INSTITUTO TECNONÓLOGICO Y DE ESTUDIOS SUPERIORES DE MONTERREY

MASTERS THESIS PROPOSAL

Design of Polymer Solutions for the Fabrication of Conducting Carbon Nano-wires

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A thesis proposal submitted in fulfillment of the requirements for the degree of Master of Science in Nanotechnology (MNT)

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Supervising Committee

The committee members, hereby, recommend that the proposal by Antonio Osamu KATAGIRI Tanakato be accepted to develop the thesis project as a partial requirement for the degree of Master of Science in Nanotechnology (MNT).

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Abstract

Faculty: Nanotechnology

School of Engineering and Sciences

Master of Science in Nanotechnology (MNT)

Design of Polymer Solutions for the Fabrication of Conducting Carbon Nano-wires

by Antonio Osamu KATAGIRI Tanaka

Carbon nano-wires are versatile materials composed of carbon chains with a wide range of applications due to their matchless properties in electrical matters. Regardless of the high interest in the implementation of carbon nano-wires in several applications and devices, no feasible processes have been developed to synthesize carbon nano-wires. Carbon nano-wires have been fabricated with the use of a photoresist, but little is known about polymers that can produce more conductive carbon nano-wires after pyrolysis. Various polymer solutions have being tested and measured through near field electrospinning (NFES) and photopolymerization processes; it was found that it is not possible to predict the behaviour of the electrospinning process, so additional properties are to be considered to achieve a stable manufacturing process. The thesis proposal is to analyse the rheology of different polymer solutions to determine if they can be easily electrospun at low voltages and then fabricate nanowires with them. The research process will include the design of polymer solutions that can be electrospun, photopolymerized, and then pyrolyzed into conducting carbon nanowires. The research is intended to engineer a newly designed polymer solution to achieve mass scale manufacturing of carbon nano-wires in a cheap, continuous, simple and reproducible manner.

keywords: nanotechnology, carbon, nano-wires, electrospinning, NFES

1 Introduction

Carbon nano-materials are subjected to great interest for research purposes due to their various potential applications in diverse areas that take advantage of the nano-scale properties. Carbon nano-materials are suitable for the catalysis, adsorption, carbon capture, energy and hydrogen storage, drug delivery, bio-sensing and cancer detection. [3] Due to some of matchless properties that allow carbon nano-materials to be utilized within multiple functionalities including high porosity, distinguished structures, uniform morphologies, high stability, high magnetic properties and high conductivity. [3]

This document bestow a thesis proposal to perform a research to engineer and design a polymer solution to achieve mass scale manufacturing of carbon nano-wires in a cheap, continuous, simple and reproducible manner. The research intends to involve several manufacturing processes such as near field electrospinning, photopolymerization, pyrolization and carbonization, as they have shown to be promising methods for synthesis of carbon nano-materials. [1] A number of processes have been developed for specific purposes of polymeric nano-fibers, some include surface deposition, composites, and chemical adjustments. Polymeric nano-fibers could be also pyrolyzed to generate carbon nano-wires with conductive capabilities [2] for electrochemical sensing and energy storage purposes.

Nanotechnology has explored different polymer patterning techniques to integrate carbon nano-wires structures. One technique is known as far-field electrospinning, a process in which electrified jets of polymer solution are jettisoned to synthesize nano-fibers which then are pyrolyzed at high temperatures. One sub-technique derived from electrospinning is near field electromechanical spinning or EMS. EMS has proved to deliver high control in patterning polymeric nano-fibers. [1]

The proposal is to continue the previous work done in regards of the synthesis of carbon nano-wires. Previous work includes the fabrication of suspended carbon nano-wires by two methods: electro-mechanical spinning and multiple-photon polymerization with a photoresist. [1] This proposal research is intended to focus on electro-mechanical spinning processes only, to bring off polymer solutions that can be electrospun by nier field electrospinning (NFES), photopolymerized and pyrolyzed into

conducting carbon nano-wires. The polymer solutions described in [1] are to be amended to achieve the goal mentioned in the previous statement.

Near-field electrospinning or NFES allows large scale manufacturability combined with controlled guidance. [2] However, the reported efforts required the use of electric fields in excess of 200 kV/m for continuous operation so that the resulting in limited control for nano-fiber patterning. [2] the current state-of-the-art synthesis processes for polymer nano-fibers lack to yield precise, inexpensive, fast, and continuous manufacturing properties.

2 Problem Definition and Motivation

Carbon nanowires have been fabricated with a photoresist by multiple-photon polymerization techniques. However little is known about polymers that can produce conductive carbon nanowires after pyrolysis.

3 Hypothesis and Research Questions

3.1 Research Hypothesis

The rheological properties of polymer solutions along with synthesis parameters (stage velocity, voltage, dispense rate) can be amended to obtain a low voltage electrospunable, photopolymerizable and graphitizable fibers to synthesize carbon nano-wires with specified dimensions (diameter and length).

3.2 Research Questions

- Are there any evidence of carbon nano-wire fabrication though electrospunable and pyrozable polymer solutions?
- What are the process parameters to consider/control for the fabrication processes of carbon nano-wires?
- What rheological properties are to be controlled/tested to deliver a electrospunable and pyrozable polymer solution?
- Are there any efforts employed to the design of polymer solutions that can be electrospun, photopolymerized, and pyrolyzed into conducting carbon nanowires?
- Are the fabrication parameters defined in [1] optimal for the synthesis of carbon nano-wires through near-field electromechanical spinning?

4 Objectives

4.1 General objective

Exercise the practice and feasibility of a new synthesis process to achieve mass scale manufacturing of carbon nano-wires in an inexpensive, continuous, simple and reproducible manner.

4.2 Particular objective

Design polymer solutions that can be electrospun by NFES, photopolymerized, and then pyrolyzed; through rheological analyses to determine if they can be easily employed for conducting carbon nano-wire synthesis.

5 Theoretical Framework

6 Methodology

7 Work Plan

References

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