University of Victoria | Graduate Studies

Notice of the Final Oral Examination
for the Degree of Master of Applied Science

of

JEHAD ALI ALSAIF

BSc (University of Hail, 2013)

"Parametric Studies of Field-Directed Nanowire Chaining for Transparent Electrodes"

Department of Mechanical Engineering

Wednesday, August 9, 2017
10:00 A.m.
Engineering Office Wing
Room 230

Supervisory Committee:
Dr. Rustom Bhiladvala, Department of Mechanical Engineering, University of Victoria (Supervisor)
Dr. Rodney Herring, Department of Mechanical Engineering, UVic (Member)

External Examiner:
Dr. Rishi Gupta, Department of Civil Engineering, UVic

Chair of Oral Examination:
Dr. George Tzanetakis, Department of Civil Engineering, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

Transparent electrodes (TEs) have become important components of displays, touch screens, and solar photovoltaic (PV) energy conversion devices. As electrodes, they must be electrically conductive while being transparent. Transparent materials are normally poor conductors and materials with high electrical conductivity, such as metals, are typically not transparent. From the few candidate materials, indium tin oxide (ITO) is currently the best available, but indium is an expensive material and ITO cost has risen with increasing demand. Therefore, alternative materials or methods are sought to encourage production needs of applications and help in reducing their price. This thesis presents and discusses results of experimental work for a method, field-directed chaining, to produce a TE device which is nanowire-based, with a figure of merit $\mathrm{FoM} = 2.39 \times 10^{-4}\ \Omega^{-1}$, comparable to ITO but with potential for far lower cost.

Using electric field-directed chaining, multiple parallel long chains of metal nanowires are assembled on inexpensive transparent materials such as glass by field directed nanowire chaining, using methods first demonstrated in our laboratory. In this work, we have improved the fraction of functional chains, by tuning the field/voltage, a key step in increasing the FoM and lowering the cost. The effect of operating parameters on TE optical and electrical properties has been studied and identified as well. From experiments with twenty seven substrates, each with a range of electric field and nanowire concentration, the highest light transmission achieved is 78% and the lowest sheet resistance achieved is 100 /sq. Among all the operating parameters, the electric field has the most significant influence on the fraction of nanowire chains that are functional. In the operating range of electric field strength available to us, we observed a monotonic increase in the fraction of functional nanowire chains. We found a counter-intuitive change in TE properties in a sub-range of nanowire concentration, associated with a change in the structure of chained patterns.