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Magnetic properties and optimization of AlNiCo fabricated by additive manufacturing

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Introduction

AlNiCo permanent magnets are widely used in instruments which require high-temperature stability, as well as in weapons such as torpedoes, missiles, aircraft and spacecraft such as satellites because of the good temperature stability. With **additive manufacturing**, the part with a complex shape that cannot be fabricated by traditional manufacturing can be built easily. The final formed parts have better performance than those fabricated by traditional methods.

Objectives

We use **SLM** (selective laser melting) to fabricate parts from AlNiCo powder in order to research the effects of **laser process parameters** on density and **Magnetic properties**.

Methods

- Powder Materials: AlNiCo
- Sample Preparation: metal 3D printer
- Microstructural: OM
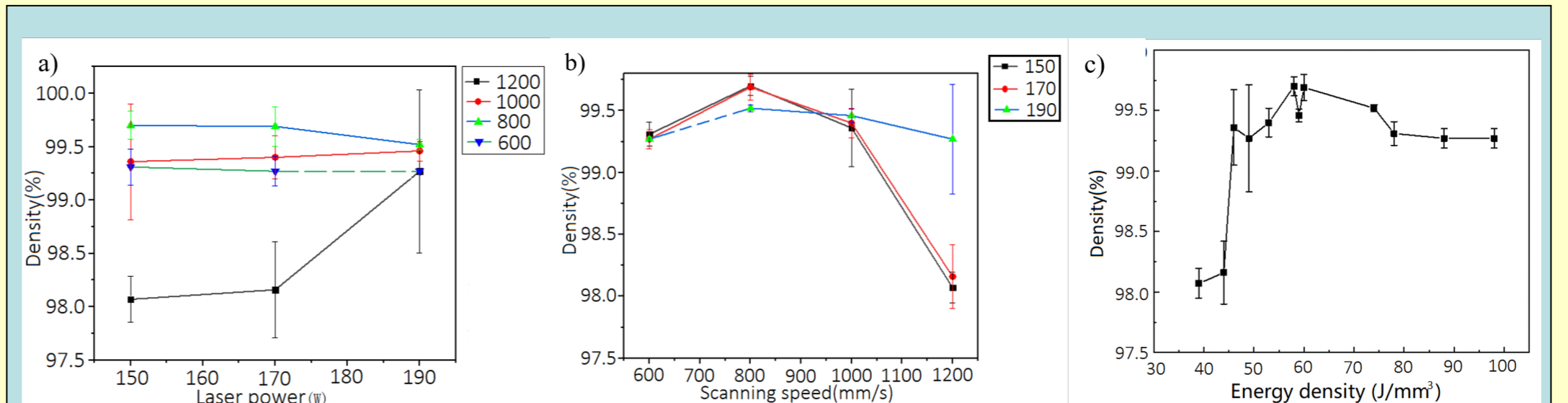- Heat Treatment and Magnetic Properties

Results

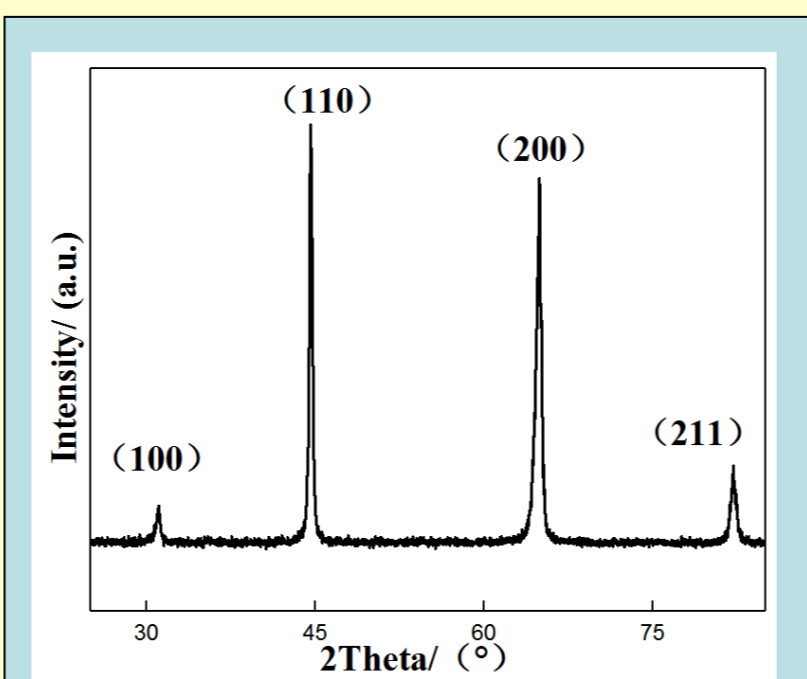**Fig. 1 Effect of (a) laser power (b) laser scanning speed (c) laser energy density on density**

Fig. 2 The XRD pattern of sample H after heat treatment

Tips:
- The laser energy density is given by:

$$\mu = \frac{p}{hvd}$$

Where p, h, v, d stand for laser power, scanning pitch, scanning speed and layer thickness.

- The process parameters of sample H are p = 170W, v=800 mm/s.
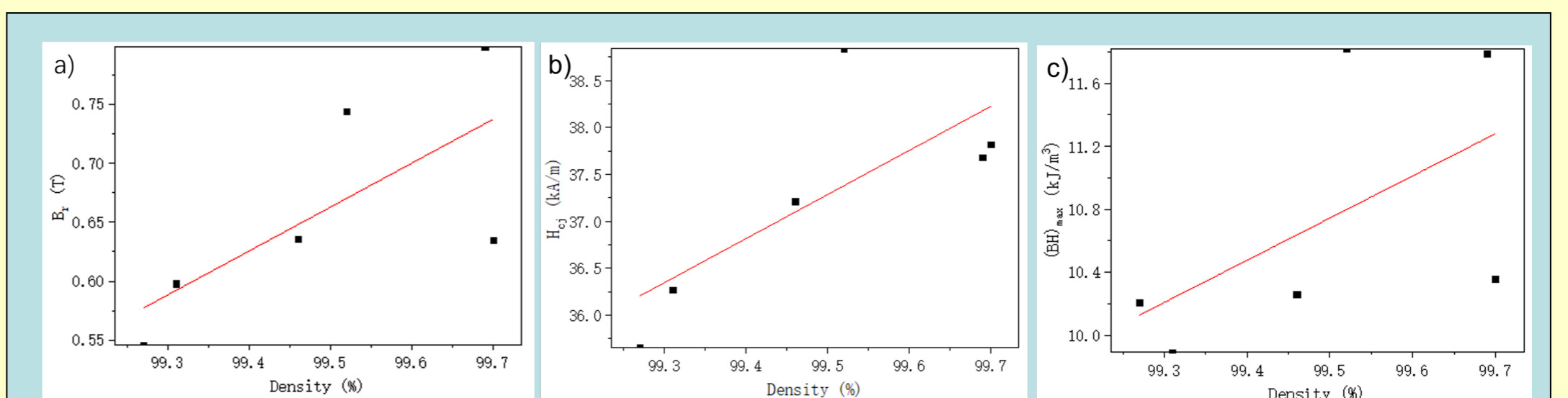

Fig. 3 Effect of density on (a) remanence (b) coercive force (c) maximum magnetic energy product

Summary

In this paper, SLM was used to study the fabricating of AlNiCo magnetic materials under laser power of 150~190 W and scanning speed of 400 mm/s~1200 mm/s. The density and magnetic properties of the fabricated parts were studied and the following conclusions were reached:

- Laser power and scanning speed are important factors that affect the density of AlNiCo samples. In a certain range, high laser power and low scanning speed can improve the density of AlNiCo samples effectively. With the increase of laser energy density, the density of samples increases first and then decreases. According to the experiments, the best process parameters of AlNiCo magnetic materials are listed as follows: the laser energy density area is 55-78 J /mm3, the scanning speed is 800 mm/s, and the laser power is 170 W.
- Within the density range mentioned in this paper, magnetic properties (a) remanence, (b) coercive force and (c) maximum magnetic energy product are all positively correlated with density.
- It is proved that the SLM preparation of AlNiCo is a promising processing method in maintaining magnetic properties to reduce processing costs and material waste.