Fabricating Using Nano-particulates with Direct Write Technology

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Abstract

Modern business trends call for miniaturization of electronic systems. One of the major impedances in this miniaturization is the conductive and inductive components in chips and circuit boards. Direct Write Technology can write these soft magnetic materials, thus allowing for further miniaturization of inductor devices. Another obstacle in electronics fabrication is the size limitations of thick screen-printing and the material limitations in ink jet printing. Direct Write Technologies address both of these limitations by providing feature sizes less than 20 microns with a wide range of materials possibilities. A discussion of the application of these nano-particulate materials by Direct Write Technologies will be presented.

Keywords : Direct Write, silver, soft magnetic material, sintering, nano-particulate

1. Introduction

The DARPA MICE program introduced four new technologies to make micron sized electrical circuits without the lithographic process. To meet the requirements of the project, techniques had to have the ability to deposit many types of materials on many different substrate materials and shapes. The four technologies developed through the MICE program are: Direct write syringe process (n-Scrypt), Thermal spraying, Matrix Assisted Pulsed Laser Evaporation (MAPLE), and Maskless Mesoscale Material Deposition (M^3D).

The M^3D system is designed for rapid prototyping of electronic equipment, legacy repair, sensor development and tissue engineering. The M^3D process utilizes a basic three-step procedure in its depositions: aerosolization, deposition, and heat-treatment of the deposition. With the M^3D process, feature definitions of 10 microns are realized [1]. The M^3D system is maskless, eliminating the need for expensive and fragile masks. The M^3D system is able to perform conformal coatings. Substances to be deposited must be in liquid form with a viscosity less than 1000 cp [2]. M^3D can deposit a wide assortment of materials, including biological, on a wide array of substrates [3]. The laser processing can be done in situ, reducing the amount of infrastructure required. The M^3D process can deposit at speeds of up to 200 millimeters per second [3]. A laser guided deposition system using the same principles, using a laser instead of an air stream to guide the materials, was also created. The laser-guided system has higher feature resolution than the air stream guided, but is not used in industrial settings [4]. Both deposition methods have been used to deposit biological cells [1, 5-6]. The advantage of the M^3D system is it's ability to read in CAD files, allowing simple transfer from design to deposition [7]. The M^3D system has been used to deposit several conductive silver inks at the South Dakota School of Mines and Technology [8].

2. Deposition of Silver Nano-Particles

Figure 1 shows the as deposited microstructure of the silver nano-particle inks. Note that the particles seem to have a very loose affiliation to each other. The intermediate stage of sintering is more easily identifiable in the silver nano-particle inks than the initial stage. Figure 2 shows an SEM image of silver nano-particle ink deposited and sintered at 500°C. The volume fraction on the surface was calculated to be 81%.

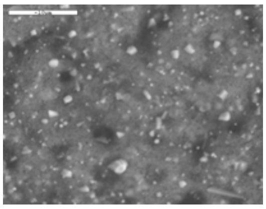

Fig. 1. SEM image showing the as deposited silver nano-particle ink sample.

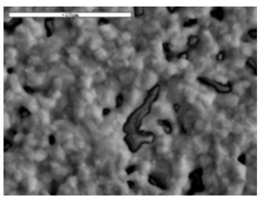

Fig. 2. An SEM image of the V2 silver nano-particle sintered at 500°C for 2 hours.

3. Soft Magnetic Based Inductor

Magnetic materials are required for many electronic devices, and there is currently no commercially available soft magnetic material designed for the M^3D process. The inductors were constructed in a five step process. The first step involved the creation of contact pads and lines for the bottom of the inductor core. The second step was to place a layer of Matrimid over the area where the core material would be placed. The third step was the deposition of the core material. The core material deposition is the most time intensive step. A layer of Matrimid was applied over the magnetic core for the fourth step, and the fifth step involved the completion of the silver lines that formed the turned wires for the inductor. The maximum temperature reached during the construction of the inductor was 500 °C. Figure 3 shows the deposition processes at various steps.

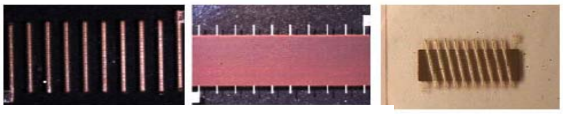

Fig. 3. Photographs of various stages of inductor construction.

4. Summary

The conductive, dielectric and magnetic materials developed at SDSM&T have excellent physical properties for the construction of electronic devices. M^3D technology is a method of direct write technology that can effectively manufacture various electronic devices. The physical properties and the low temperature sintering of the devices made in this manner allow for the construction of many novel and experimental devices.

5. Acknowledgements

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6. References

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