Simulation of a Tether Structure for Ultra-stretchable Monolithic Silicon Fabric

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Introduction

The role of stretchable electronics systems allows the design of new reconfigurable macro-electronics, that extends a device capability to function as a distributed sensor network which can potentially be used for wearable electronics. At the moment such devices are primarily based on polymeric materials such as PDMS or Polyimide. Nevertheless, silicon has been the predominant material in electronics for decades. For this reason, we selected silicon as the base material structure for a hexagonal islands network, which are connected through spiral springs to form an ultra-stretchable arrangement. In this work we simulated a spiral tether structure for stretchable and adaptable electronic systems. The spirals interconnect several hexagonal islands as show in Figure 1.

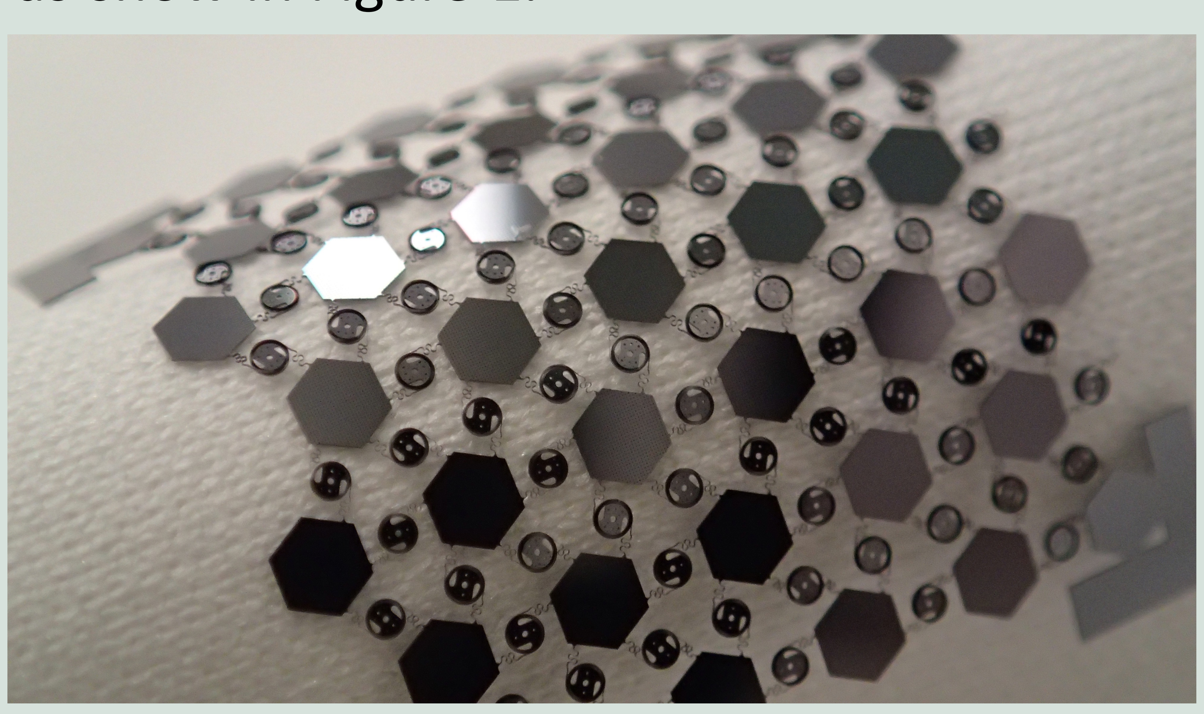

Figure 1 Digital photograph of an array of 800µm side hexagons interconnected by single 5µm arms spirals.

Design and Simulation

The structure design was exported from Tanner Tools L-edit software as a DXF file, using the CAD import module of COMSOL. The 2D drawing was imported to a work-plane and then extruded to the specific thickness needed. The structure's material was Silicon (single-crystal), which was selected from the predefined materials library. The physics being used for this simulation was the Solid Mechanics module.

To deform the structure a Prescribed Displacement condition was set to the other end of the spiral structure and the value was set to a predefined parameter to be able to perform an extended study.

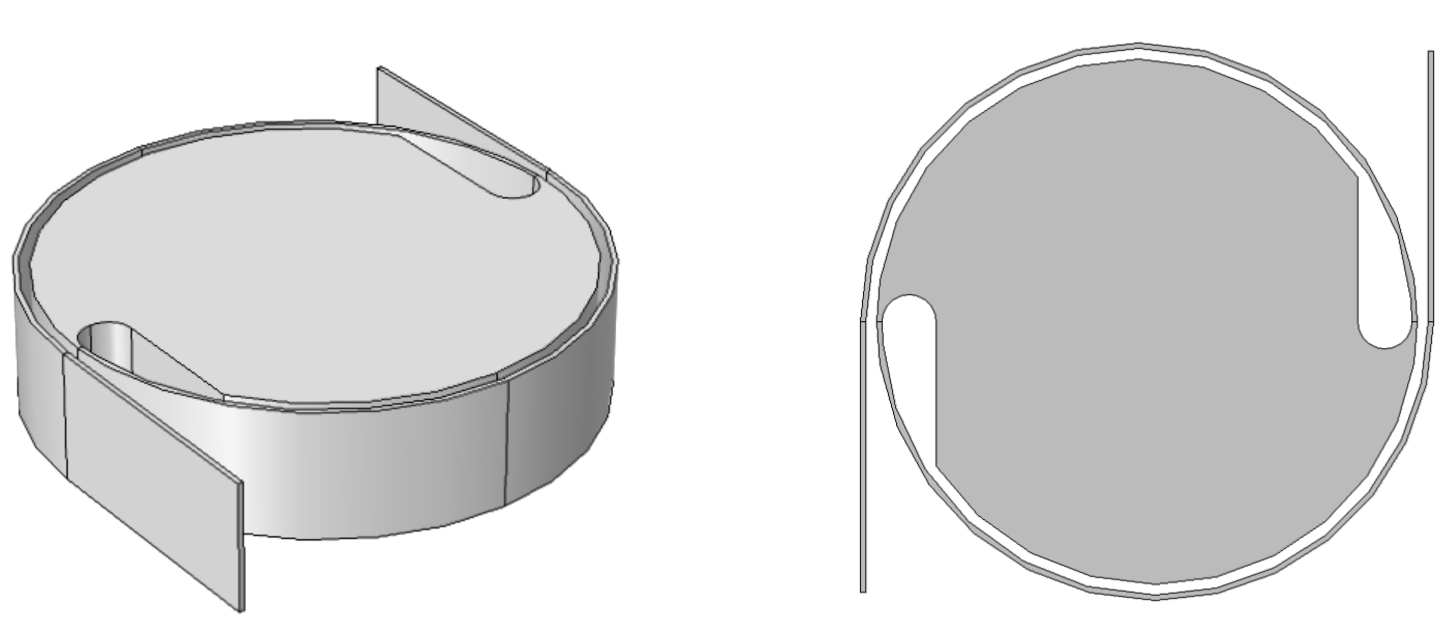

Figure 2 (Left) Isometric view and (Right) Top view of the simulated structure in its initial state

Results

The simulation was used to evaluate the spirals strain distribution and to identify possible weak points in the structures' design. In Figure 3 (Left) we show the simulation results of a fully extended spiral. Figure 3 (Right), shows the corresponding strain and Figure 4 shows a graph of the von Mises stress in the spiral, when is extended to different horizontal displacement of up to 675µm. The maximum stress and strain location are at the beginning of the arms. The Von Mises stress has a maximum of 4000 MPa, which is much lower than the tensile strength of the silicon.

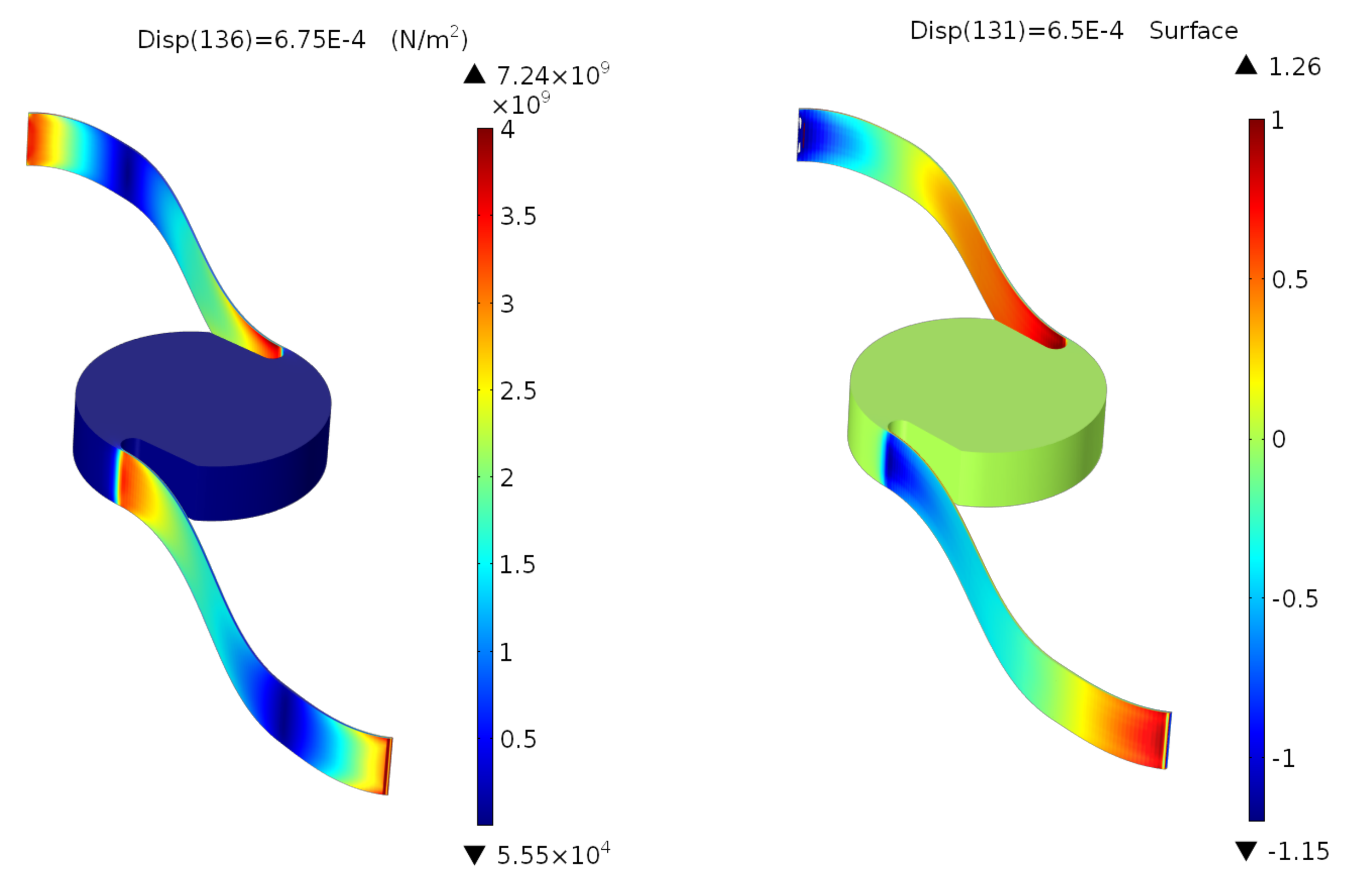

Figure 3 (Left) Von Mises Stress (Right) Strain results of the extended structure.

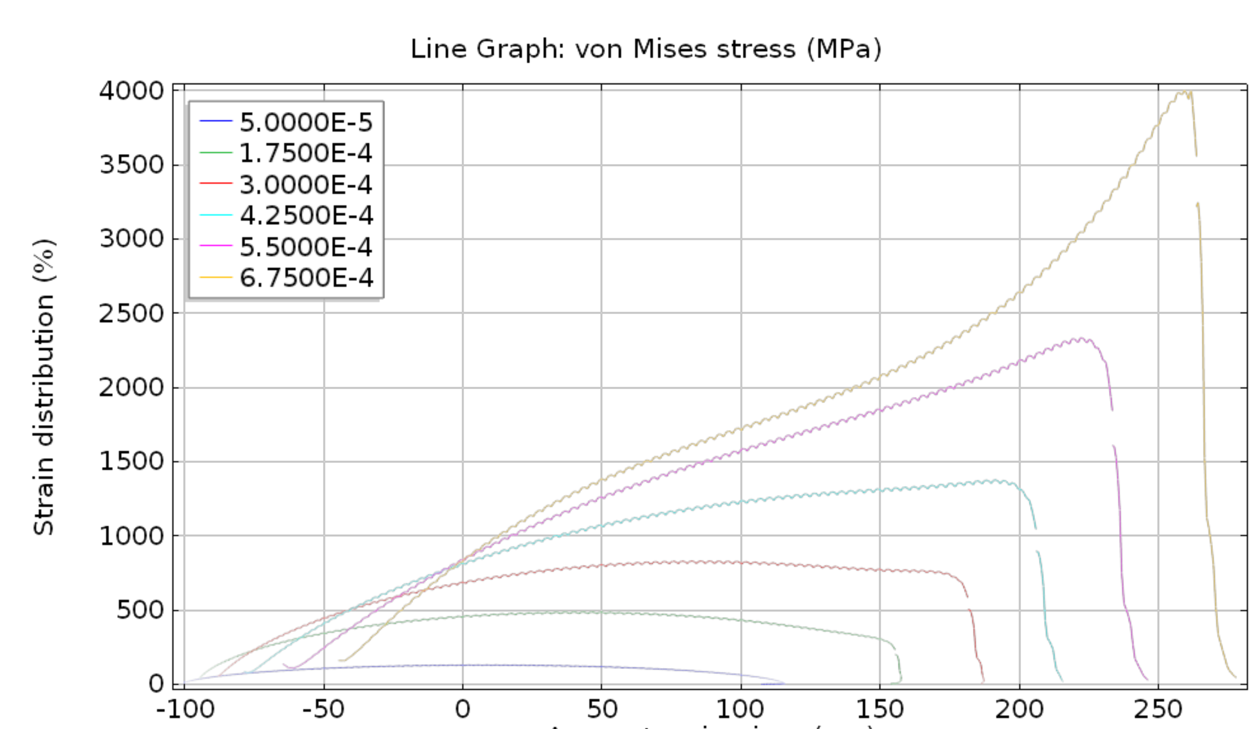

Figure 4 Von Mises results for the different extensions of the structure.

Conclusions

The spiral design has the maximum stress and strain points at the beginning of the arms that could be decreased by adding a new feature to the arms to alleviate the stresses and avoid an earlier fracture.

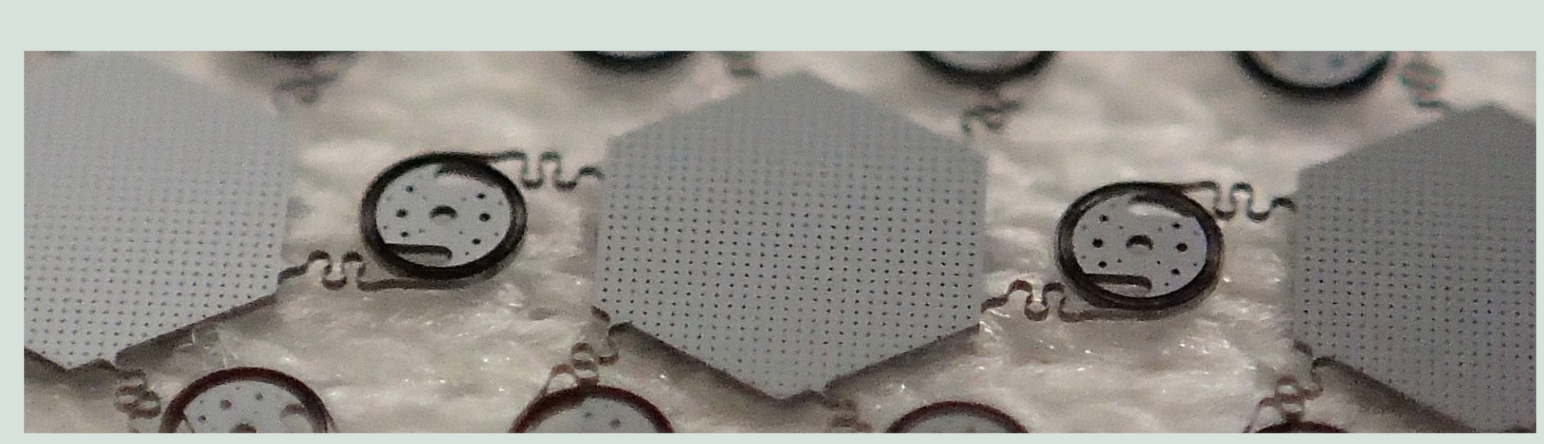

Figure 5 Optical photograph (zoomed view) of fabricated silicon devices.

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