The manufacture of soft magnetic alloy using micro-powder

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Magnetic alloy are of great interest because of various applications such as electric devices and medical devices. The alloys have been mostly fabricated with the powder metallurgy method which is carried out through a series of common processes including sintering, vacuum melting, and machining. Among them, vacuum melting is a critical step to obtain high quality alloys not only because it prevents the alloy from contamination due to oxidization during alloying but also it makes uniformly alloying. However, this method is very expensive and has limitation in fabricating the patterned and the micro-sized alloys. Herein, we present a rapid method to make high quality magnetic alloys with sub-millimeter pattern scale using Laser cladding method.

The Laser used in this work is a CW CO2 laser (maximum power: 4kW), and the cladding power is kept at 400W. Purchased high purity Fe, Ni, Co, and Al metal powders are used for binary and ternary alloys. More than two types of metal powders with diameter in the range of 50 to 150 μm are simultaneously injected at a speed of 4g/min with Ar gas. Different growth rates and heights are observed depending on the type and composition of the alloys. By x-ray fluorescence we also observed the difference between the output composition and the input composition, which is strongly dependent on the size and melting point of the injected metal powders. When metal powders with particle size of less than 100 μm were used, the surface of the alloy has many cracks and porous cross-section was observed. Based on the above results, we manufactured soft magnetic alloys such as Fe-Al, Fe-Co (binary alloy), and AlNiFe (ternary alloy) by considering the density and melting points of different metal powders and optimizing the composition and laser power. The microstructural properties and composition uniformity of the alloys are characterized by SEM and EDX, and the magnetic property and crystallization are analyzed by VSM and XRD, respectively. We could also fabricate alloys that can be used directly in everyday life through simple surface treatment process. Therefore in terms of easy molding, the technique of laser cladding can be utilized in various related industrial applications.