NanoWestern

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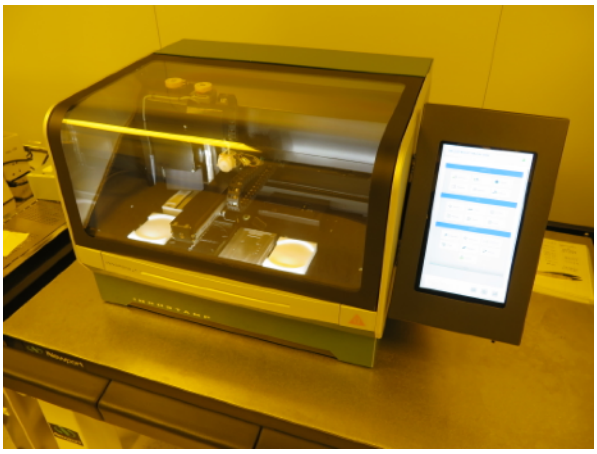
Dear Western Nanofabrication users,

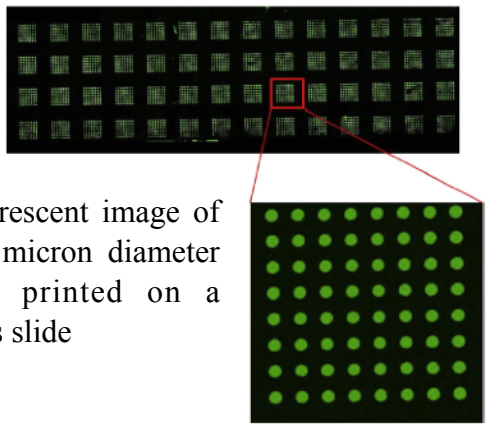
The past months have been busy in modernizing our facility with new instrumentation to better serve your projects. A new nanoimprint apparatus is now available for use enabling micro to nanoscale printing over a 4 inch wafer. Imprint lithography relies on the use of a reusable rubber stamp onto which are inscribed features to be reproduced. The stamp is inked with a solution of your choice such as fluorophores, nanoparticles, semi-conductor inks…, and positioned over the surface to reproduce these features. For those of you who desire to inscribe small features onto large surfaces with nanoscale resolution this is the tool of choice!

In parallel, we are modernizing our SEMs with better sample manipulation features for the production of TEM samples and a new stage for our electron beam lithography system with the latest options to design and inscribe nanoscale features with high resolution and with stitching possibilities. The new ebeam system should be operational in the new year.

As always we welcome new projects using our facility and encourage you to have your students trained using our state of the art technologies. Fast service work for SEM imaging is also an efficient way to obtain rapid control over the production of your materials and structures therefore enhancing the pace of your research. We are also engaged in accommodating academia-industry projects using our facility and we will support all projects involving micro and nanoscale fabrication.

François Lagugné-Labarthet
Western Nanofabrication Director
Chair of NanoOntario Inc.





Fluorescent image of 150 micron diameter disk printed on a glass slide

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Electrohydrodynamic Atomization to Fabricate Tunable Nano- to Micro-Scale Materials for Cutaneous Tissue Repair

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Chronic wounds present a significant burden on patients and the healthcare system. Two to four percent of the global healthcare expenditure, 80% of the 20-fold increase in lower extremity amputation among diabetic patients, and a 30% one-year mortality rate of diabetic amputees are accounted for by chronic wounds[1]. Clinical treatment of chronic wounds involves debridement, topical dressings and treatment of infection. Current dressings serve to retain moisture and protect the wound bed however, do little to actively facilitate healing.

Tissue engineered approaches to chronic wound treatment aim to actively recover the natural structure and function of the healthy wound environment with biomaterial alternatives to conventional dressings. Electrohydrodynamic atomization is one method capable of fabricating nanofibrous scaffolds which closely mimic the structure of the natural extracellular matrix (ECM), and multilayered microspheres capable of controlled drug release.

The aim of this work is to design and validate a novel electrohydrodynamic scaffold combining electrospun nanofibers and electrosprayed microspheres as a bioactive granulation tissue mimetic wound dressing for the treatment of chronic wounds.

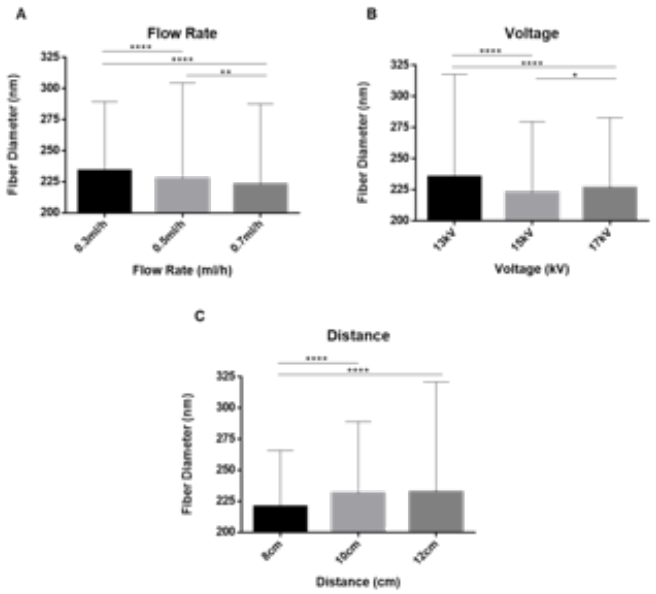

Figure 1. Effect of flow rate, distance and voltage on fiber diameter**.** N=3, n=1350, one-way ANOVA, $p<0.05$. All data is represented as mean ± SD.

Initial design of the electrospun scaffolds involved characterization of the morphological features of the nanofibers in response to varied process parameters. After fabrication, 8mm^2 punches were mounted on aluminum stubs, osmium coated and imaged using the LEO (Zeiss) 1530 scanning electron microscope at the Western Nanofabrication Facility. ImageJ software was then used to quantify fiber diameter.

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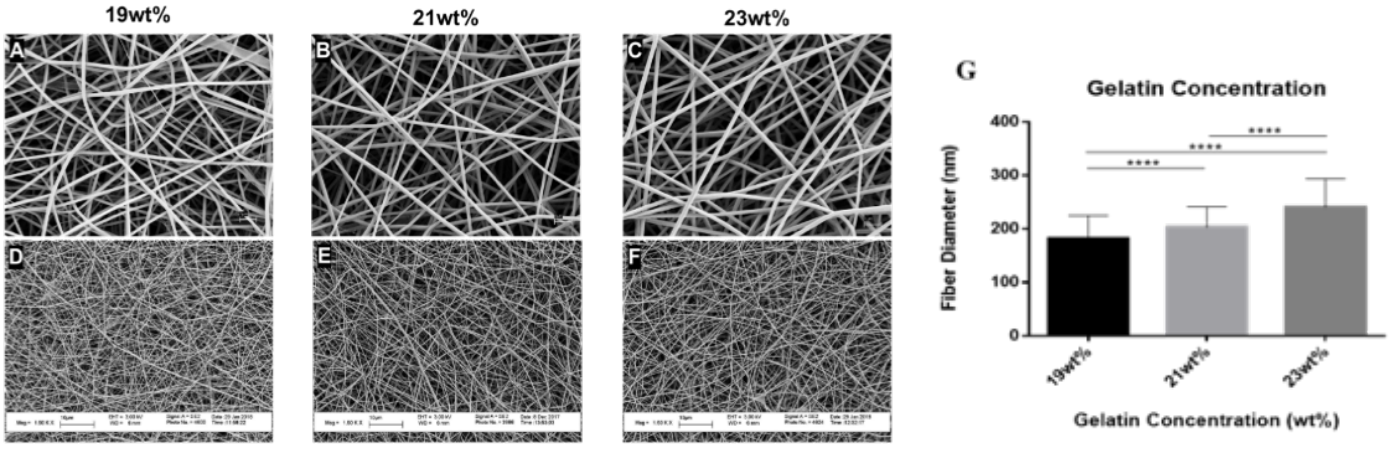

Figure 2. Effect of varied solution concentration on fiber diameter. A-F) Representative images of scaffolds 7500x magnification (A-C, scale bar = 1μm) and 1500x magnification (D-F, scale bar=10μm). G) Average fiber diameter in response to varied gelatin concentrations. N=3, n=450, one-way ANOVA, $p<0.05$. Data represented as mean ± SD.

Fiber diameter measurements (Figure 1) were calculated in response to 27 parameter combinations with varied flow rate (0.3ml/h, 0.5ml/h, 0.7ml/h), collector distance (6cm, 10cm, 12cm) and voltage (13kV, 15kV, 17kV). Concentration of gelatin solution was held constant at 21wt%. Three different gelatin concentrations (Figure 2) were tested (19wt%, 21wt% and 23wt%). Optimized parameters were held constant: 0.5mL/h flow rate, 17kV voltage, 8cm collector distance.

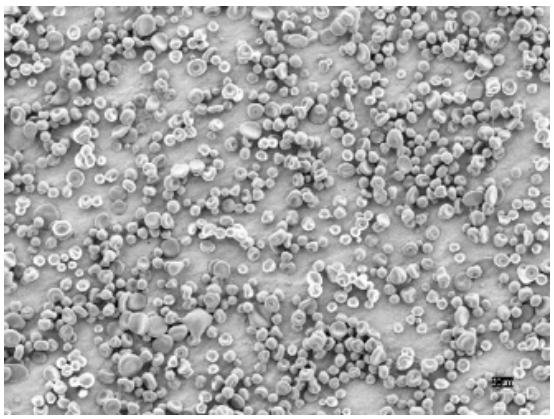

Figure 3. Coaxially electrosprayed core-shell microspheres for controlled drug delivery. Scale bar = 20μm.

Fiber diameter significantly decreased with increasing flow rate. Fiber diameter significantly decreased from 13kV to 17kV and significantly increased between 15kV and 17kV. Increasing collector distance significantly increased fiber diameter at each distance. Fiber diameter significantly increased with increasing gelatin concentration.

This study supports the capability of electrohydrodynamic atomization to fabricate tunable nano- to micro-scale materials for cutaneous tissue repair. Future work will aim to achieve a scaffold that more closely resembles the structure of the natural ECM (fiber diameters ranging from 30 to 130nm)[2], complete additional morphological assessment of electrosprayed core-shell microspheres (Figure 3), and test the viability of the novel scaffold in vitro and in vivo.

References:

[1] Forbes SJ and Rosenthal N. Preparing the ground for tissue regeneration: from mechanism to therapy. Nat Med, 2014. 20(8):857-69.

[2] Murugan R, Ramakrishna S. Design strategies of tissue engineering scaffolds with controlled fiber orientation. Tissue engineering, 2007. 13(8):1845-66.

Rate Dependent Plasticity of Small (Micron and Submicron) Metal Volumes

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Nano-size material systems and components are now regularly being fabricated for use in a wide variety of new applications. These systems exhibit mechanical properties that can be drastically different from their macroscopic counterparts. Classic continuum mechanics based theories cannot describe the mechanical strength and deformation behaviour of such materials primarily because the sample size is similar to the size scale of discrete imperfections within the crystal. There is thus a need for understanding the fundamental operative plastic deformation mechanisms in such samples. Doing so, compression tests on high purity (99.998%) single and poly-crystalline Au was performed. Gold micro and nano spheres of different initial diameters are fabricated using ebeam lithography and dewetting technique.

Coated spheres were fabricated by depositing a 80 nm thickness W layer on the surface using sputtering technique, to study the effect of constraining layer. Micro-compression test was used to study the mechanical behaviour of the samples. The deformation was performed under constant loading rate conditions. Fig. 1 compares the behavior of coated and non-coated samples. Fig. 2 shows the deformed samples after 700nm compression and formation of shear bands at the surface of non-coated ones.

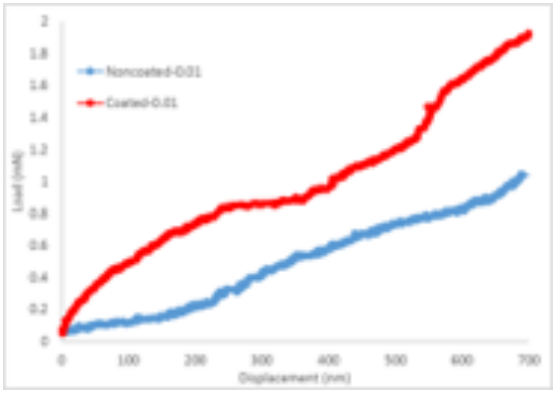

Figure. 1. Load-displacement curves for the compression of coated and non-coated 2200nm samples with 0.01 rate.

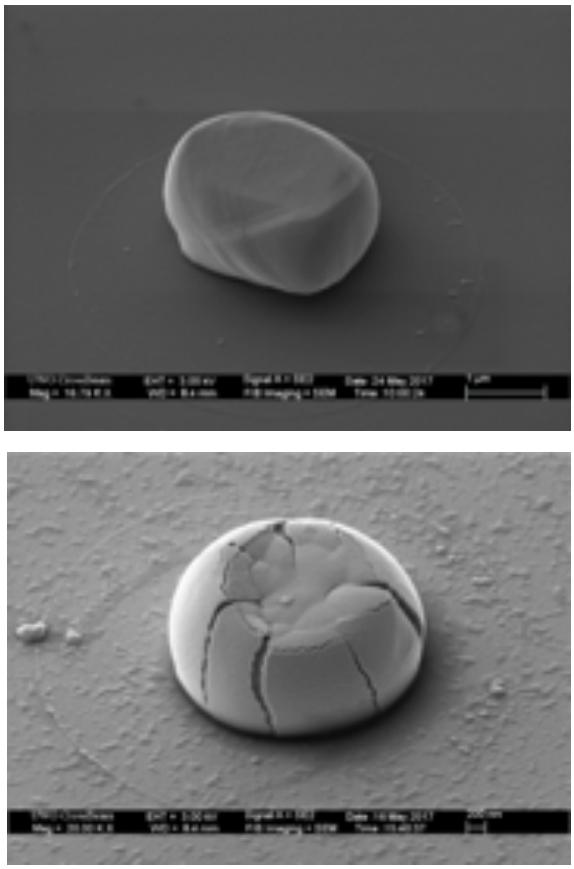

Figure. 2. SEM images of the deformed 2200 nm spheres under 0. 01 loading rate

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