Laser polishing of additively manufactured Ti6Al4V parts and subsequent stress relieving

M. W. McDonald[1], W. S. Gora[1], Y. Tian[2], S. G. Stevenson[3], M. Ardron[3], P. Prangnell[2], N. J. Weston[3], D. P. Hand[1]

1- Institute of Photonics and Quantum Sciences, School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh EH14 4AS
2- School of Materials, The University of Manchester, Manchester M13 9PL
3- Renishaw plc, Research Park North, Riccarton, Edinburgh EH14 4AP

Additive manufacturing has gained interest as it allows for the creation of complex, freeform, three-dimensional shapes which would be difficult to produce using traditional manufacturing techniques. For most applications (e.g. medical implants), the as-built surface finish of these parts is not sufficient in many applications therefore the surface must be improved with some post-processing.

Currently this post-processing is carried out using a variety of techniques, including electrochemical and mechanical (abrasive) polishing, each with their own downsides. Electrochemical polishing is non-selective in its processing area, masking is necessary for parts which require multiple surface finishes (e.g. dental implants) or further processing to reintroduce this roughness. Mechanical polishing is difficult to achieve with complex three-dimensional parts, hence requires a time consuming and highly skilled manual process. Laser polishing offers solutions to these issues as it allows for selectivity in processing and can be easily automated to polish freeform surfaces.

Laser polishing uses a laser beam to create a small melt pool on the surface of the material. The surface tension drives the molten material from the peaks to the valleys, therefore reducing the surface roughness. This non-contact process can potentially provide shorter processing times than electrochemical and mechanical polishing with improved repeatability. Additionally, the absence of hazardous chemicals or abrasives delivers a more environmentally friendly process.

In this work, we show surface quality improvements of selective laser melted Ti6Al4V components when using laser polishing for both an SPI 100-C fibre laser and a diode laser. A range of energy densities and line overlaps are investigated to produce the highest quality surface finish. These parameters are used to laser polish cranial and dental implants manufactured using selective laser melting. The tensile stress produced in the polishing process is shown to be removed using a standard heat treatment process.