NANOWIRE PRINTING: ELECTROHYDRODYNAMIC PRINTING PROCESS ALLOWS DEPOSITION OF ADVANCED MATERIALS ON NANOSCALE

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ABSTRACT

A process study was carried out using a prototype for a nanowire research printer, which was developed within the scope of the INTERREG RocKET Reloaded project E-Nanoprint-Pro. This direct-write nanowire deposition tool opens possibilities for research on functional nanowires for a wide field of applications. The field includes applications with transparent conductors or lab-on-a-chip devices. This poster describes highlights from the process study.

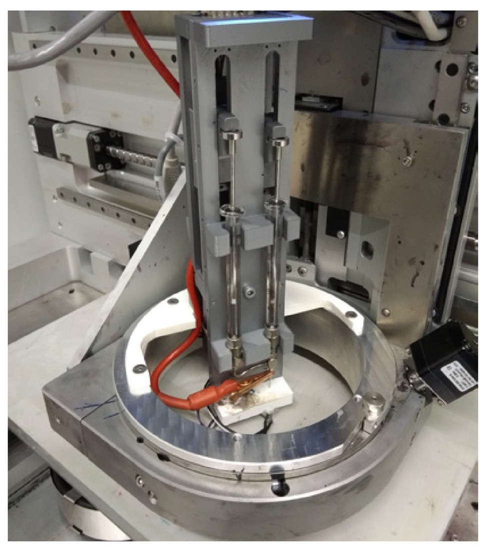

figure 1. The nanowire printhead prototype, implemented on an x-y-z stage.

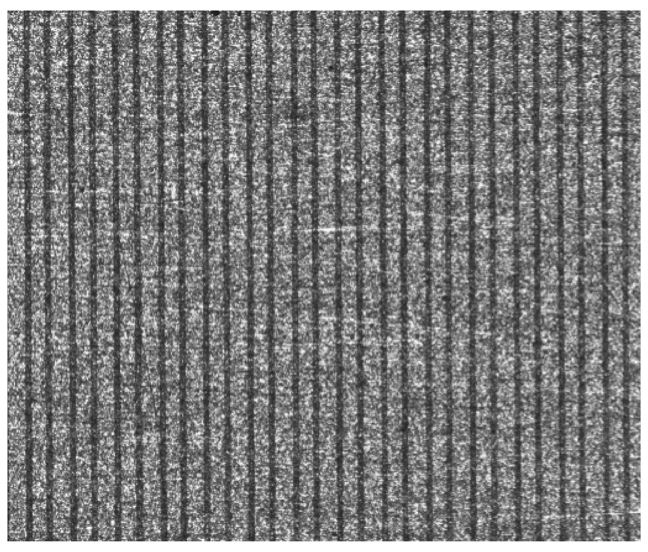

figure 2. PEO nanowires on a Cu substrate. Wire diameter of 20 μm.

ELECTROSPINNING BASICS

Printed Electronics structures with nanoscale dimensions can be made using the novel Near-Field Electro-Hydrodynamic Nanowire Printing (ENP) process. Key in this process is the high voltage between the metallic needle tip and the collector. Electrostatic forces are used here for stretching a viscoelastic fluid. Increasing the electric field stretches a pendant drop into a Taylor cone. Eventually a fiber is spun from this Taylor cone [1]. The Near-Field region allows controlled deposition of this nanowire. The fluid in the picture below is a polymer solution. By adding precursors or coaxial spinning, functional nanowires can be spun [2].

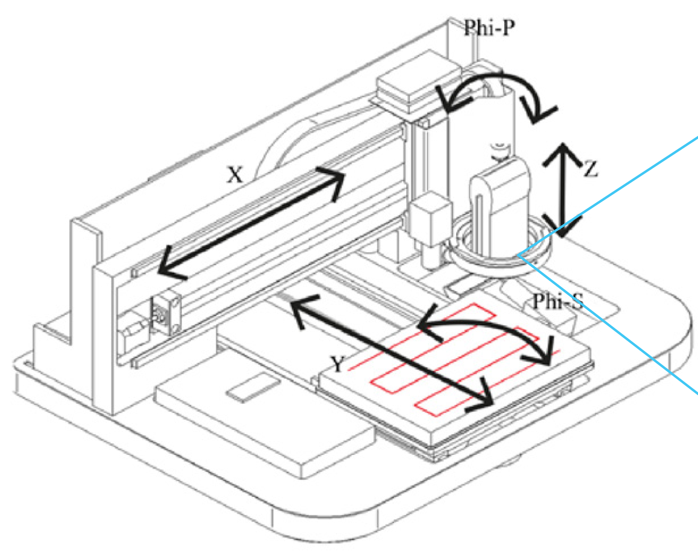

figure 3A. System set-up.

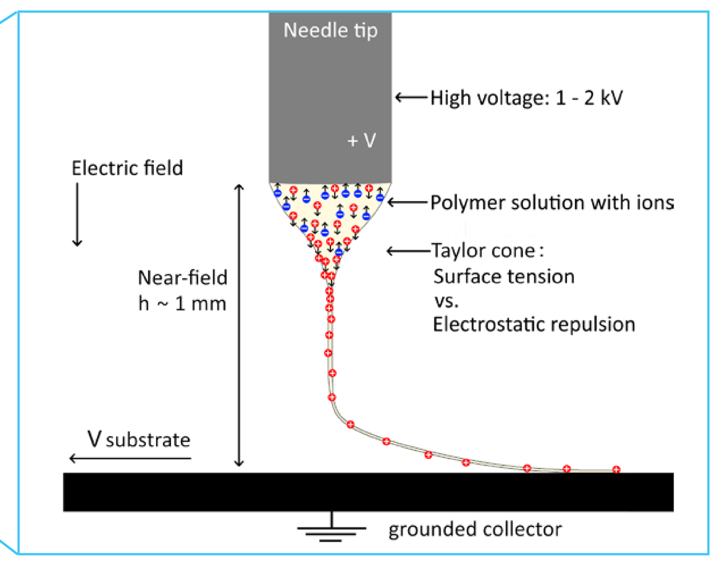

figure 3B. Electrospinning working principle.

AMBITION

The ambition of this project is to investigate this innovative printing technology, using a recently developed prototype of a nanowire research printing tool. More specifically:

- To develop a near-field Electrohydrodynamic Nanowire Printing tool for direct-write mode deposition of nanowires. This stand-alone tool comes with proprietary control-electronics. A vision system will be implemented. It is compatible with multiple motion platforms.

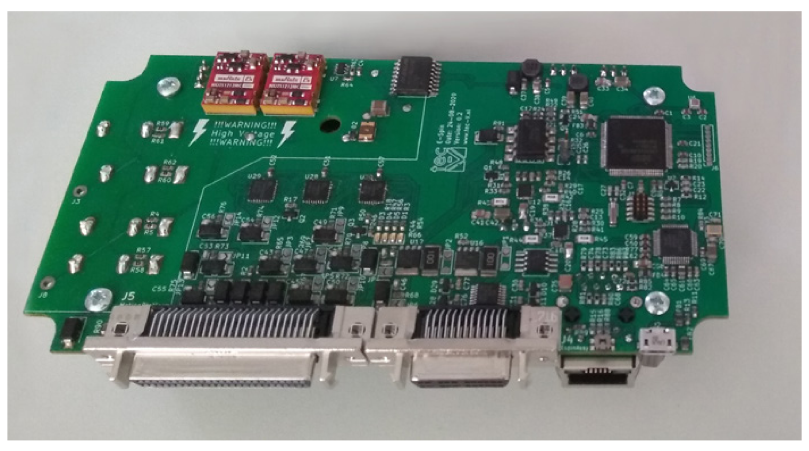

figure 4. Control electronics for this printing tool.

- Research on coaxial electrospinning of conductive nanowires. Printed meshes of conductive nanowires could bring a good replacement for Indium tin oxide (ITO), which is a scarce and brittle material used for transparent conductive layers in touch screens. Within E-Nanoprint-Pro, the project partners DoMicro, Coatema, microTEC, tec-V and TechToBizz are also investigating a couple of other promising applications that can be enabled by this new technology. An example of such an application is the printing of conductive wires for microfluidics devices.

figure 5: Flexible touch screen.

References

1. K. Garg, J.L. Bowlin, Biomicrofluidics **5**, 013403 (2011)
2. A. Greiner and J.H. Wendorff, Angew. Chem. **46**, 5670-5703 (2007)

RESULTS

The ENP-printer is ready for material research on electrospinning functional nanowires. Process development was done with this tool to verify the equipment. A parameter study shows relevant relations between diameter and electric field, print speed, flow rate and substrate type. A polymer solution with PEO is used on both Cu and PET substrates. Controlled deposition of wires with sub-micron diameter is achieved, see below.

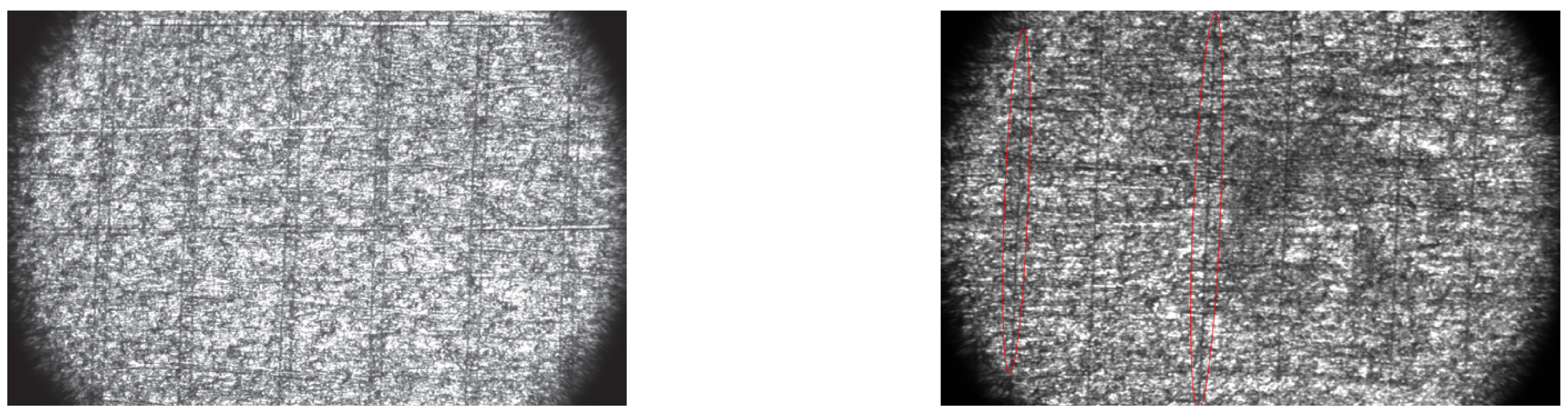

figure 6. PEO wires on a Cu substrate. Wire diameters of 12 μm (left) and submicron wires (right, wires encircled in red).

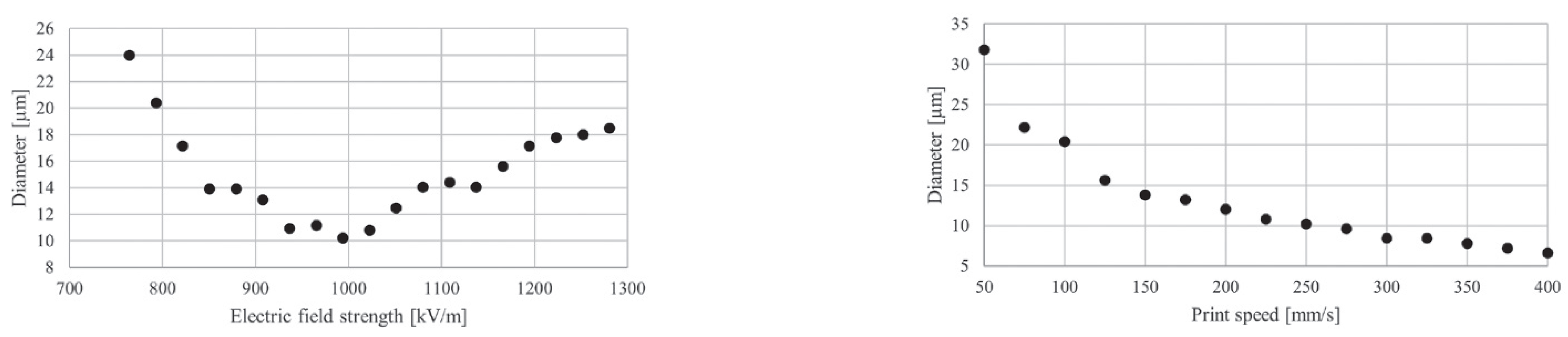

figure 7. Parameter study shows a clear relation between the wire diameter and the electric field strength (left) and the print speed (right).

Current research focusses on electrospinning functional materials like coaxial structures with a conductive core consisting of silver nanoparticles.

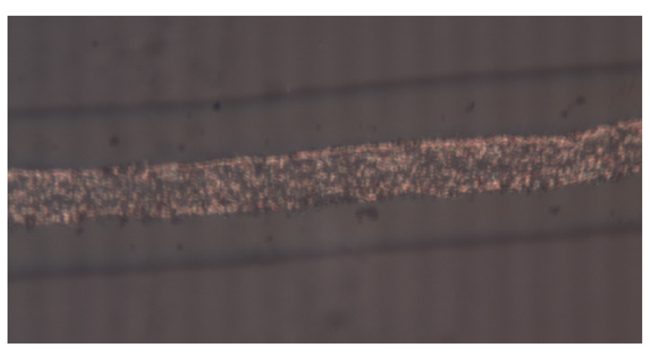

figure 8. Coaxial nanowire with silver core (~15 μm) and PEO shell.

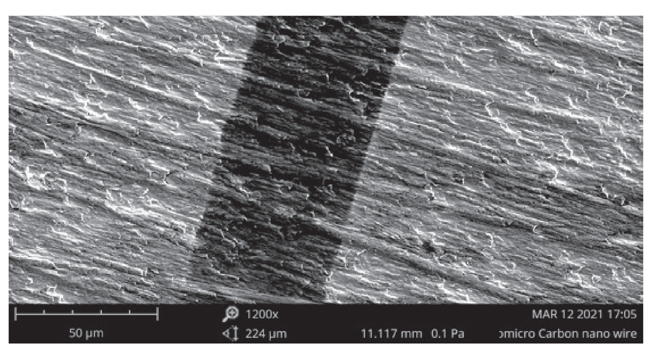

figure 9. SEM image of coaxial wire on Cu substrate.

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