Direct Write Plasma Printing of Metallic Films from Metal Oxides nanoparticles by *in-situ* Tailoring of Oxidation State

A. Dey [1,2] , S. Krishnamurthy[2] , R. Gandhiraman[1]

1. Center for Nanotechnology, NASA Ames Research Center, California, USA
2. Dept. of Engineering and Innovation, The Open University, Milton Keynes, UK

Printing of nanostructured films with tailored oxidation state and electronic structure can have far reaching applications in several areas including printable electronics, optoelectronics, solar cells, catalytic conversion and others. Widely used inkjet/aerosol/screen printing techniques require pre and post processing for enhanced adhesion and tailoring the chemical state of the materials. The use of nanocolloidal ink in general results in oxidation of the nanoparticles. Controlled deposition of functional materials with tailored physical, chemical and electronic characteristics is needed for advanced manufacturing of flexible electronic devices. Herein we demonstrate the plasma jet printing technology's unique capability to print and *in-situ* the electronic properties and surface morphology of copper oxide nanoparticles. Our X-Ray absorption studies reveal that the copper oxide nanoparticles can be *in-situ* reduced using our direct write plasma printing technology as shown the figure. Here the printing was carried out using CuO nanocolloidal ink. Additionally a highly conductive film can be obtained with average resistance value of 7 Ω. The temperature and the reactivity of plasma can be varied by changing the gas mixtures, flow rates of the gasses and applied voltage. From 25 °C to 200 °C. A varied morphology of thin films can also be obtained with different gas mixtures. This system also promotes adhesion to substrate, uniformity in deposition and formation of densely packed nanoparticle structure with high throughput. The applicability extends to printing on 3D objects as well. We believe this technology will prove to be revolutionary in the field of flexible printed electronics.