Printing Nanoparticle Copper Ink to Form Functional Electronic Devices

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Abstract

Printing as an electronics fabrication technology has clear advantages over traditional methods such as vacuum deposition and etching. The most obvious benefit is the additive nature of printing which when compared with subtractive methods has the potential to greatly reduce waste thereby reducing cost and overall environmental impact. Realizing the great potential of printing electronics has been limited by the availability of low cost inks. To date stable, reliable, and market ready inks for printing conductive lines and circuit patterns have been made almost exclusively of the precious metal silver. Displacing entrenched manufacturing methods will require materials with much lower costs than silver. Applied Nanotech, Inc. (ANI) has developed an ink comprised primarily of copper nanoparticles that can be printed by various techniques, including inkjet. This copper ink will greatly reduce the projected costs of printing electronics when compared with currently available inks.

ANI's nanoparticle copper ink has proven to be suitable for use in many applications. This has been found through printing, sintering, and characterization experiments making use of several types of substrates. Copper ink formulated specifically for inkjet printing has a viscosity of 20cP and surface tension of 30mN/m. This ink can be inkjet printed to form lines as narrow as 30µm. Once sintered this material has roughly 1/3rd the electrical conductivity of bulk copper metal. In other words it is more conductive than nickel or iron, meaning that it is sufficiently conductive for many uses. In terms of functionality in antenna applications this copper ink has proven to be comparable or better than silver ink, i.e., lower attenuation, at frequencies in common use for mobile phone antennas as well as RFIDs. While oxidation is always a concern when using copper, ANI has found that in 6 months of ambient storage printed conductors showed no change in conductivity. Accelerated testing in hot, wet environments shows only small changes in conductivity.

ANI has succeeded in creating simple electronic devices such as functional RFID antennas using this copper ink on various types of plastic film as well as paper and FR4, the glass filled epoxy composite familiar to printed circuit board manufacturers. Due to its material properties and low raw materials cost, copper ink has the potential to push printed electronics from the lab to the fab.