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Conductive Elastomer Based Microelectrode Arrays For Spinal Cord Stimulation

Flurin Stauffer, Vincent Martinez, Klas Tybrandt, Alexandre Larmagnac, Janos Vörös

Laboratory of Biosensors and Bioelectronics, ETH Zurich, Switzerland
stauffer@biomed.ee.ethz.ch

Conductive Elastomers

Stretchable electronics enables novel and diverse conformal devices for monitoring, diagnosing and therapeutic purposes in medicine. We explore materials and fabrication methods to produce patterned conductive elastomers for use as microelectrode arrays (MEAs) for spinal cord stimulation to facilitate functional recovery in spinalised mammals [1]. These composite materials can also be tailored to be used in strain sensing applications. Important requirements for three main applications of conductive elastomers are:

1. Stretchable Interconnects & Compliant Electrodes

- Stable impedance while stretching
- High conductivity
- High stretchability

2. Stretchable Strain Sensors

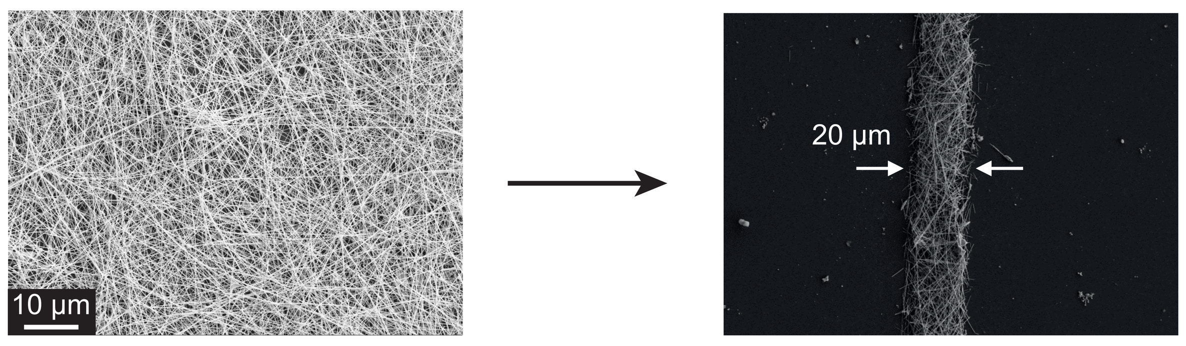
- High gauge factor (sensitivity) & stretchability
- Linear resistance change
- Stability & no hysteresis

3. Actuators

- Electrodes must remain conductive while undergoing large deformations
- Low material stiffnes
- High electrical breakdown strength

Patterned Silver Nanowire Networks

Novel composites based on silver nanowire (AgNW) networks embedded in PDMS have been shown to be promising for use as highly conductive elastomers [2]. By controlling the track dimensions the resistance change upon strain can be tailored [3]. Photolithographical patterning of siver nanowire networks enables feature sizes down to 10 µm.

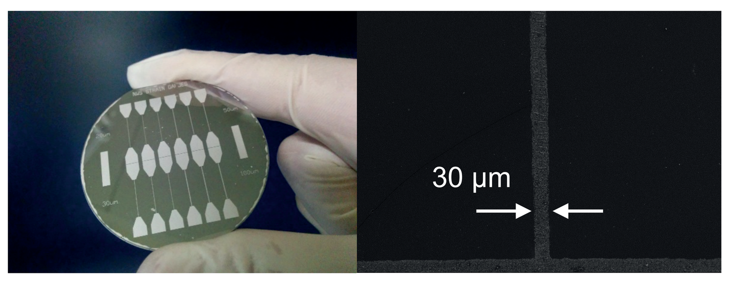


We characterized the electromechanical properties of silver nanowire tracks embedded in PDMS with high aspect ratio (100 - 500) by progressive strain cycling:

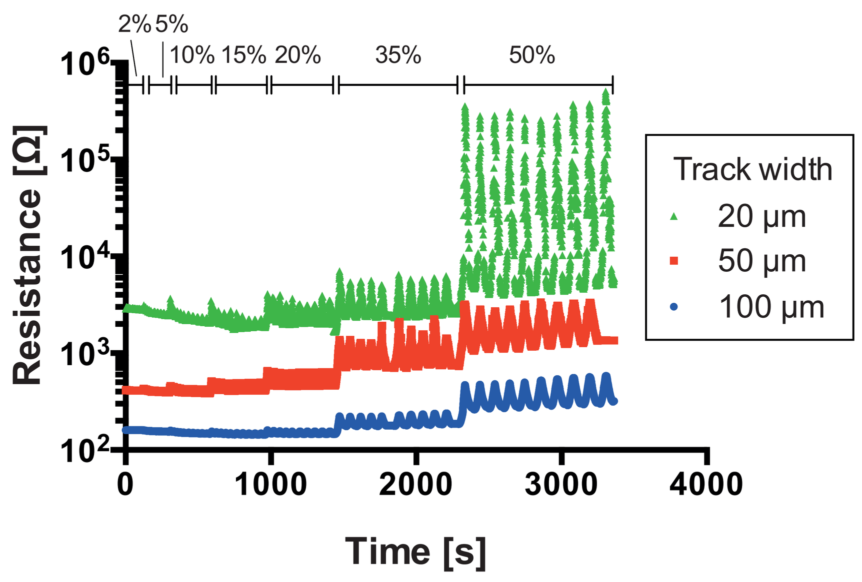
1. AgNW track dimensions
   - Length: 1 cm
   - Width: 20 - 100 µm
   - AgNW film thickness: 3 µm

2. Stretchable, conductive and transparent grid structures enable high yield and diverse resistance response tuning.

1 Stretching AgNW - PDMS tracks

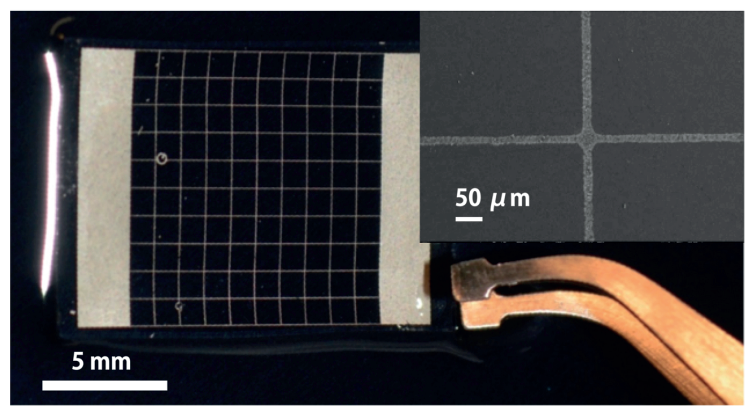


Wafer with AgNW-PDMS tracks and an SEM image of a 30 µm wide track.

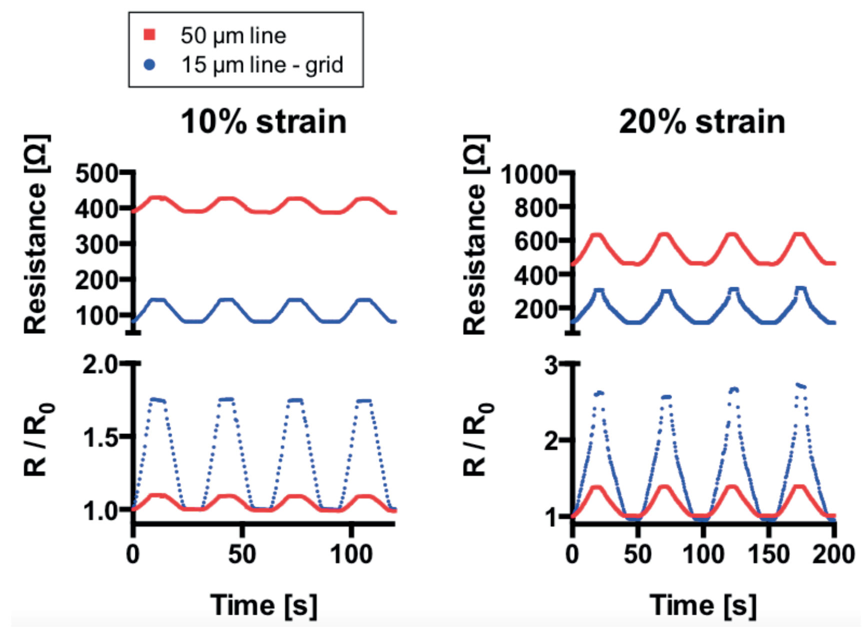


Resistance change of AgNW-PDMS tracks under progressive strain cycling.

2 Single tracks vs. grids



Patterned AgNW-PDMS with 15 µm grid tracks.

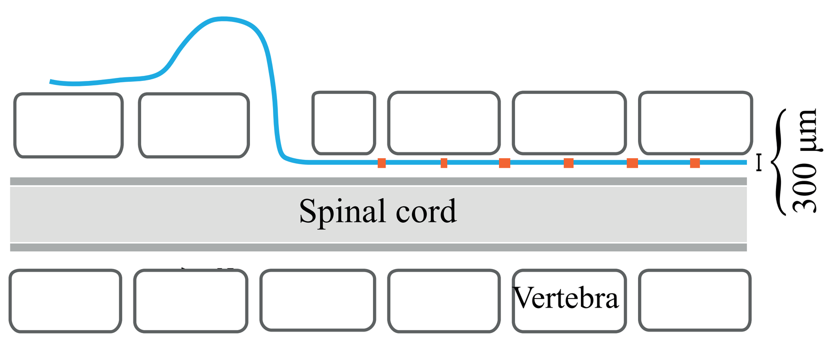


Resistance change of AgNW-PDMS tracks and grids under 10% and 20% strain cycles.

Example: Stretchable Microelectrode Arrays

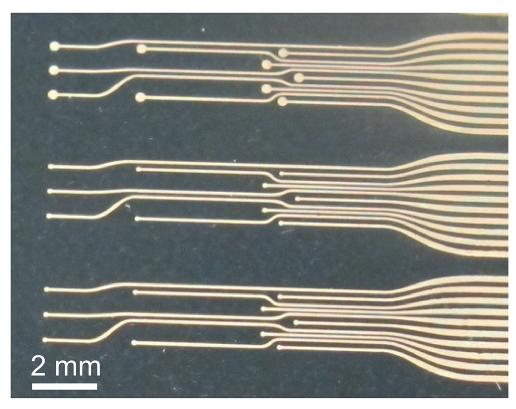
We develop stretchable microelectrode arrays (MEAs) for spinal cord injury rehabilitation [4]. Soft neural implants with mechanical properties similar to nervous tissue are promising for long-term implantation [5]. In current implants the number of electrodes is limited by the fabrication method and/or the electromechanical performance of the material. Novel composite materials enable miniaturization of such implants.

Electrode requirements:
- Low electrode impedance
- Highly stretchable, soft & mechanically robust
- Biocompatible and long-term stable for chronic implantation



Schematic side view of a stretchable MEA in the spinal canal.

First generation stretchable MEA based on conductive PDMS with 6 electrodes during implantation [4].



Miniaturized stretchable MEA with 10 electrodes (under development).

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Laboratory of Biosensors and Bioelectronics

ETH zürich