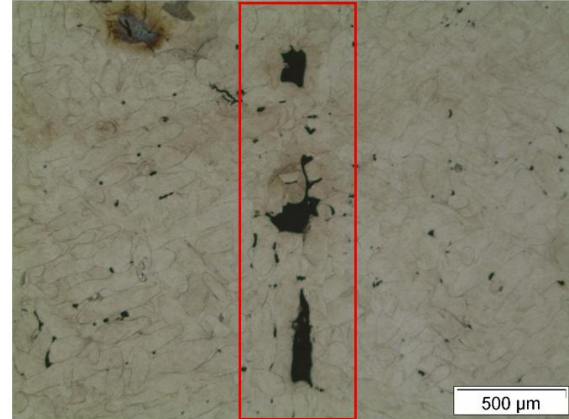
The results indicate that *Ish* redistributes lack-of-fusion defects, leading to a more uniform porosity distribution, as previously reported by [12]. In the present study, *Ish* also reduced the overall porosity (**Table 5**). A local comparison between configurations O135S0 (**Table 7c**) and O135S1 (**Table 8c**) shows that introducing *Ish* reduced porosity across the analyzed specimen surfaces. One possible explanation is that shifting successive layers promotes partial remelting of the island interfaces in the underlying layer, thereby eliminating some pores formed at the island boundaries. This assumption is based on the observation of Qiu et al. [8] about additional remelting. Another possible mechanism is the truncation of scan vectors within boundary islands, inherent to the *Ish* strategy (**Fig. 2b**) and referred to here as the *island border effect*, which results in strips of short scan vectors near the layer boundaries. This locally increases heat accumulation and improves remelting of the previous layer. Because the specimens were relatively small (10×10 mm), this localized thermal effect may have influenced a significant portion of the part. This interpretation is consistent with Holman et al. [14] who associated short scan vectors at chessboard partition boundaries with local heat accumulation. However, these hypotheses require experimental confirmation in future studies.

3.3 Top surface analysis of interisland lack-of-fusion defects

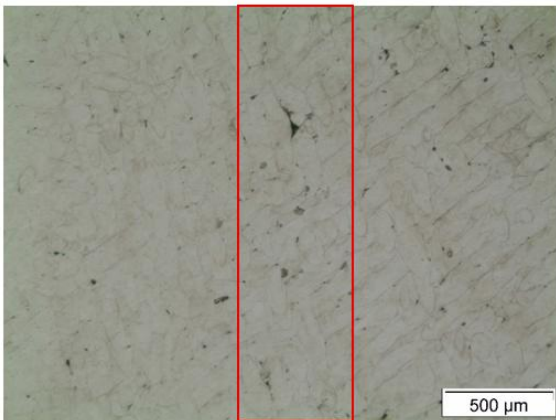
Representative optical micrographs of the top face (XY axis) of the specimens manufactured with the different *IO* values (8%, 50%, 92%, and 135%), after chemical etching, are shown in **Fig. 10**. The images were directed at the junction between adjacent islands, revealing the pores. The angular morphology of these defects is consistent with lack-of-fusion porosity, characterized by irregular and non-spherical shapes [4]. In the O8S0 configuration (**Fig. 10a**), large pores are clearly observed; in the O50S0 configuration (**Fig. 10b**), the pores are still clearly visible, although their size and frequency are reduced. In the O92S0 configuration (**Fig. 10c**), the interface between adjacent islands becomes less, indicating improved remelting and mitigation of lack-of-fusion defects. Finally, in the O135S0 configuration (**Fig. 10d**), the island boundaries are no longer visually detectable, suggesting effective fusion and the elimination of interface-related porosity.



(a)



(b)



(c)



(d)

Fig. 10 Optical micrographs of the top face (XY plane) showing pore at the island interfaces for configurations with *IO*: (a) O8S0, (b) O50S0, (c) O92S0 and (d) O135S0 (50x magnification)

3.4 Estimated build time

The estimated build time for all configurations defined in **Tables 1** and **2** by the RP3 software is shown in **Fig. 11**.

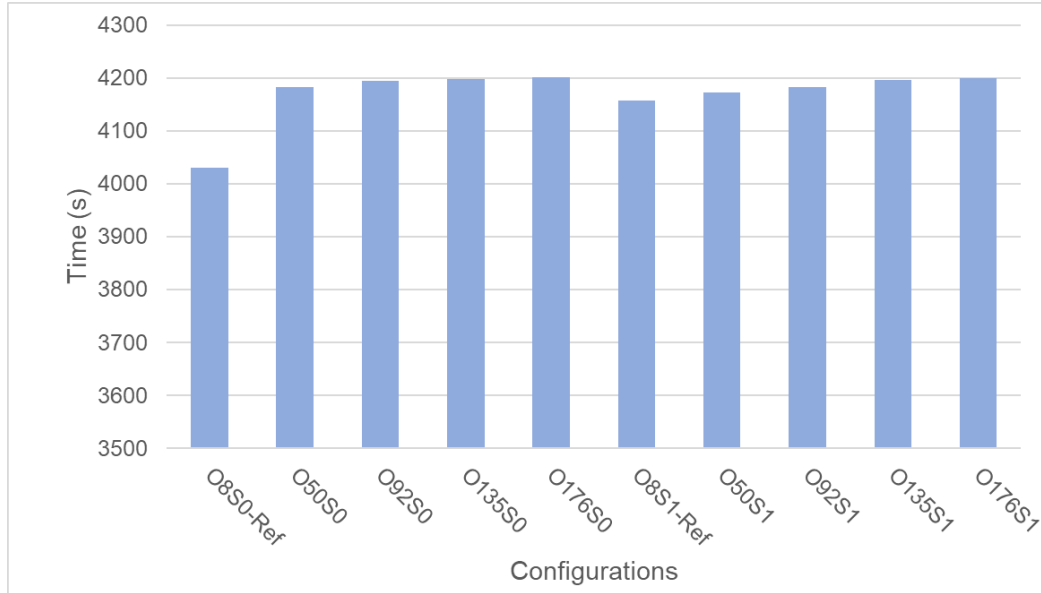


Fig. 11 Estimated build time for all configurations

As observed, the O8S0 configuration exhibited the shortest build time. This is because the 10×10 mm specimen was divided into four 5×5 mm islands per layer, resulting in the minimum number of scan-track segments in each island (see **Fig. 2a**). Increasing the *IO* to 50% or higher extends the scan tracks into neighboring islands, introducing a scan-track truncation (similar to the *Ish* with *island border effect*), which increases the number of scan vectors on some island (also creating strips of short vectors) and, consequently, the frequency of laser on/off transitions. Beyond this initial increase, further overlap only marginally extends the build time. Consequently, all shifted configurations exhibited similar build times.

Under the investigated processing conditions, O135S1 provided the best balance between porosity and productivity, achieving an overall porosity of 0.10%, whereas O176S1 further reduced porosity to 0.08% at the expense of only a 0.07% increase in build time. Therefore, the selection between O135S1 and O176S1 should be based on the porosity requirements of the final component.

4. Conclusion

This study evaluated different island overlap (*IO*) configurations in the chessboard strategy, with and without interlayer shift (*Ish*), to process AISI 316L with a 200 W fiber laser PBF system, focusing on minimizing porosity at island interfaces. A porosity assessment method based on image analysis of the XZ plane was proposed, in which the surface was divided into three regions: two lateral sections (columns *a* and *c*) and a central column (column *b*). This approach proved effective for identifying localized defects at island interfaces when no *Ish* was used.

The results without *Ish* showed that increasing *IO* progressively reduced porosity at island junction regions due to enhanced remelting and improved fusion. In the experiments, an *IO* of 135% produced porosity in the interface region (column *b*) comparable to that measured in the lateral regions, indicating defect homogenization across the analyzed surface. Increasing the *IO* to 176% further reduced central column porosity.

The results also demonstrate that an *Ish* alone is insufficient to eliminate interisland voids. When a 1 mm *Ish* was applied with a minimal *IO* (O8S1), porosity decreased only marginally compared to the shiftless condition (O8S0). Furthermore, keeping the *Ish* constant while increasing the *IO* yielded a progressive, substantial reduction in porosity. This clearly indicates that *IO* had the dominant effect on porosity under the investigated processing conditions.

When *IO* was combined with *Ish*, a further decrease in porosity was observed. For instance, at an *IO* of 135%, the porosity decreased from 0.14% (O135S0) to 0.10% when a 1 mm shift was applied (O135S1). This indicates that, in our study, given the specimen size and island border effect, the combination of both parameters was the most effective strategy for mitigating pores at island interfaces with minimal impact on build time. These findings are limited to the investigated 165 W laser power and ~80 μm spot size. However, the discussed mechanisms involving the geometry of the bead, uncovered regions variation at island junctions according to infill raster angle, underlying remelting and truncation of scan vectors may be applicable to other process windows and machine configurations.

Future work should investigate the influence of interlayer remelting on pore size and morphology across successive layers in PBF-LB components using larger specimens to minimize *island border effects* and better isolate the influence of interlayer remelting.

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Statements & Declarations

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