INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student: : VIMAL KUMAR SINGH YADAV

Roll Number: : 146102016

Programme of Study : Ph.D.

Thesis Title: Micro-Cantilever Printing Based Devices and Applications

Name of Thesis Supervisor(s) : Prof. Roy P. Paily

Thesis Submitted to the Department/ Center : Electronics and Electrical Engineering

Date of completion of Thesis Viva-Voce Exam : 23/10/2020

Key words for description of Thesis Work : Silver nanoparticles, Micro-cantilever Printing, Gas sensors, Schottky diodes, Zinc oxide nanowires

SHORT ABSTRACT

Printed electronics are increasingly applied for signage, lighting, product identification, packaging flexible electronic devices, photovoltaic devices, medical and diagnostic devices, antennas, displays, sensors, thin-film batteries, electrodes and myriad others. Devices are typically made by printing the electronic circuit or other component or device on a substrate using an electrically conductive metal-based ink. The prime focus of the thesis is to optimize micro-cantilever based printing (MCP) technology. As the first contribution of the thesis, the analysis of the interactions between liquid dispersions of polyaniline emaraldine salt (PANI-ES) and silver nanoparticles (AgNP) over various substrates such as silicon, glass, indium tin oxide (ITO), polyethylene terephthalate (PET) and poly vinyl alcohol (PVA) surfaces has been performed. This analysis has been carried out in terms of concentration of the dispersion, particle size, solvophilic or solvophobic nature of the substrate, evaporation rate of solvents, ambient humidity and post-processing. Substantially low ratios of printed dot feature size to suspended particle size have been obtained, indicating that the MCP can provide a much finer print resolution for flexible and printed electronic circuit components as compared to traditional inkjet, screen or gravure printing. The second contribution of thesis is the fabrication and electrical characterization of printed micro-resistors of AgNPs using three different printing techniques based on MCP technology. These printing techniques are referred to as spot overwrite printing (SOP), dip-ink printing with spot overwrite printing (DIPSOP) and surface patterning tool drag printing (SDP). The minimum feature size of sub-1μm and a print resolution of sub-2 μm is achieved using these techniques. The printed micro-resistors have been found to be nearly 7 times less costly as compared with existing surface mount chip resistors used on printed circuit boards. The third contribution of the thesis is the development of low-cost, simple and rapid process for fabrication of printed Schottky diodes based on drop-casted ZnO multiple or single nanowires (NWs) and micro-cantilever printed Ag contacts. The fabricated diodes have been applied for detection of CO_2, CO and NO_2 at room temperature. The fourth contribution of the thesis is the development ZnO NW mat and ZnO single nanowire Schottky barrier field-effect transistors (SBFETs) with the help of MCP technology. The printed NW mat based FETs are applied as NO_S sensor. Moreover, an analytical current model for ZnO single nanowire based field-effect transistor (FET) is developed. The analytical model is based on charge carrier distribution in a ZnO nanowire channel which has been modelled based on one-dimensional (1-D) density of states. Such simple mathematical models can help to understand the underlying physics and electronic transport phenomena for nanoscale devices and can help to improve the understanding of the gas sensing mechanism with variety of analytes.