

Carbon Nanofiber/Carbon Nanotube/Metal Hybrid Nanostructures for Lithium-ion Batteries

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Abstract

- Carbon nanofibers' application in lithium-ion batteries can result in improvements in their electrochemical performance.
- Metal nanoparticles, e.g. Sn, Sb, have very high theoretical specific capacities.
- Incorporation of CNTs can improve electrical conductivity of CNFs.

Purpose

- To enhance the capacity of the lithium-ion batteries by using metal nanoparticle hybrid structures.
- The general aim is to combine CNF and CNT in order to increase the conductivity of the whole structure.

Introduction

- **Commercial lithium-ion batteries**
 - The materials play a crucial role in their capacity.
 - Carbon nanofibers show excellent lithium-storage performance when used directly as anode materials.
- **Polyacrylonitrile (PAN)**
 - Organic polymer, high carbon yield, fit for electrospinning.
- **Electrospinning**
 - Effective method to produce ultra-thin fibers from a wide range of polymeric materials.
 - Suited to the production of fibers using large and complex molecules.
- **Carbon nanofibers (CNFs)**
 - Cylindric nanostructures with graphene layers arranged as stacked cones, cups or plates.
- **Carbon nanotubes (CNTs)**
 - Allotropes of carbon with a cylindrical nanostructure.
 - Used as additives to various structural materials.

Methods

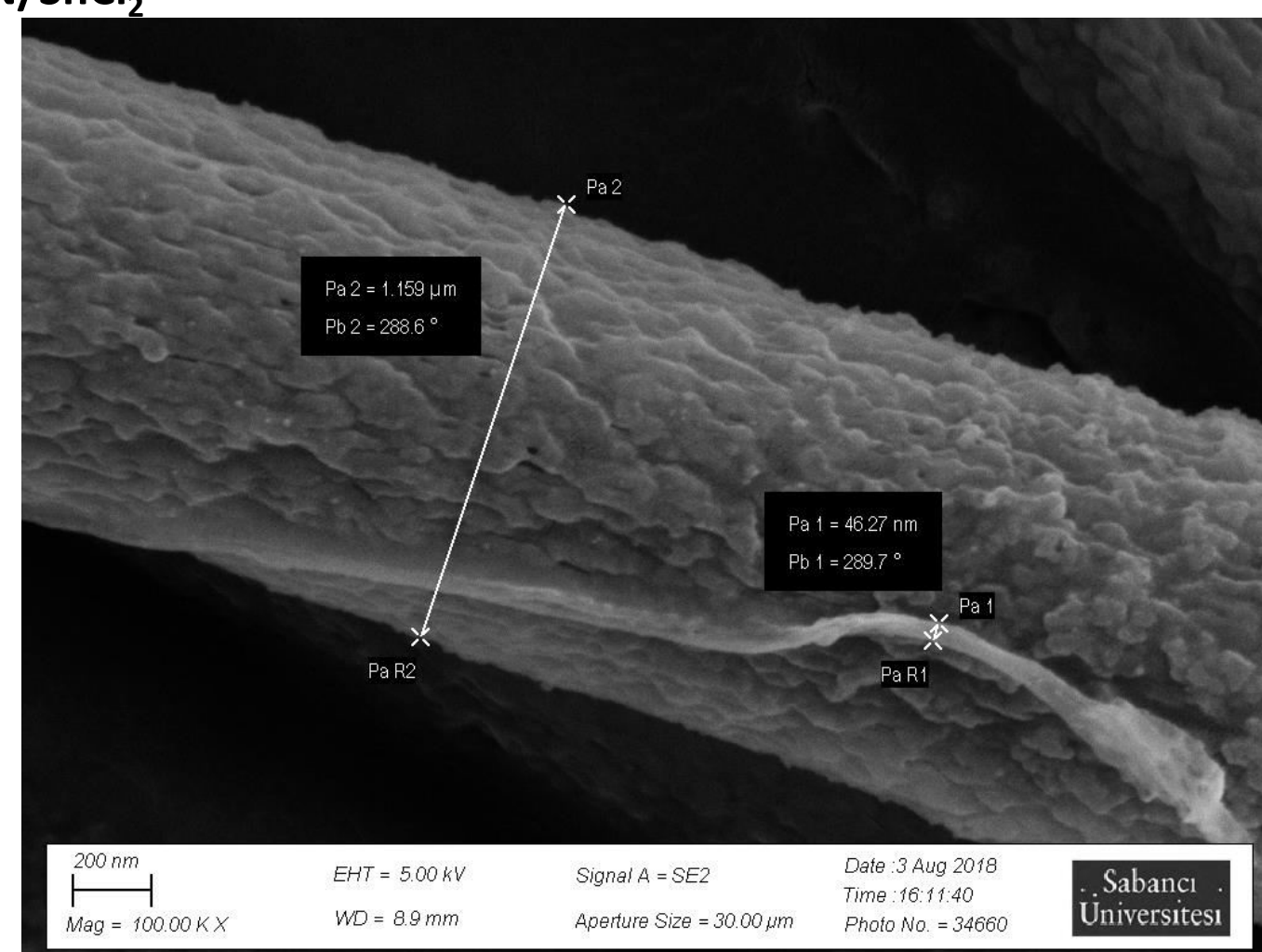
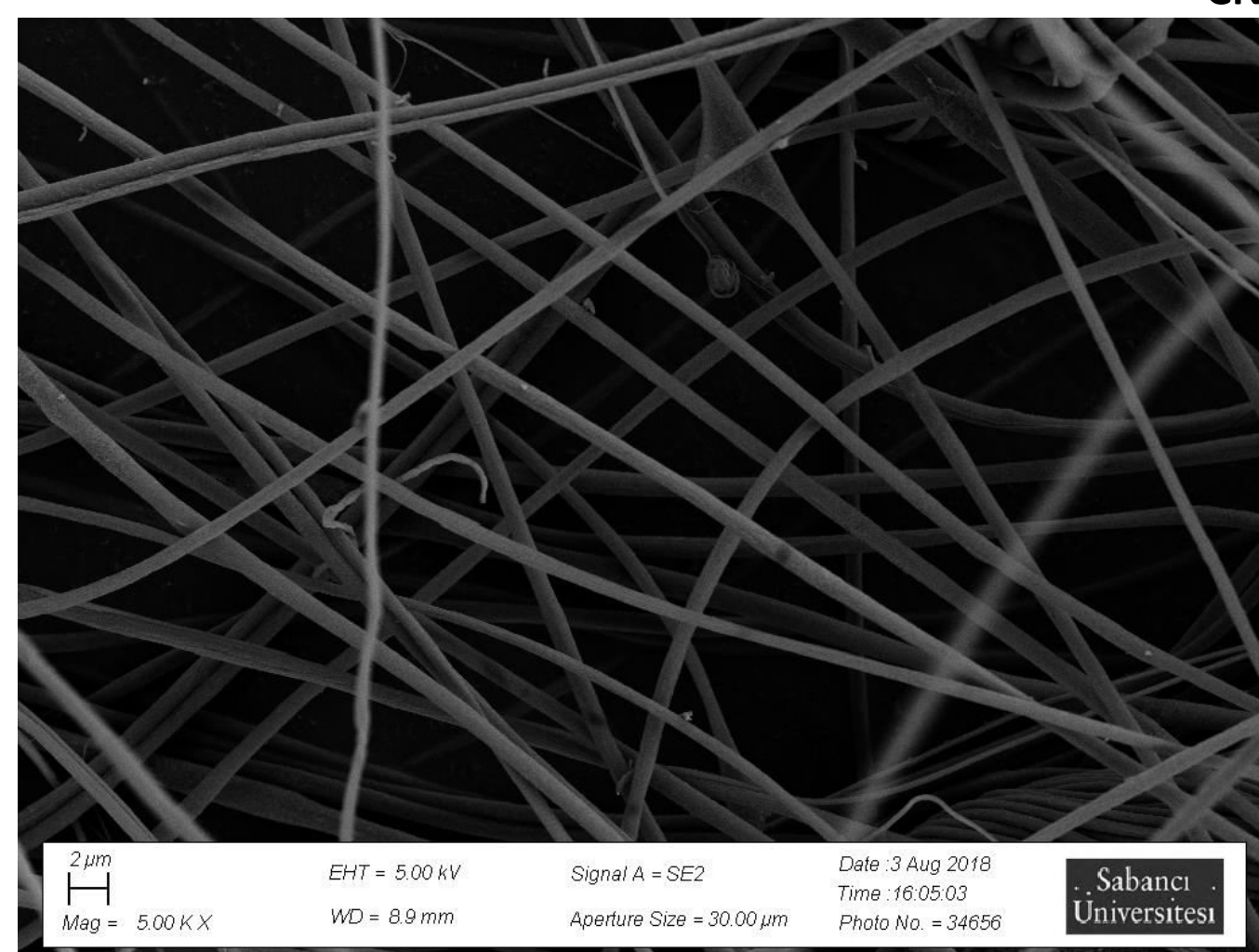
- **CNT/Sn**
 - Oxidation of CNT.
 - Microwave-assisted reduction of metal salts
 - Washing.
 - Purification and freeze drying the samples.
- **CNF/Sn**
 - Polymeric nanofibers with SnCl_2 , SbCl_2 via electrospinning.

- Characterization techniques
 - Scanning Electron Microscope (SEM).
 - Energy-dispersive X-ray spectroscopy (EDX).

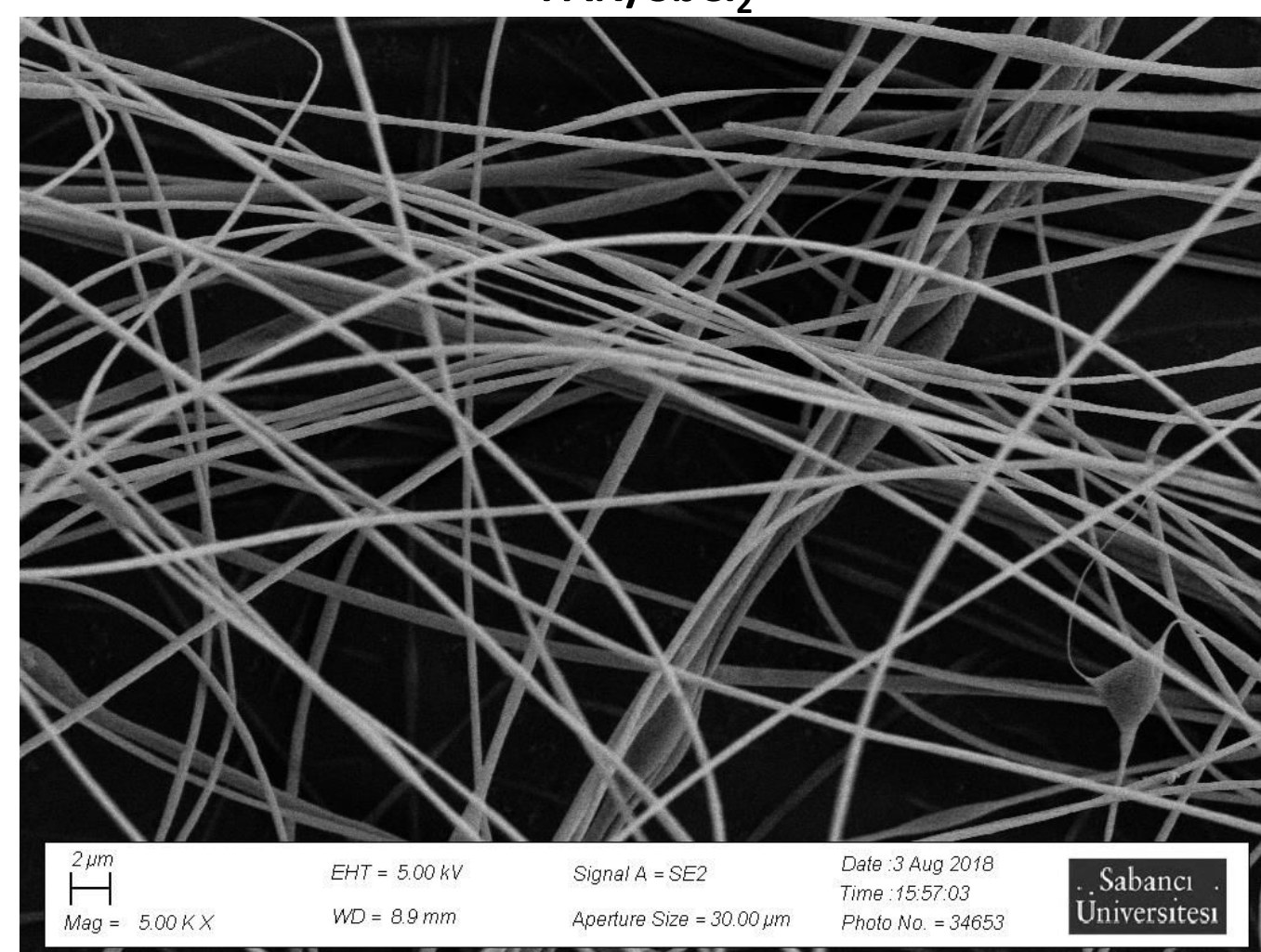
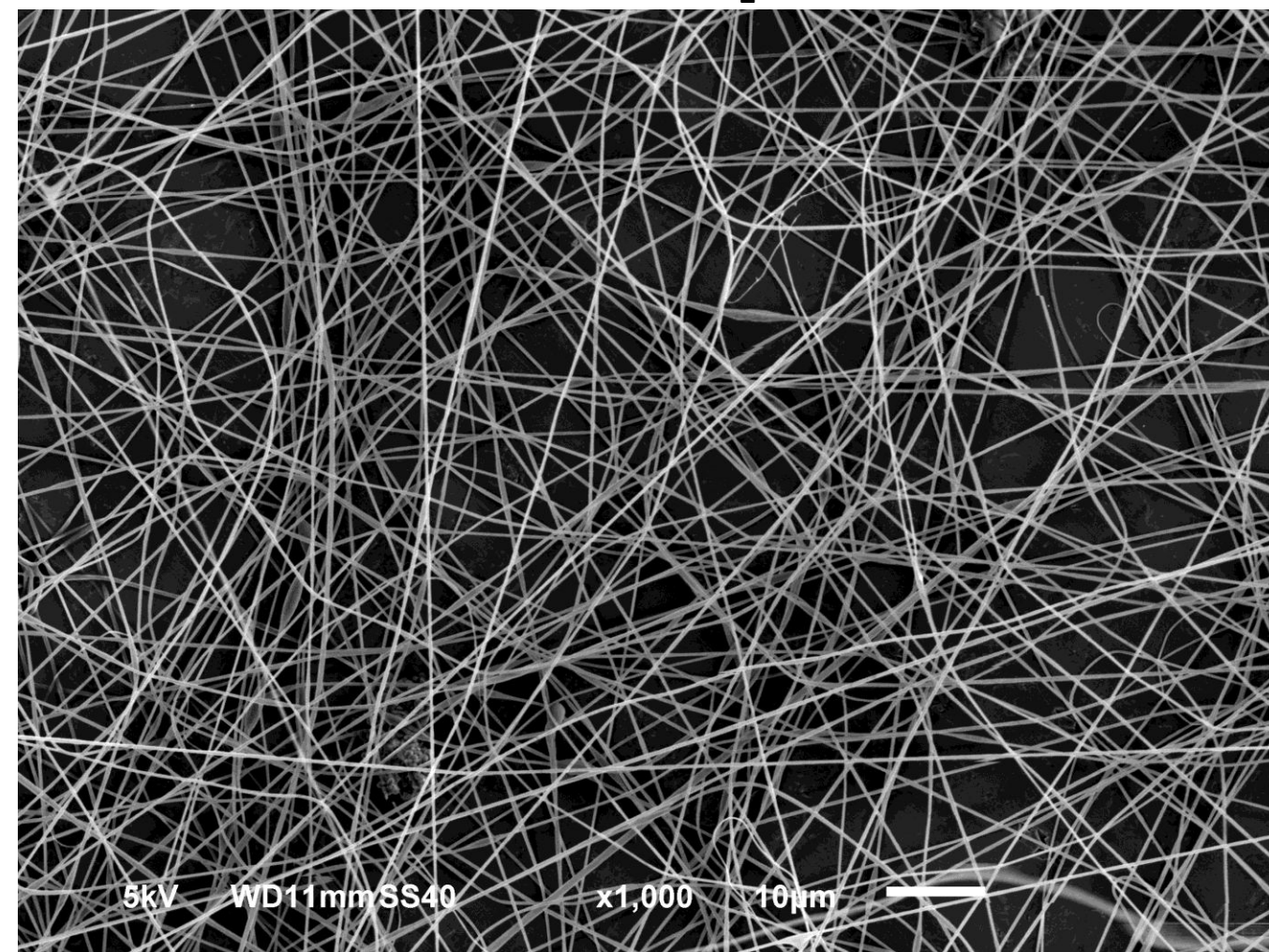
Results

Electrospun nanofibers containing Sn and Sb

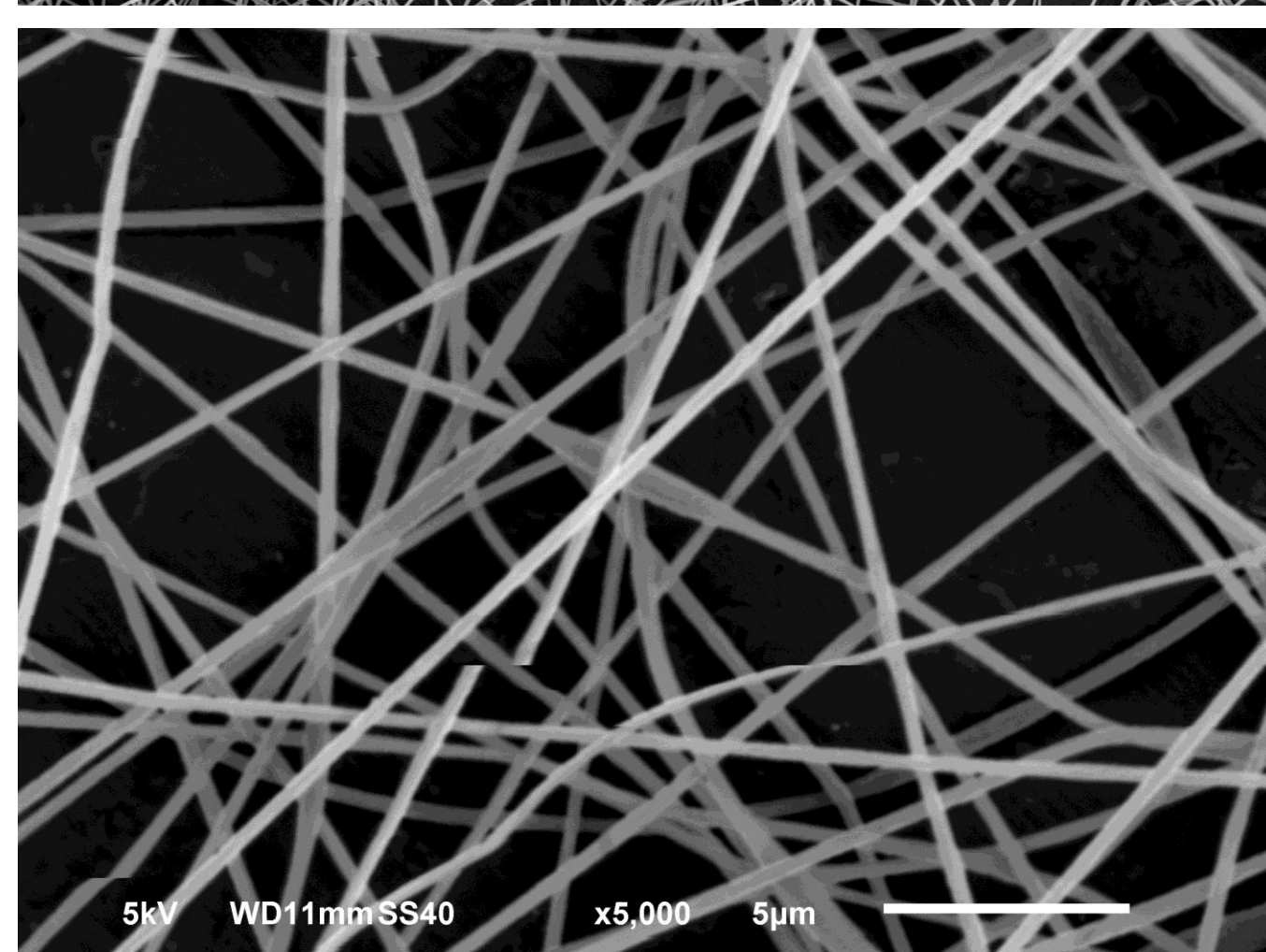
CNT/PAN/SnCl₂



PAN/SnCl₂

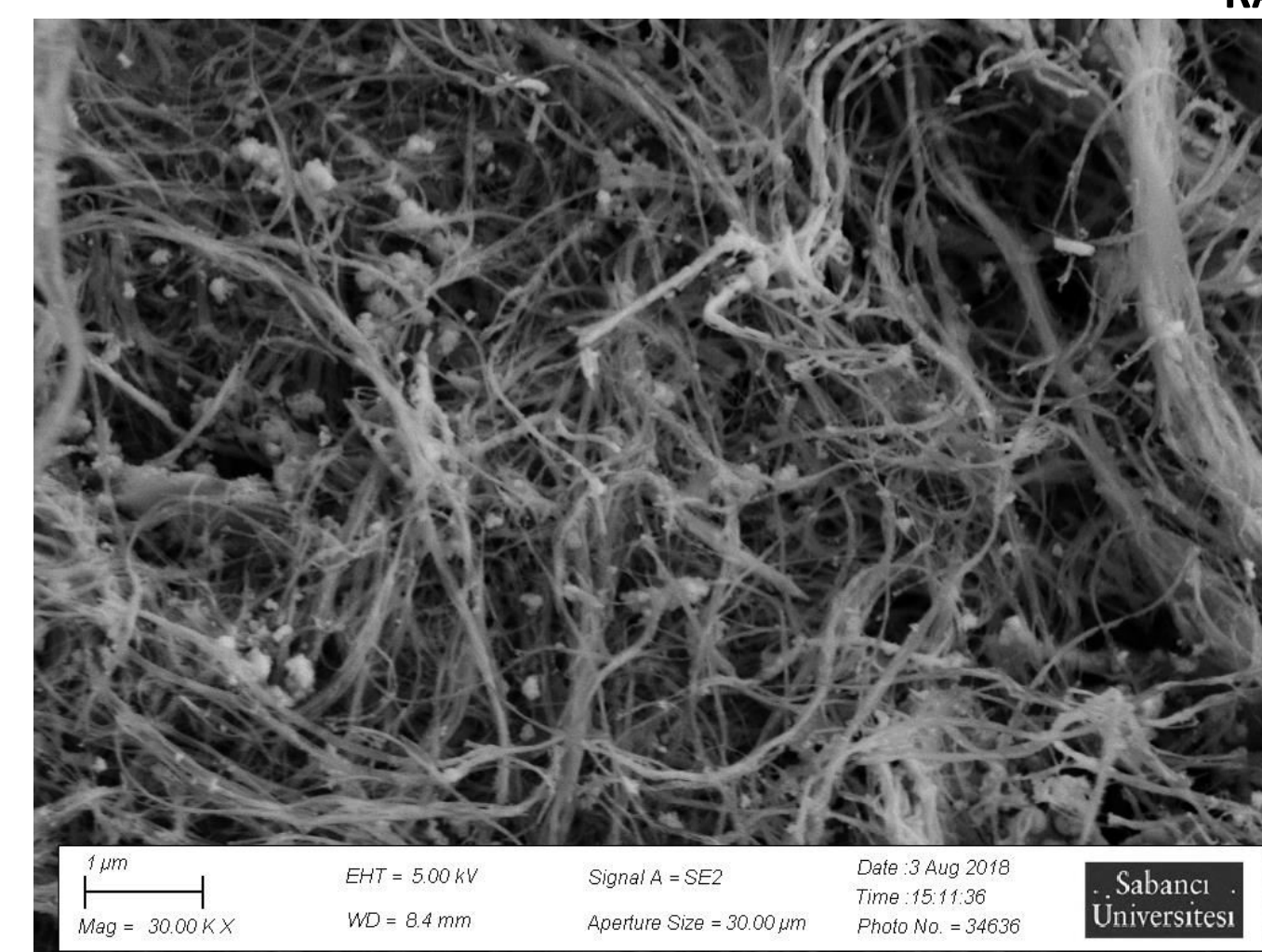


PAN/SbCl₂

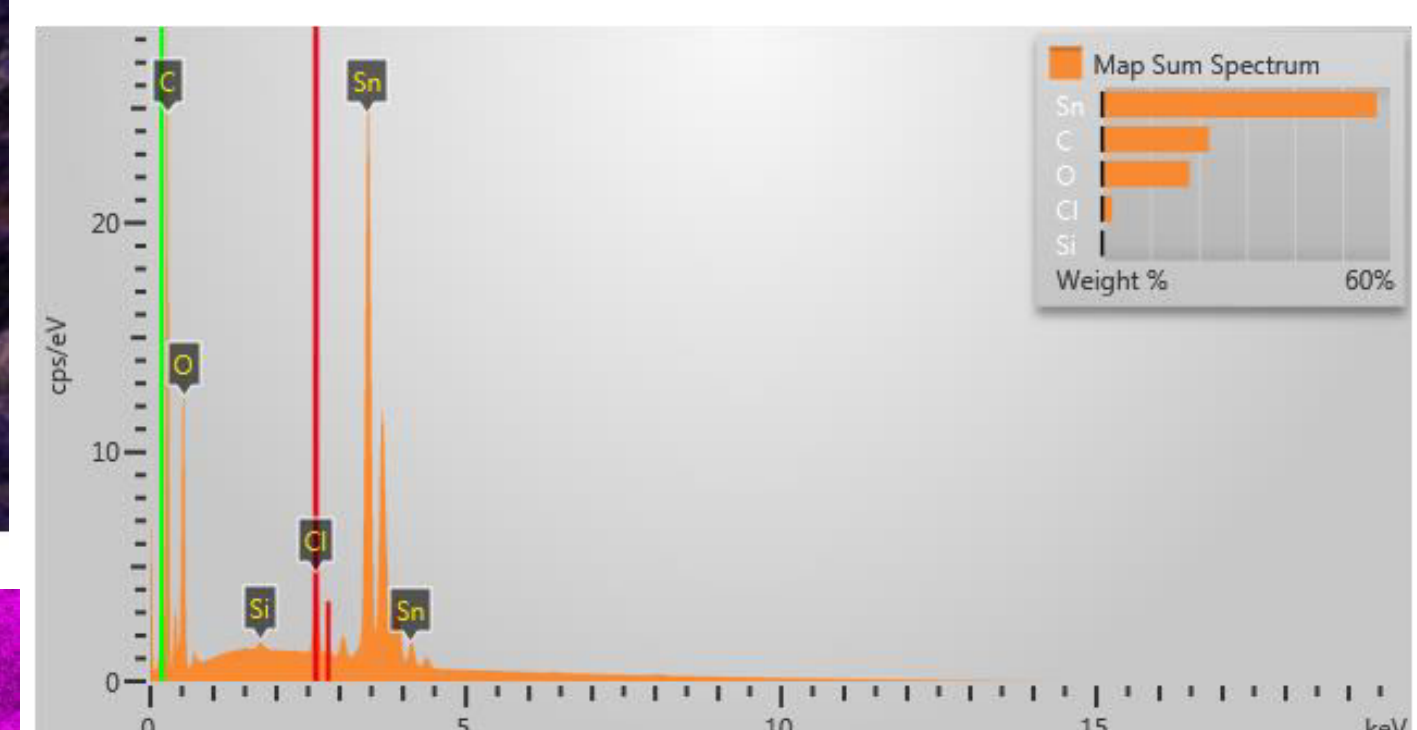
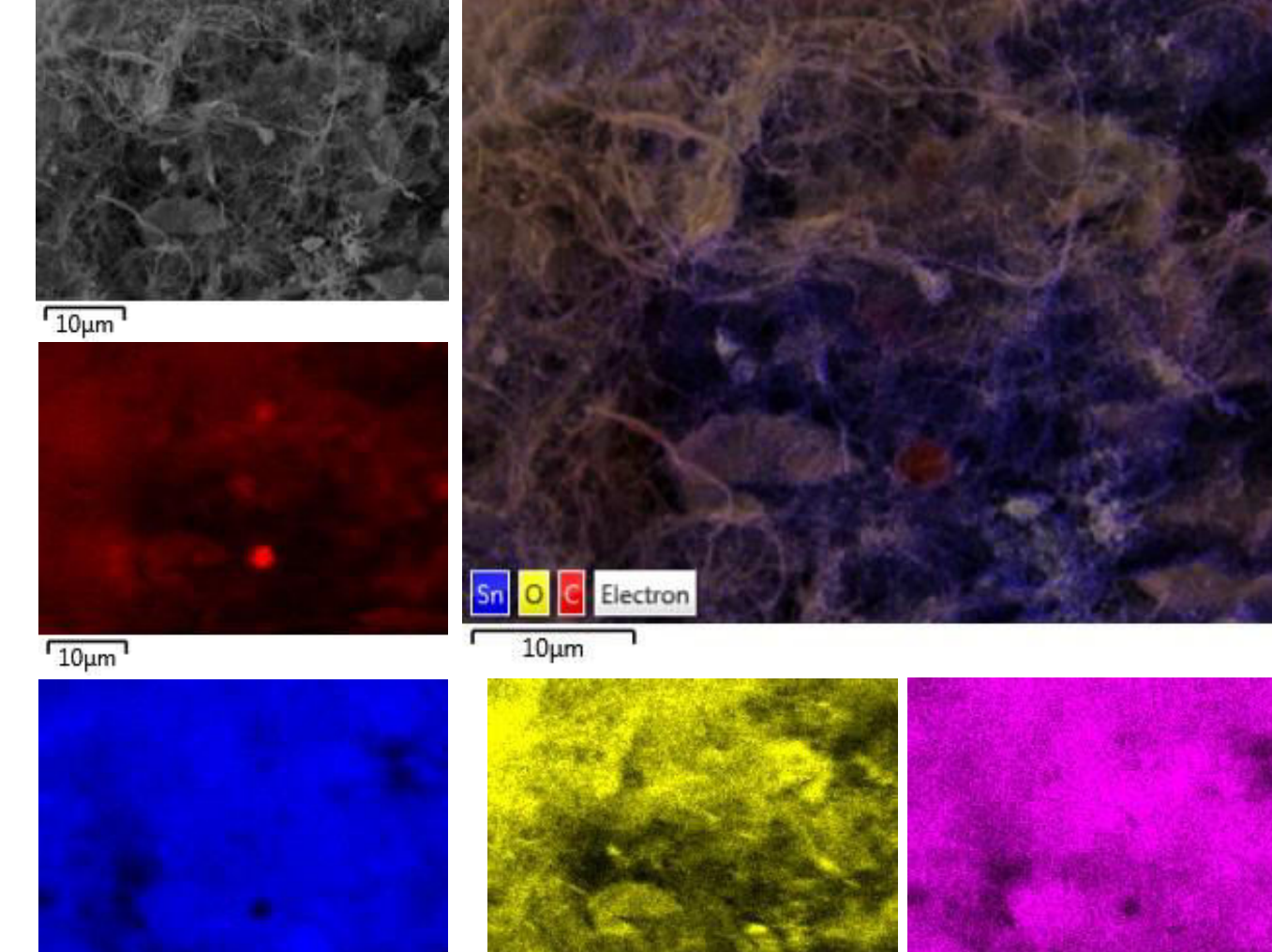


Reduction of SnCl₂ with oxidized CNT

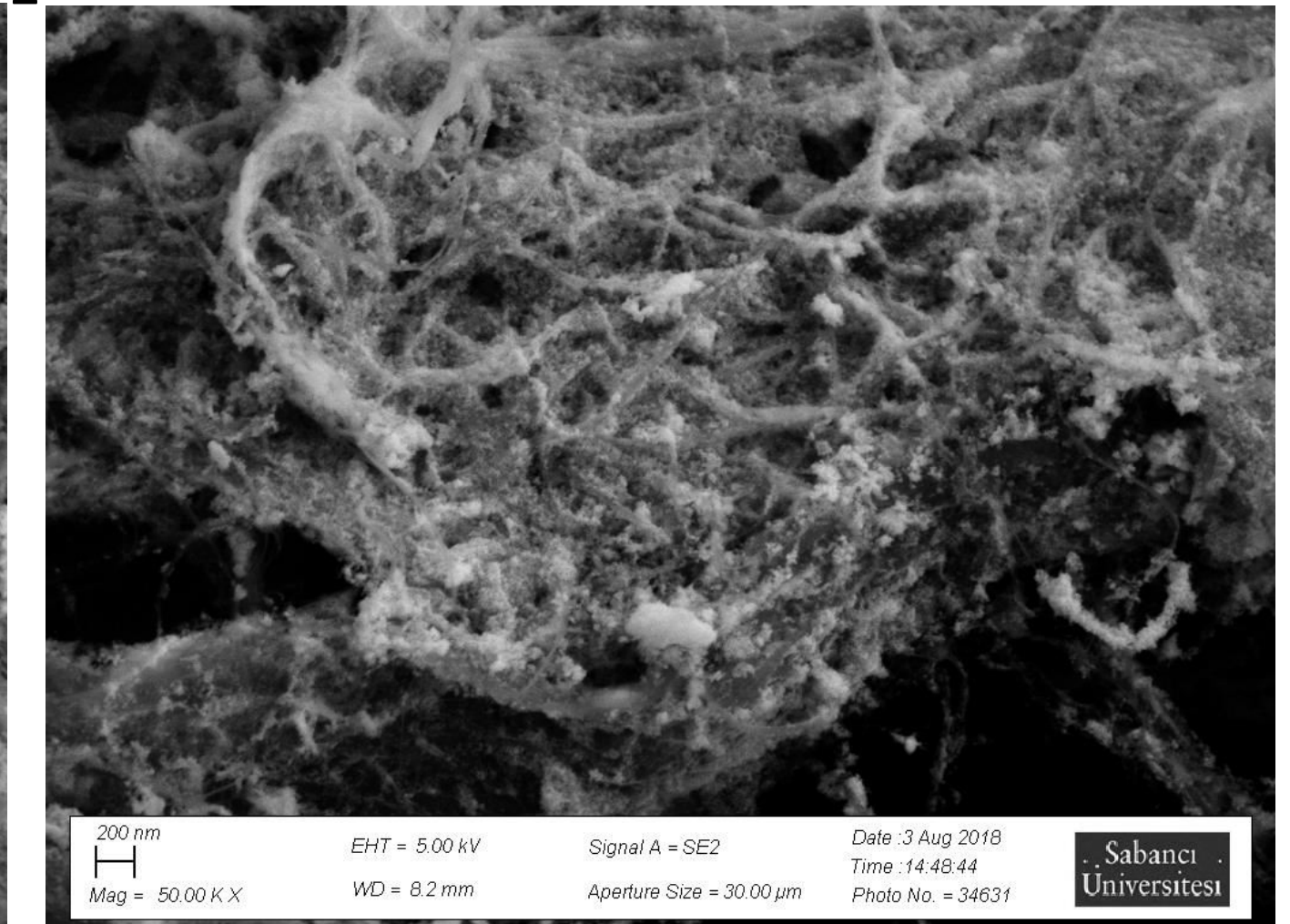
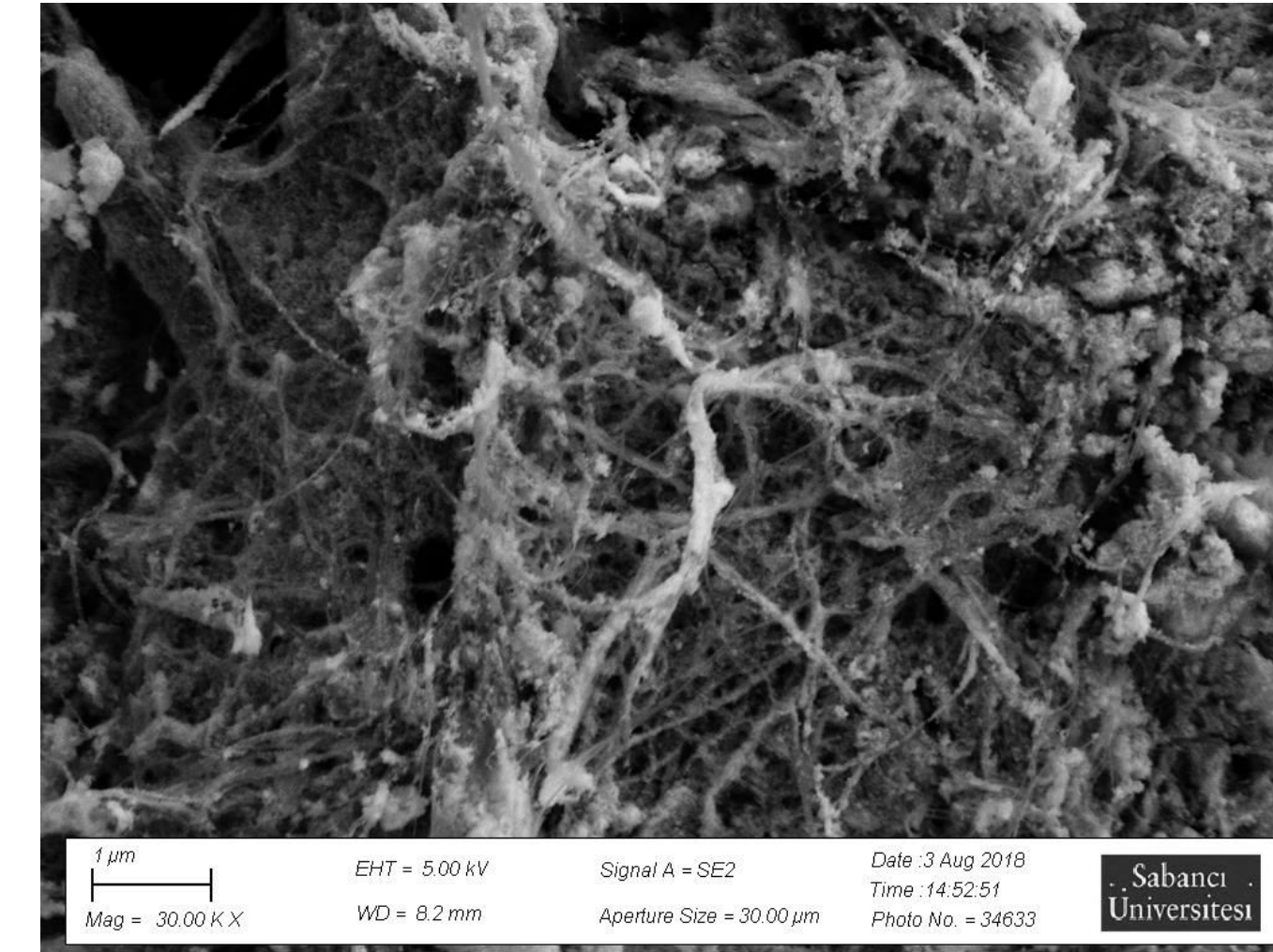
RAE_CNT01



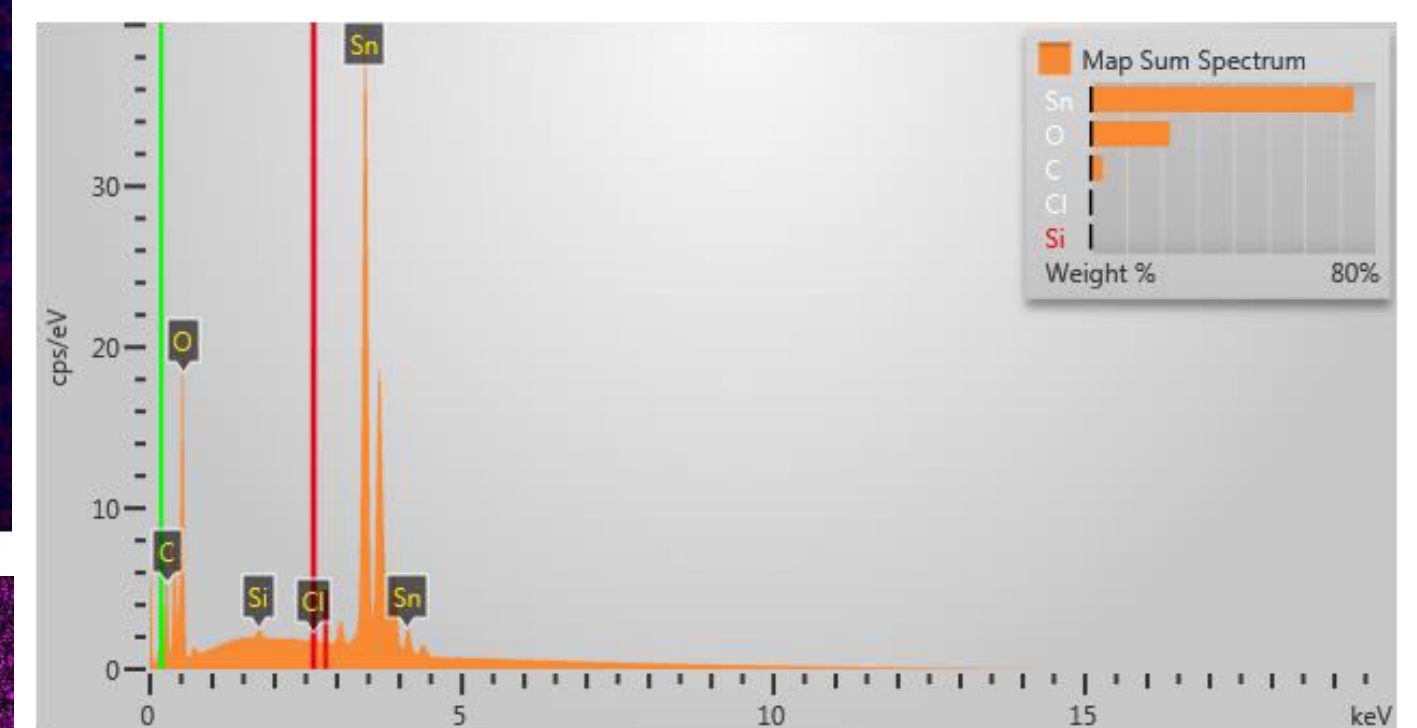
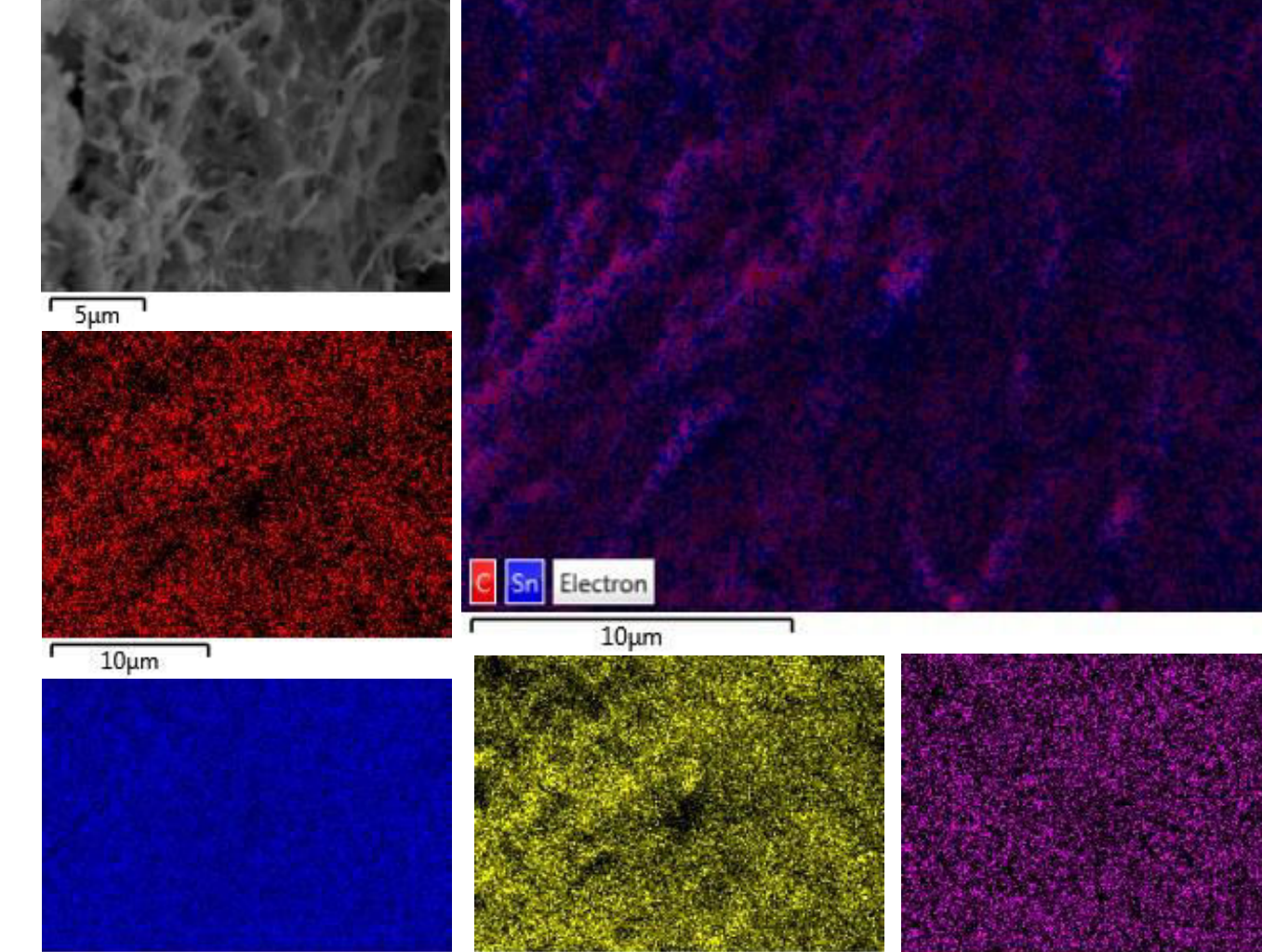
EDS Layered Image 4



RAE_CNT02



EDS Layered Image 2



Summary

- CNT/Sn hybrid nanostructures were obtained via microwave-assisted reduction in milder conditions.
- CNF/CNT/Sn, CNF/Sn and CNF/Sb structures were obtained via electrospinning.
- The samples were characterized via SEM and EDX.

Future Work

- Transmission electron microscopy (TEM) analysis will be done.
- CNT will be incorporated into CNF.
- Developed materials will be tested in lithium-ion batteries.

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References

1. J. Jung, C. Lee, S. Yu and I. Kim, J. Mater. Chem. A, 2015, DOI: 10.1039/C5TA06844D.
2. Zhang, Biao, Kang, Feiyu, Tarascon, Jean-Marie and Kim, Jang-Kyo. 2016, DOI: 10.1016/j.pmatsci.2015.08.002.