MSE-11: Additive Manufacturing of Soft Magnetic Composites

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Problem Statement:

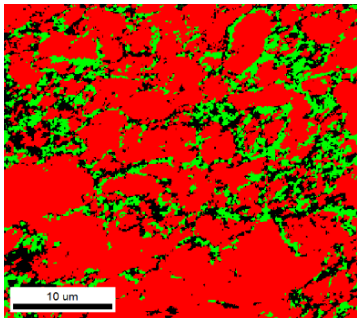
What is the effect of increasing weight percent and increasing laser power on the magnetic and microstructural properties of direct metal laser sintered (DMLS) nickel-zinc-copper (NiZnCu) ferrite coated α-iron powder?

Approach:

Correlated microstructural and magnetic properties by increasing weight percent of coating and laser printing power:

- Printed samples of 5 wt.% and 15 wt.% NiZnCu at 95 W and 135 W
- Heat treated one 135 W, 5 wt.% sample at 700 °C for 1 hour in a nitrogen atmosphere.
- Characterized samples using SEM, EDS and EBSD.
- Magnetically tested samples using AC, DC, and VSM.

Results:



5 wt.% at 135 W EBSD High Magnification

AC Testing Results: 5 wt.% at 135 W.

	Sample	Coercive Field (Oe)	Core loss (W/kg)
50 Hz	no heat treat average	44	111.46
	heat treat	39	95.31
400 Hz	no heat treat average	167	2934.37
	heat treat	171	3134.64
1000 Hz	no heat treat average	191	5592.34
	heat treat	187	5792.25

- SEM and EDS/EBSD showed insufficient coating in the 5 wt.% samples.
- AC & DC magnetic testing showed similar trends in coercivity values when heat treatments were conducted.

Discussion & Conclusions:

- Amount and efficiency of coating varied widely throughout the 5 wt.%, 135 W sample.
- Heat treatment reduced porosity, average grain diameter, and average percent zinc, but increased average pore size and average percent ferrite.
- Heat treatment initially decreased coercivity and core loss at 50 Hz due to lower porosity.
- Coercivity and core loss increased for 400 and 1000 Hz due to poor coating coverage.

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