Production and Mechanical Characterization of Electrospun Ceramic/metallic Nanofiber

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Introduction and Objectives

- In high energy particle physics there is a demand for multi-MW high performance particle production targets.
- Nanofiber microstructure will have better performance than current solid targets in mitigating increased thermal tress waves, radiation damage.
- Objective is to fabricate ceramic/metallic nano-fiber with high strength, thermal shock resistance using low cost electrospinning process.

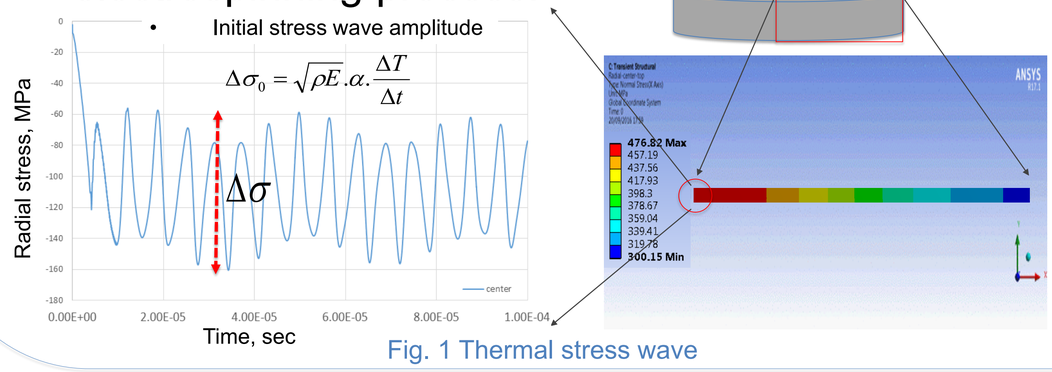


Fig. 1 Thermal stress wave

Electrospinning process

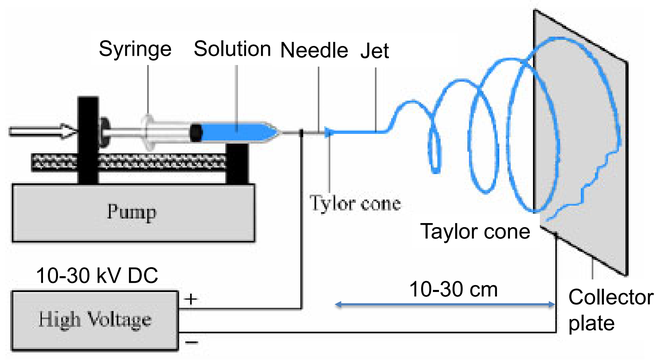


Fig. 2a Electrospinning set up

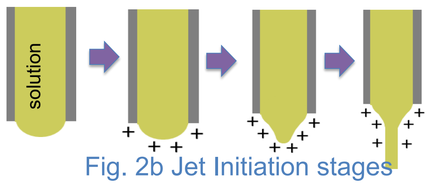


Fig. 2b Jet Initiation stages

Process initiates when electrostatic repulsion over comes surface tension

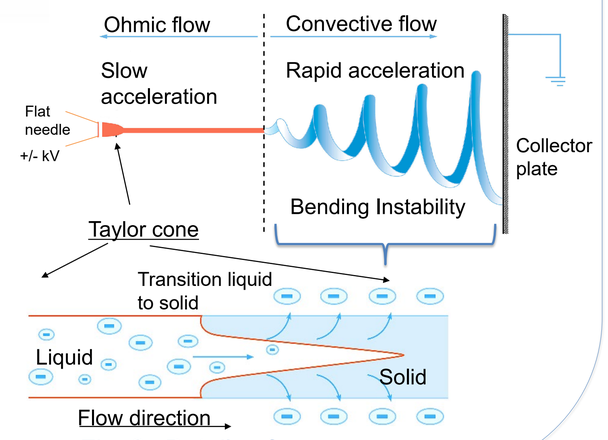
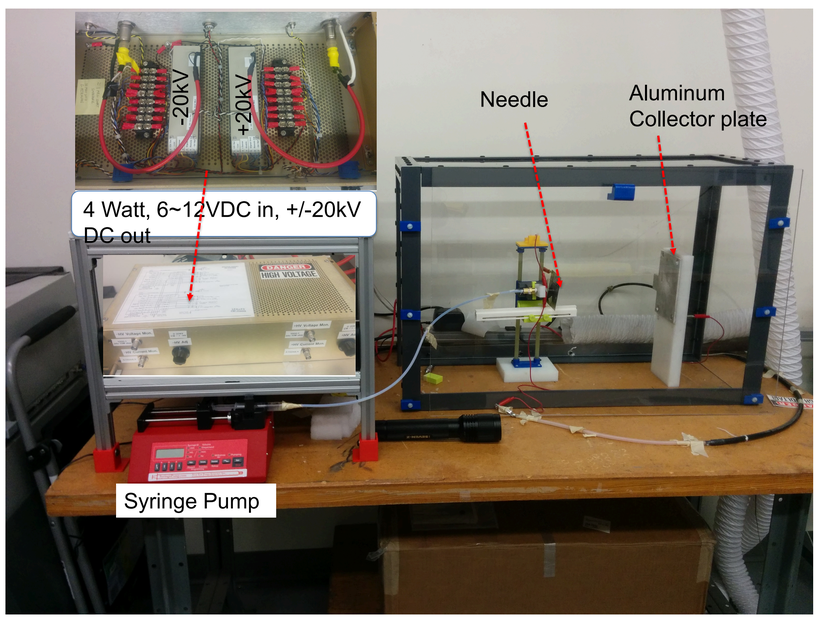
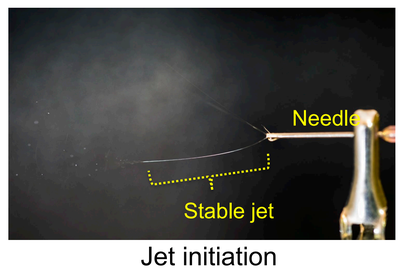


Fig. 2c Details of process zone

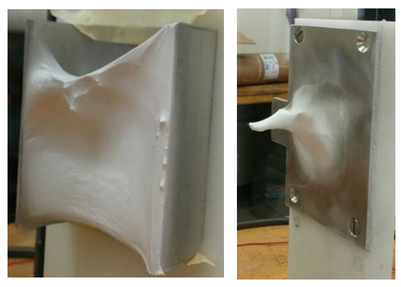
Process carried out at room temp. and atm. pressure

In-house electrospin set up





Jet initiation



Nano-fiber mat

Fig. 3 Lab scale electrospin unit

- Much safe to use (120W→4W!)
- Mobile compact unit →Can be run on 9 or 12 V battery

Ceramic/metallic nanofiber production

Inorganic precursor:

(Zirconium Carbonate +Acetic Acid → Zirconia

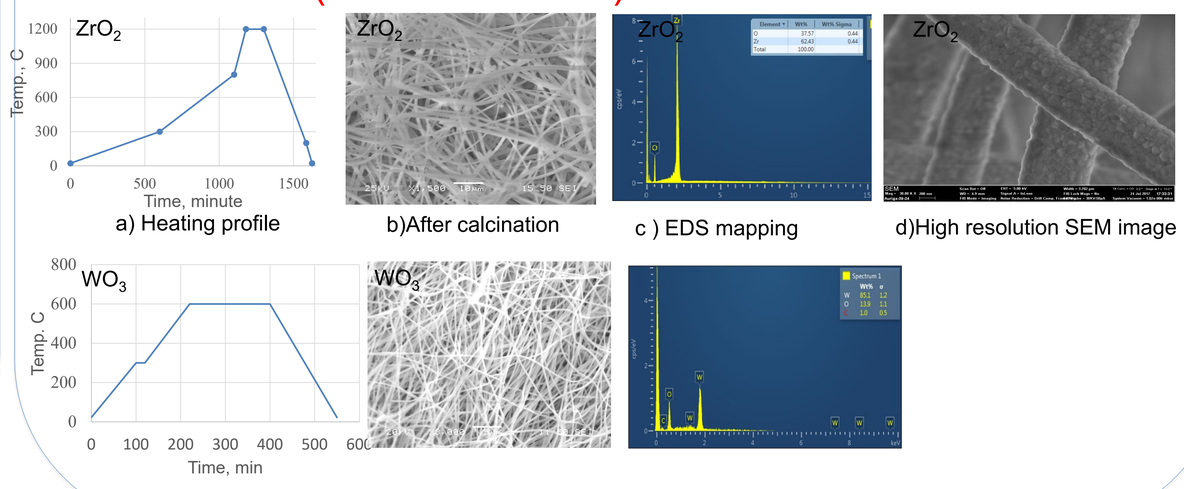
Ammonium meta-tungstate + D.I. Water→ WO_3)

+

Polymer solution : PVP+Ethanol/Aceton

↓

Calcination (Heat treatment)



a) Heating profile b)After calcination c) EDS mapping d)High resolution SEM image

Fig. 4 Ceramic/metallic nanofibers after heat treatment

Single nanofiber micro-mechanical testing- Atomic Force microscopy

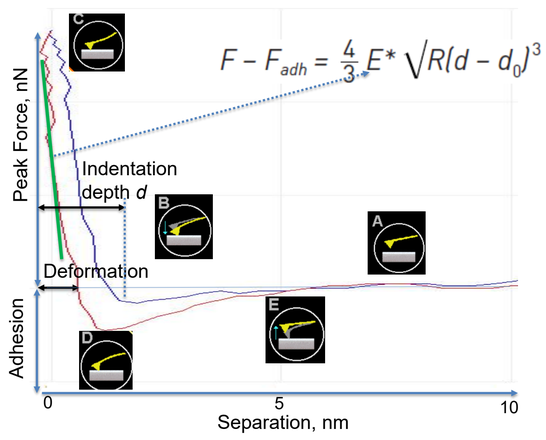


Fig. 5a Tip Deflection in contact mode, ZrO_2

Diamond tip cantilever
Spring Constant: 450 N/m
Resonant Freq. : 70 Hz

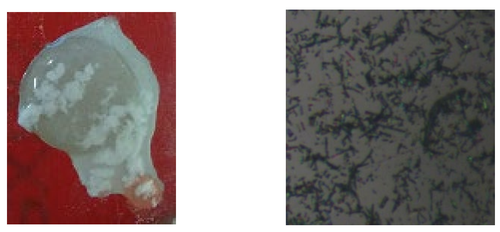


Fig. 5b Nanofiber solution casted on mica substrate

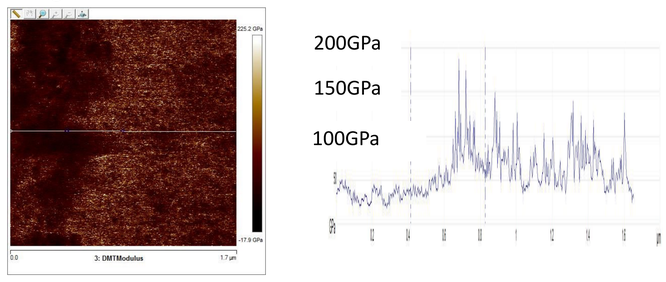


Fig. 5c Elastic modulus mapping ZO_2

Summary and Future work

- Set up a low cost, low power, safer electrospinning unit.
- Success in fabricating metallic and ceramic nanofiber.
- AFM technique to evaluate single nanofiber modulus.
- Ceramic nanofiber looks promising as future candidate target material.

Future work

- Single fiber bending test for tensile strength.
- Single fiber thermal properties evaluation.
- Radiation damage studies using ion irradiation.

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