Fabrication Of Gradient Structures in the Ni-Al System via SLM Process

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Layer-by-layer fabrication of gradient structures from intermetallic materials in the Ni-Al system by the selective laser melting (SLM) method is considered one most promising approach to manufacturing functional parts for airspace industry [1]. The intermetallic phases NiAl and Ni_3Al have high heat resistance and strength. Therefore, in the present report we describe the SLM conditions and the regime optimization for laser treatment in the gradient powder Ni-Al composition.

Nickel Metco 56C-NS (Sulzer Metco Co.) powder was used with content 95.5% Ni and dispersion of -75 +11 μm. As an aluminum-containing powder we used AMDRY 355 - alloy AlSi12 with dispersion -45 μm. Particle size analysis was conducted on the ALPAGA 500 NANO (OCCHIO SA) granulomorphometer equipped with statistical analysis software. Steel substrates had a round shape with a side of 50 mm. The SLM setup in the MSTU «STANKIN» includes: ytterbium fiber laser LK-200-B (JSC ESTO - Lasers, Russia), Raylase SuperScan-II-15 [Y] D2 equipment (RAYLASE, Germany), the powdered delivering system of home based manufacturing, and the weldMARK 2.0 software (RAYLASE, Germany).

At first, the optimal regimes for the SLM process of individual monolayers in Ni + Al = 3: 1; 1: 1; 1: 3 wt% systems were worked out. Results for the SLM in the Ni + Al = 3: 1 system were compared with the SLM process of a prealloyed intermetallic powder Ni85Al15 (graded PR N85YU15, POLEMA, RF). A detailed scheme of the gradient structure and three-dimensional product manufacturing via SLM is described in [2]. Fig. 1 shows some examples of our results.

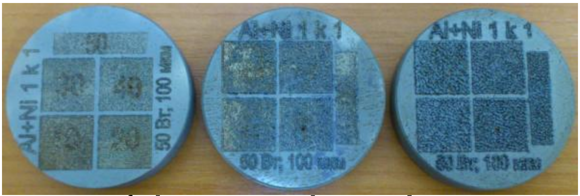

Fig. 1 Appearance of the SLM in the Ni-Al = 1: 1 system: a) one monolayer; b) two; c) three layers. The SLM regimes (power, spot size, and scan speed) are indicated in the figure. Step between passes was 0.1 mm.

We considered that the optimal regimes for the SLM in the Ni-Al = 1: 1 system are as follows: under 50 W on air, 30, 40, 50 mm/s; under 100 W (hereinafter, in argon),100, 120, 140 mm/s; under 150 W, 160, 200, 240 mm/s. We determined that the optimal regimes for the SLM in the Ni-Al = 3: 1 system are as follows: under 150 W, 160, 200 mm/s. Finally, the SLM optimal regimes for prealloyed intermetallic powder Ni85Al15 under 150 W (in Ar) are 120, 160 mm/s.

The most suitable regime of the SLM process (P = 150 W, v = 160 mm/s) for all mixtures had been chosen from the methodological point of view for a more thorough analysis, comparing and exploring the possibilities of the functional graded structures (FGS) fabrication in the Ni-Al system with variable content elements.

Prepared FGS samples were used for further analysis by the optical microscopy (Olympus BX51M, Japan) and scan electron microscopy (VEGA 3 LMH, Czech Republic) equipped for the EDS microanalisys. The phase composition of the SLM parts was determined by XRD with the use of a DRON-3 (Bourevestnik Inc., St. Petersburg, Russia) diffractometer in Co-K_α radiation.

Thus, our studies into the Ni-Al system for the creation of separate layers (in general complexity reached up to 6-10 layers) by the 3D SLM process enabled us to determine the range of optimal SLM parameters that would be acceptable for the fabrication of 3D products by this method and for future mechanical testing.

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References

[1] *I. V. Shishkovsky,* Laser controlled intermetallics synthesis during surface cladding, pp. 237–286. J. Lawrence et.al. (Eds.), Laser Surface Engineering. Processes and applications, Woodhead Publishing Series in Electronic and Optical Materials, Elsevier Science & Technology, on-line ISBN 978-1-78242-074-3. 2015. 718 p.

[2] *I. Shishkovsky, F. Missemer, N. Kakovkina, and I. Smurov,* Intermetallics synthesis in the Fe-Al system via layer-by layer 3D laser cladding. Crystals. Vol. 3, pp. 517–529. 2013. doi:10.3390/cryst3040517 (open access regime).