

Description of Additional Supplementary Files

File Name: Supplementary Movie 1

Description: Progression of the melt pool and vapor depression in Al6061 bare plate under moving laser illumination. The sample thickness is 0.75 mm. The imaging frame rate is 50 000 fps. The laser spot size is 88 μm , the power is 416 W, the scan speed is 0.3 m/s. The pixel resolution of 1.98 μm . The exposure time for each image is 1 μs .

File Name: Supplementary Movie 2

Description: Progression of the melt pool and vapor depression in Al6061 bare plate under moving laser illumination. The sample thickness is 0.75 mm. The imaging frame rate is 50 000 fps. The laser spot size is 88 μm , the power is 416 W, the scan speed is 0.6 m/s. A pixel resolution of 1.98 μm . The exposure time for each image is 1 μs .

File Name: Supplementary Movie 3

Description: Progression of the melt pool and vapor depression in Al6061 bare plate under moving laser illumination. The sample thickness is 0.75 mm. The imaging frame rate is 50 000 fps. The laser spot size is 88 μm , the power is 416 W, the scan speed is 0.9 m/s. A pixel resolution of 1.98 μm . The exposure time for each image is 1 μs .

File Name: Supplementary Movie 4

Description: Progression of the melt pool and vapor depression in Al6061 bare plate under moving laser illumination. The sample thickness is 0.75 mm. The imaging frame rate is 50 000 fps. The laser spot size is 88 μm , the power is 416 W, the scan speed is 0.75 m/s. A pixel resolution of 1.98 μm . The exposure time for each image is 1 μs .

File Name: Supplementary Movie 5

Description: Progression of the melt pool and vapor depression in Al6061 bare plate under moving laser illumination. The sample thickness is 0.75 mm. The imaging frame rate is 50 000 fps. The laser spot size is 88 μm , the power is 416 W, the scan speed is 0.45 m/s. A pixel resolution of 1.98 μm . The exposure time for each image is 1 μs .

File Name: Supplementary Movie 6

Description: Progression of the melt pool and vapor depression in Al6061 bare plate under moving laser illumination. The sample thickness is 0.76 mm. The imaging frame rate is 50 000 fps. The laser spot size is 88 μm , the power is 520 W, the scan speed is 0.3 m/s. A pixel resolution of 1.98 μm . The exposure time for each image is 1 μs .

File Name: Supplementary Movie 7

Description: Progression of the melt pool and vapor depression in Al6061 bare plate under moving laser illumination. The sample thickness is 0.76 mm. The imaging frame rate is 50 000 fps. The laser spot size is 88 μm , the power is 520 W, the scan speed is 0.45 m/s. A pixel resolution of 1.98 μm . The exposure time for each image is 1 μs .

File Name: Supplementary Movie 8

Description: Progression of the melt pool and vapor depression in Al6061 bare plate under moving laser illumination. The sample thickness is 0.76 mm. The imaging frame rate is 50

000 fps. The laser spot size is 88 μm , the power is 520 W, the scan speed is 0.6 m/s. A pixel resolution of 1.98 μm . The exposure time for each image is 1 μs .

File Name: Supplementary Movie 9

Description: Progression of the melt pool and vapor depression in Al6061 bare plate under moving laser illumination. The sample thickness is 0.76 mm. The imaging frame rate is 50 000 fps. The laser spot size is 88 μm , the power is 520 W, the scan speed is 0.9 m/s. A pixel resolution of 1.98 μm . The exposure time for each image is 1 μs .

File Name: Supplementary Movie 10

Description: Progression of the melt pool and vapor depression in Al6061 bare plate under moving laser illumination. The sample thickness is 0.76 mm. The imaging frame rate is 50 000 fps. The laser spot size is 88 μm , the power is 520 W, the scan speed is 1.2 m/s. A pixel resolution of 1.98 μm . The exposure time for each image is 1 μs .

File Name: Supplementary Movie 11

Description: Progression of the melt pool and vapor depression in Al6061 bare plate under moving laser illumination. The sample thickness is 0.75 mm. The imaging frame rate is 50 000 fps. The laser spot size is 88 μm , the power is 520 W, the scan speed is 0.76 m/s. A pixel resolution of 1.98 μm . The exposure time for each image is 1 μs .

File Name: Supplementary Data 1

Description: Dataset including all process parameters, material properties, and measured keyhole dimensions.

File Name: Supplementary Data 2

Description: Dataset including transient powers with different process parameters and material properties.