**Supplementary Materials SI**

# Phase-field simulation of lack-of-fusion defect and grain growth during laser powder bed fusion of Inconel 718

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**Table S1**. **Orthogonal table of** $L\_{49}\left(7^{8}\right)$ **for simulation design**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | Laser power / W | Scanning speed / (mm·s–1) | Energy density / (J·mm–3) | Rotation angle / (°) |
| 1 | 150 | 700 | 53.6 | 0 |
| 2 | 150 | 800 | 46.9 | 15 |
| 3 | 150 | 900 | 41.7 | 30 |
| 4 | 150 | 960 | 39.1 | 45 |
| 5 | 150 | 1000 | 37.5 | 67 |
| 6 | 150 | 1200 | 31.3 | 75 |
| 7 | 150 | 1400 | 26.8 | 90 |
| 8 | 250 | 700 | 89.3 | 15 |
| 9 | 250 | 800 | 78.1 | 30 |
| 10 | 250 | 900 | 69.4 | 45 |
| 11 | 250 | 960 | 65.1 | 67 |
| 12 | 250 | 1000 | 62.5 | 75 |
| 13 | 250 | 1200 | 52.1 | 90 |
| 14 | 250 | 1400 | 44.6 | 0 |
| 15 | 275 | 700 | 98.2 | 30 |
| 16 | 275 | 800 | 85.9 | 45 |
| 17 | 275 | 900 | 76.4 | 67 |
| 18 | 275 | 960 | 71.6 | 75 |
| 19 | 275 | 1000 | 68.8 | 90 |
| 20 | 275 | 1200 | 57.3 | 0 |
| 21 | 275 | 1400 | 49.1 | 15 |
| 22 | 300 | 700 | 107.1 | 45 |
| 23 | 300 | 800 | 93.8 | 67 |
| 24 | 300 | 900 | 83.3 | 75 |
| 25 | 300 | 960 | 78.1 | 90 |
| 26 | 300 | 1000 | 75.0 | 0 |
| 27 | 300 | 1200 | 62.5 | 15 |
| 28 | 300 | 1400 | 53.6 | 30 |
| 29 | 325 | 700 | 116.1 | 67 |
| 30 | 325 | 800 | 101.6 | 75 |
| 31 | 325 | 900 | 90.3 | 90 |
| 32 | 325 | 960 | 84.6 | 0 |
| 33 | 325 | 1000 | 81.3 | 15 |
| 34 | 325 | 1200 | 67.7 | 30 |
| 35 | 325 | 1400 | 58.0 | 45 |
| 36 | 350 | 700 | 125.0 | 75 |
| 37 | 350 | 800 | 109.4 | 90 |
| 38 | 350 | 900 | 97.2 | 0 |
| 39 | 350 | 960 | 91.1 | 15 |
| 40 | 350 | 1000 | 87.5 | 30 |
| 41 | 350 | 1200 | 72.9 | 45 |
| 42 | 350 | 1400 | 62.5 | 67 |
| 43 | 200 | 700 | 71.4 | 0 |
| 44 | 200 | 800 | 62.5 | 15 |
| 45 | 200 | 900 | 55.6 | 30 |
| 46 | 200 | 960 | 52.1 | 45 |
| 47 | 200 | 1000 | 50.0 | 67 |
| 48 | 200 | 1200 | 41.7 | 75 |
| 49 | 200 | 1400 | 35.7 | 90 |

**Table S2. Mechanical properties of Inconel 718 fabricated by LPBF**

|  |  |  |  |
| --- | --- | --- | --- |
| UTS / MPa | YS / MPa | Elongation / % | Ref. |
| 953 | 683 | 26.4 | [1] |
| 1010 | 700 | 36.3 |
| 1023 | 775 | 31.8 |
| 1011 | 668 | 22.0 | [2] |
| 866 | 531 | 21.0 |
| 845 | 580 | 20.0 | [3] |
| 1010 | 737 | 20.3 |
| 998 | 800 | 28.0 |
| 1070 | 780 | 30.9 | [4] |
| 1023 | 677 | 28.1 | [5] |
| 943 | 596 | 35.0 | [6] |
| 940 | 647 | 35.5 | [7] |
| 1085 | 816 | 19.7 | [8] |
| 1010 | 737 | 20.6 |
| 904 | 572 | 19.0 |
| 991 | 643 | 13.0 |
| 1075 | 789 | 31.2 | [9] |
| 995 | 627 | 36.1 |
| 1007 | 695 | 28.6 | [10] |
| 1004 | 663 | 27.9 |
| 913 | 604 | 33.6 |
| 900 | 580 | 22.0 | [11] |
| 1037 | 751 | 34.0 | [12] |
| 995 | 664 | 21.0 |

**Table S3. Relative density of Inconel 718 fabricated via LPBF**

|  |  |  |
| --- | --- | --- |
| **Energy density / (J·mm–3)** | **Relative density / (%)** | **Ref.** |
| 73.33 | 73.63 | [13] |
| 110.00 | 86.85 |
| 120.00 | 92.51 |
| 130.00 | 98.45 |
| 10.10 | 59.00 | [14] |
| 20.83 | 98.01 |
| 53.03 | 99.95 |
| 53.01 | 99.99 |
| 53.07 | 99.80 |
| 66.33 | 99.24 |
| 52.39 | 98.95 | [15] |
| 44.31 | 98.15 |
| 65.31 | 99.23 |
| 57.81 | 99.16 |
| 55.28 | 99.02 |
| 66.50 | 99.23 |
| 48.01 | 98.73 |
| 35.97 | 97.20 |
| 39.79 | 97.61 |
| 62.08 | 99.22 |
| 66.25 | 99.24 |
| 65.83 | 99.24 |
| 59.06 | 99.15 |
| 48.54 | 98.76 |
| 39.24 | 97.78 |
| 60.63 | 99.19 |
| 66.25 | 99.24 |
| 57.34 | 99.11 |
| 41.61 | 97.82 |
| 63.13 | 99.23 |
| 54.18 | 98.94 |
| 47.79 | 98.59 |
| 40.89 | 97.91 |
| 52.54 | 98.90 |
| 64.39 | 99.24 |
| 45.79 | 98.58 |
| 44.01 | 98.40 |
| 37.02 | 97.55 |
| 59.20 | 99.17 |
| 66.43 | 99.24 |
| 66.17 | 99.24 |
| 57.60 | 99.12 |
| 36.01 | 97.36 |
| 51.65 | 98.95 |
| 47.15 | 98.56 |
| 66.33 | 99.24 |
| 55.98 | 99.04 |
| 40.43 | 97.97 |
| 66.92 | 99.24 |
| 59.10 | 99.19 |
| 28.25 | 95.56 |
| 28.84 | 95.40 |
| 42.60 | 98.30 |
| 59.04 | 99.19 |
| 28.32 | 95.63 |
| 28.74 | 95.50 |
| 42.58 | 98.30 |
| 59.04 | 99.19 |
| 28.33 | 95.64 |
| 28.72 | 95.54 |
| 42.54 | 98.31 |
| 59.04 | 99.19 |
| 28.34 | 95.65 |
| 28.70 | 95.55 |
| 42.54 | 98.31 |
| 17.86 | 81.44 |
| 20.41 | 83.26 |
| 36.23 | 97.16 |
| 87.72 | 98.19 |
| 58.48 | 98.11 |
| 41.15 | 98.19 |
| 62.66 | 97.73 |
| 44.09 | 97.54 |
| 41.77 | 96.34 |
| 29.39 | 95.79 |
| 90.58 | 98.04 |
| 100.64 | 98.19 |
| 92.59 | 98.10 |
| 60.39 | 99.47 |
| 44.80 | 97.79 |
| 43.13 | 98.15 |
| 45.29 | 98.24 |
| 131.58 | 98.68 |
| 92.59 | 97.73 |
| 87.72 | 97.87 |
| 61.73 | 98.24 |
| 93.98 | 97.80 |
| 66.14 | 97.45 |
| 44.09 | 96.76 |
| 62.66 | 97.96 |
| 84.54 | 98.21 |
| 180.00 | 97.25 |
| 70.31 | 97.73 |
| 37.19 | 96.34 |
| 22.96 | 86.76 |
| 143.75 | 95.80 |
| 143.75 | 97.62 |
| 37.34 | 97.32 |
| 37.34 | 97.13 |
| 127.27 | 97.00 |
| 62.50 | 97.41 |
| 127.27 | 97.02 |
| 62.50 | 96.95 |
| 117.86 | 97.48 |
| 93.75 | 97.57 |
| 93.75 | 97.35 |
| 117.86 | 97.75 |
| 67.47159 | 99.90 | [16] |
| 30.54 | 97.71 | [17] |
| 32.94 | 97.59 |
| 34.32 | 98.21 |
| 35.24 | 97.50 |
| 37.15 | 98.61 |
| 37.24 | 97.47 |
| 37.36 | 98.76 |
| 39.00 | 99.19 |
| 40.01 | 98.78 |
| 41.77 | 98.02 |
| 42.17 | 99.43 |
| 42.22 | 99.36 |
| 45.61 | 99.58 |
| 45.68 | 99.39 |
| 47.85 | 99.64 |
| 49.36 | 99.51 |
| 53.13 | 99.58 |
| 54.45 | 99.67 |
| 55.92 | 99.84 |
| 56.51 | 99.70 |
| 59.35 | 99.65 |
| 63.90 | 99.63 |
| 66.67 | 99.96 |
| 67.62 | 99.77 |
| 68.39 | 99.91 |
| 72.38 | 99.93 |
| 74.23 | 99.75 |
| 79.87 | 99.80 |
| 83.47 | 99.99 |
| 84.10 | 99.87 |
| 90.69 | 99.94 |
| 98.60 | 99.78 |
| 106.09 | 99.58 |
| 111.23 | 99.99 |
| 112.31 | 99.81 |
| 120.66 | 99.76 |
| 30.73 | 95.04 | [18] |
| 35.23 | 97.78 |
| 38.21 | 98.82 |
| 42.48 | 99.11 |
| 44.38 | 97.67 |
| 47.41 | 99.92 |
| 48.54 | 98.84 |
| 54.07 | 99.26 |
| 54.72 | 99.90 |
| 60.56 | 99.78 |
| 63.65 | 99.97 |
| 69.44 | 99.92 |
| 76.31 | 99.99 |
| 81.29 | 99.99 |
| 86.53 | 97.28 |
| 92.06 | 99.79 |
| 97.69 | 99.99 |
| 121.39 | 99.99 |
| 125.00 | 99.37 |
| 138.49 | 97.25 |
| 161.82 | 98.82 |
| 173.34 | 92.72 |
| 190.55 | 97.20 |
| 277.47 | 94.54 |

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