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Multiple Beam, Powder Bed Fusion, Additive Manufacturing

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Introduction

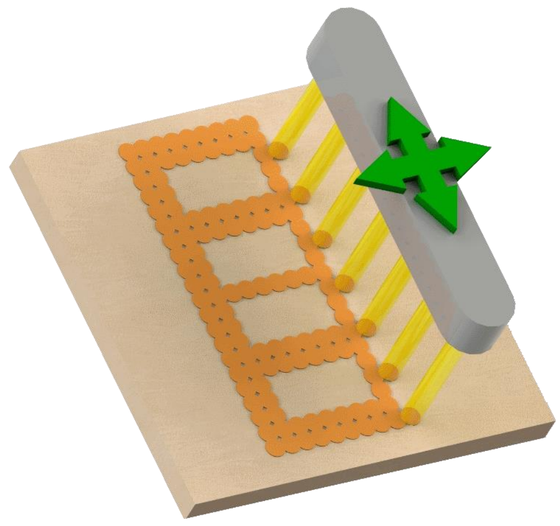
Powder bed fusion is an AM process in which thermal energy selectively fuses regions of a powder bed. Typically the energy is supplied as a point source from a laser or e-beam which is scanned across the surface of the preplaced powder. Once a layer has been selectively fused the powder bed is lowered, another layer is deposited and the process repeats. The final part can then be removed and the unfused powder removed.

Aims

To answer the questions, `'*Within the powder bed fusion context,* How do *sequentially placed melt balls interact with each other and can the use of multiple beams and an appropriate scanning strategy offer measurable improvements in thermal stress relief and management?*'

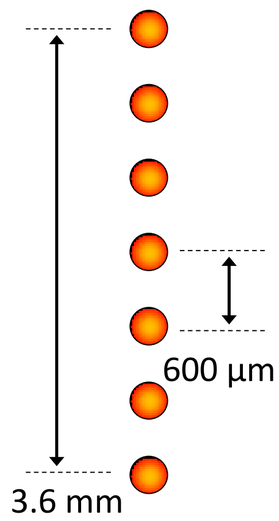
Operating principle

- Seven high power laser diodes fibre coupled to optical head
- Diode output 30 W @ 974 nm
- Fibres arranged in 1 by 7 array and focussed upon powder bed
- Each diode is individually addressed as array is scanned across powder bed



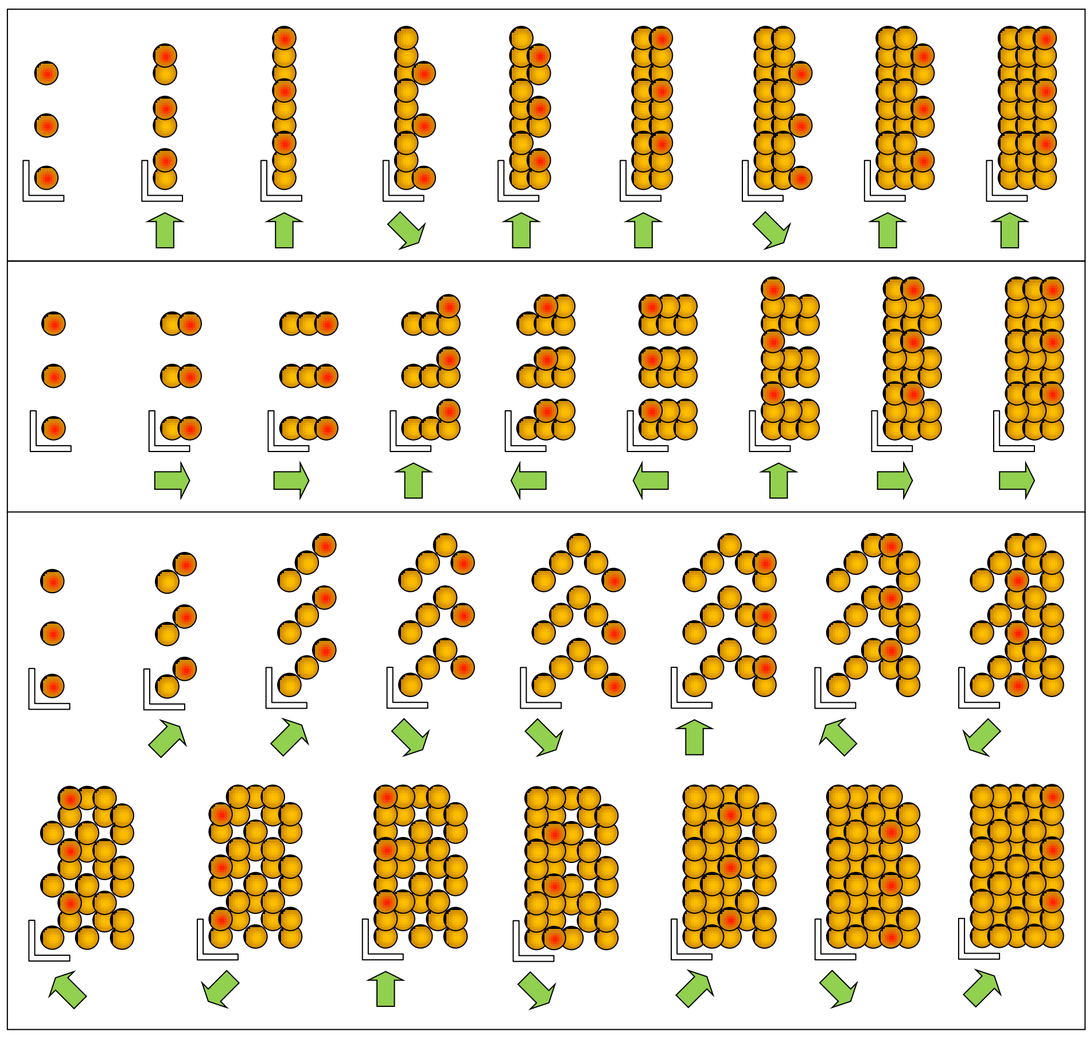
Beam spacing

- Beams do not overlap so 'fill in' strategy required when melting a continuous area



Scanning strategies

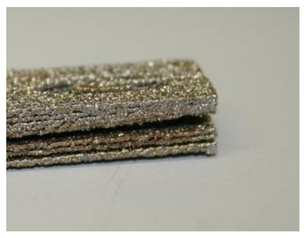
- Several strategies have been developed that are based upon vertical, horizontal or diagonal movement



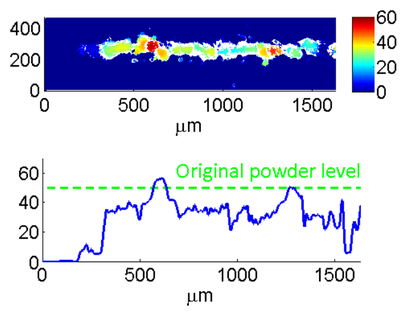
- Strategy can be varied based upon the direction of each successive parallel pass and the number of 'infill' spots within the pitch of the LED array

Single track building

- To constrain warpage, multiple layer objects require affixing to a rigid substrate
- Good substrate bond and interlayer bond needed to prevent de-lamination
- Uniformity of height of melt bead on substrate critical for quality of bond and Z axis build resolution

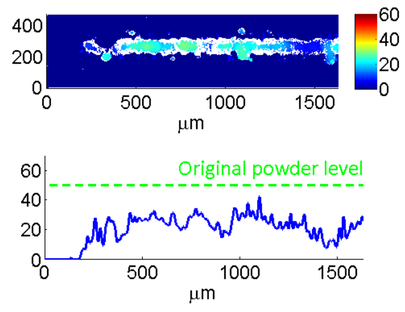


De-lamination



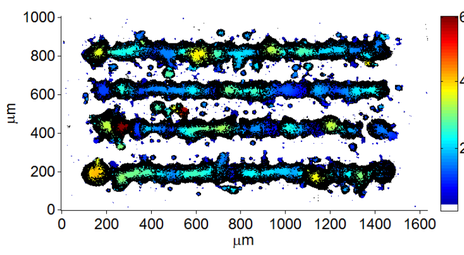
Left: Too little energy, poor uniformity

Right: Appropriate energy, good uniformity

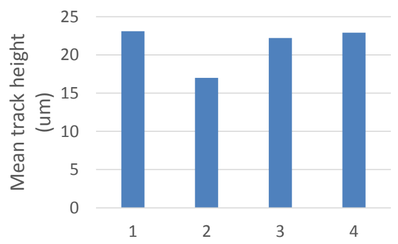


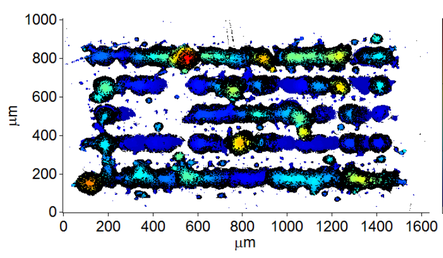
Track spacing

- Each track pulls in surrounding powder leaving denuded areas
- Subsequent track height affected by denudation
- Minimum spacing dependent upon track parameters

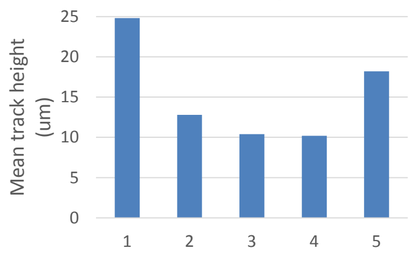


Track spacing =208 µm gives even track heights





Track spacing = 156 µm gives uneven track heights



Future work

- Optimisation of exposure parameters for good inter-layer bonding whilst preserving good intra-layer consolidation
- Analysis of microstructure and heat affected zones produced by different scanning strategies to validate exposure parameters
- Quantify the sources of layer height variation and minimise
- Establish powder re-fill building strategy to overcome problems created by denudation

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