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Laser direct writing of Co-superalloy lines for micro-fabrication applications

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ABSTRACT

Co-superalloy lines were deposited on stainless steel by a direct laser writing technique: laser micro-cladding by lateral powder injection.

With the aim of producing small strips as thin and narrow as possible, the mean size of the powder used was 8 µm. Using such fine particles makes conventional powder feeders useless, due to the formation of agglomerates unable to be feed. Therefore a new powder feeder, here described, was designed, constructed and tested. A processing parameters map was established, identifying the working window for laser micro-cladding.

The new power feeder and a high brightness, good beam quality fiber laser allowed producing fine lines just 14 µm wide and 7.2 µm thick. Microstructure and mechanical properties, in terms of Hardness and Elastic Modulus, were evaluated confirming that the fine strips maintain the main characteristics of the hardfacing alloy.

Potential applications include micro-part fabrication and repairing such as micro-moulds, and production of 3D parts at sub-millimetre scales.

1. Introduction

Laser direct writing has been the object of study of many research groups throughout the World for the last four decades [1,2]. And is still today an active field of research due to its precision, relative simplicity, and high yielding rate; but also due to the attractive beauty of the idea behind this technique that is "writing with light" [3,4]. Laser direct writing comprises a family of different techniques used to deposit fine lines of a certain precursor material on a given substrate (including laser induced forward transfer (LIFT), Matrix-assisted pulsed-laser evaporation (MAPLE), laser chemical vapour deposition (LCVD), selective laser sintering (SLS), selective laser melting (SLM), or two-photon polimerization) [5,6]. These techniques are certainly quite different but sharing the common fact that the source of energy is a laser beam.

The miniaturization of objects and devices is one of the manufacturing activities that has most evolved in the last 20 years and has been a driven force pushing the development of different laser and non-laser based techniques [7,8]. One example of miniaturization is the micro moulds used for various applications such as microfluidics or microinjection [9]. Fabrication and repairing of such micro moulds requires the deposition of small amount of a certain material (usually hard and wear resistant) on a given surface [10]. Existing thin film techniques such as Chemical Vapour Deposition (CVD), sputtering in its different variants, pulsed laser deposition (PLD), Plasma-Assisted Chemical Vapour Deposition (PACVD) or Laser Chemical Vapour Deposition (LCVD) allow the deposition of thin layers of a certain material, with high quality (in terms of purity and homogeneity). Usually these techniques are carried out inside a high-vacuum reaction chamber. When the material needs to be deposited on a limited small place, some of the techniques require a mask (reducing flexibility), and if the thickness of the layer exceeds the micrometre, normally a long deposition time is required (exceeding the hour) [11,12].

On the other hand, techniques available to produce thick coatings are rather difficult to be adapted to the micrometre range [13]. Laser cladding is one of these so called "thick coating" techniques that has been successfully modified to produce features at micrometre scale [14,15].

Laser cladding is a well know technique in which a high power laser is used as energy source to melt the precursor coating material over the surface of a given substrate. At the same time a superficial thin part of the substrate is also molten in order to achieve a strong metallurgical bond [16]. The coating precursor material can be applied in different ways, being the blowing powder technique the most robust one. Laser cladding allows producing coatings made of single [17] or multiple layers [18]. Application of coatings produced by this technique range

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