Notice of the Final Oral Examination
for the Degree of Doctor of Philosophy

of

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MSc (University of British Columbia, 2016)
BSc (University of Tehran, 2013)

“Textile-based Sensors for In-situ Monitoring in Electrochemical Cells and Biomedical Applications”

Department of Mechanical Engineering

Wednesday, October 14, 2020
12:00 P.M.
Remote Defence

Supervisory Committee:
Dr. Mohsen Akbari, Department of Mechanical Engineering, University of Victoria (Co-Supervisor)
Dr. Ned Djilali, Department of Mechanical Engineering, UVic (Co-Supervisor)
Dr. Jeremy Wulff, Department of Chemistry, UVic (Outside Member)

External Examiner:
Dr. Woo Soo Kim, Mechatronic Systems Engineering, Simon Fraser University

Chair of Oral Examination:
Dr. Nishant Mehta, Department of Computer Science, UVic

Dr. Stephen Evans, Acting Dean, Faculty of Graduate Studies
Abstract

The textile porous gas diffusion layer of polymer electrolyte membrane fuel cells (PEMFCs) is a suitable substrate to blend e-textile technology for in-situ diagnostics in PEMFCs. This work includes contributions to understanding water transport and conductivity in the carbon cloth gas diffusion layer (GDL), and further developing thread-based relative humidity (RH) and temperature sensors, which can be sewn on a cloth GDL in PEMFCs. Besides, we explore the application of the developed RH and temperature sensors in wearable biomonitoring. First, an experimental prototype is developed for evaluating water transport, thermal conductivity and electrical conductivity of carbon cloth GDLs under different hydrophobic coatings and compressions. Second, we demonstrate the addition of external threads to the carbon cloth GDL to (1) facilitate water transport and (2) measure local RH and temperature with a minimal impact on the physical, microstructural and transport properties of the GDL. We illustrate the roll-to-roll process for fabricating RH and temperature sensors by dip-coating commodity threads into a carbon nanotubes (CNTs) suspension. The thread-based sensors response to RH and temperature in the working environment of PEMFCs is investigated. As a proof-of-concept, the local temperature of carbon cloth GDL is monitored in an ex-situ experiment. Finally, we optimized the coating parameters (e.g. CNTs concentration, surfactant concentration and a number of dipping) for the thread-based sensors. The response of the thread-based sensors in room conditions is evaluated and shows a linear resistance decrease to temperature and a quadratic resistance increase to RH. We also evaluated the biocompatibility of the sensors by performing cell cytotoxicity and studying wound healing in an animal model. The novel thread-based sensors are not only applicable for textile electrochemical devices but also, show a promising future in wearable biomonitoring applications.