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# Materials for Biomedical Soft Robots

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## INTRODUCTION

Soft Robotics is a branch of robotics with components consisting of highly compliable, elastomeric materials. These properties offer inherent advantages of flexibility and adaptability when compared to conventional rigid robotic systems. They can perform delicate roles and have improved safety with inadvertent or purposeful contact due to the soft nature and lower inertia.

Areas such as health-care and surgical technologies particularly benefit from advances in this field as these systems can assist with anything from sensing in minimally invasive surgery (Jones, D et al. 2017), to rehabilitation technology for stroke patients (Maeder-York, P et al. 2014).

## BACKGROUND

Elastomeric material is frequently used as a vessel for inflation to accomplish different ranges of motion where a strain-limiting element is embedded within a monolithic structure to reduce the mechanical complexity (Galloway et al. 2013). Compliant dynamic systems can be manufactured from a single element where normally a sophisticated joint system is required.

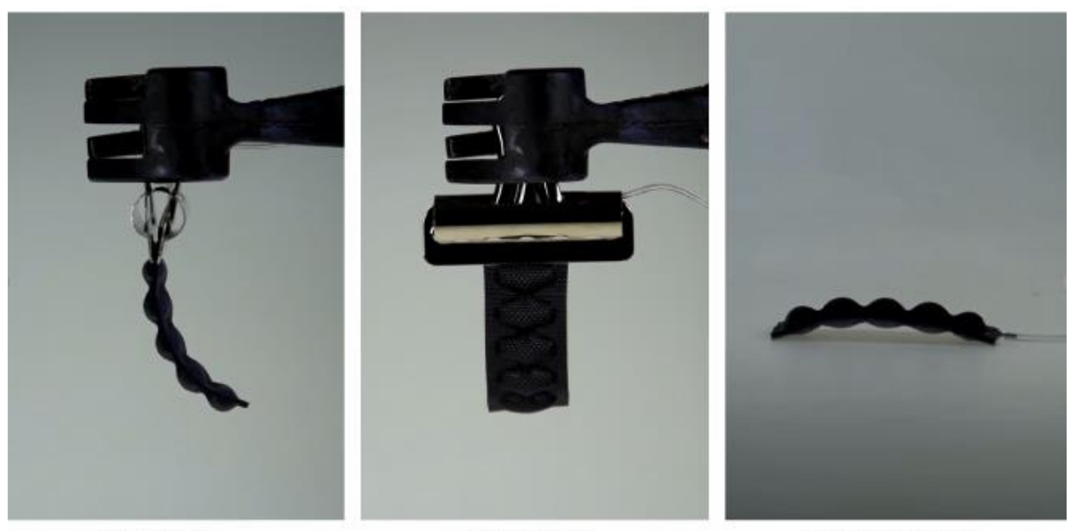



*Fig 1:* Thin Soft Layered Actuator (tSLA) developed at the University of Leeds[1]

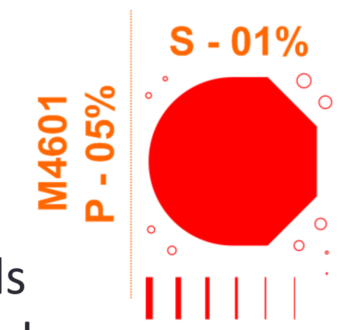
In *fig 1,* the actuator contains a strain limiting layer which unidirectional bending; when pneumatically actuated, air is forced along channels which inflates one side but is restricted on the other.

This research focuses on alternate materials used for application.

## CHARACTERISATION OF LASER CUT SILICONE

Part of the primary research involved investigating the use of different laser cut silicones for use in a soft actuator. Silicone is widely used as the elastomeric bulk material due to its characteristics. By laser cutting the silicone, incisions and engraving can be made to alter the properties and thickness of the material in specific areas. This creates different strain limiting regions to create an actuation.

Investigation on the effect of laser cutting silicone was conducted by altering power-speed variables. A matrix of cells for each material with speed and power varying from 1% to 100% was created. This cell design was chosen to investigate the effects on hole accuracy, cut width and engraving.




The cells were laser cut by colour coordinating each cell to a corresponding laser speed using the RGB colour palette. As the cutter could only recognize 8 colours per run, the sample had to be placed on the cutting bed and ran 3 separate times, each changing the speed increment for a particular colour:

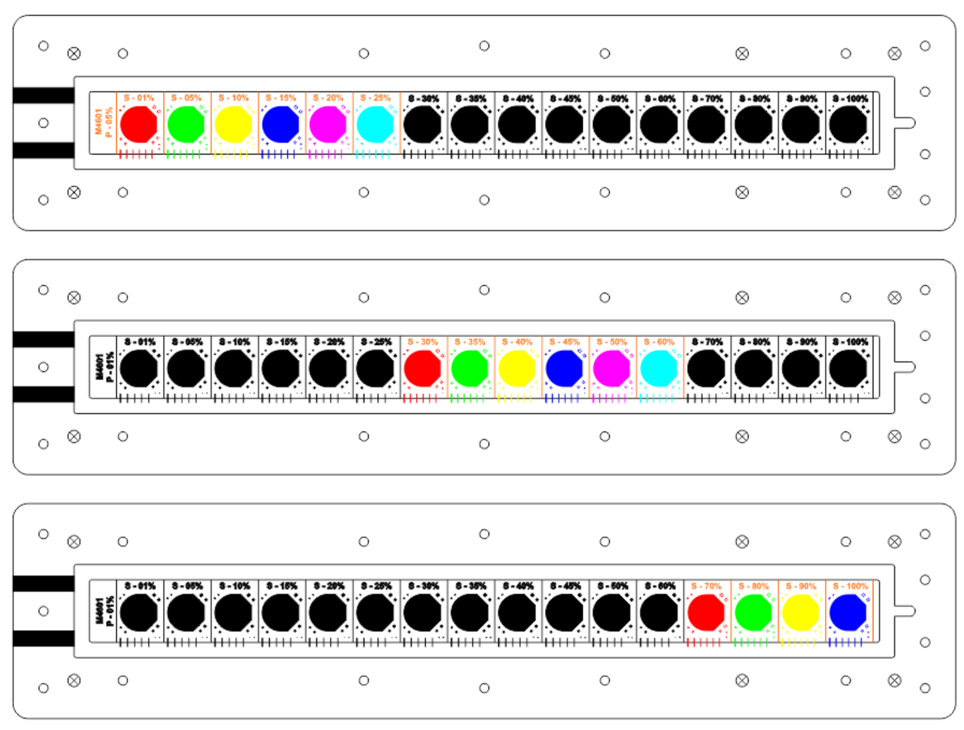


*Fig 2:* Laser cutting file for a specific laser power to complete a full range of laser speeds for a sample

Materials tested thus far were;

- Elastosil M4601; 28A Shore Hardness (most hard)
- Dragonskin 20; 20A
- Ecoflex 00-50; 00-50 (Least hard)

Where the shore durometer depicts the hardness of an elastomeric material with Ecoflex 00-50 being below the shore A Scale.

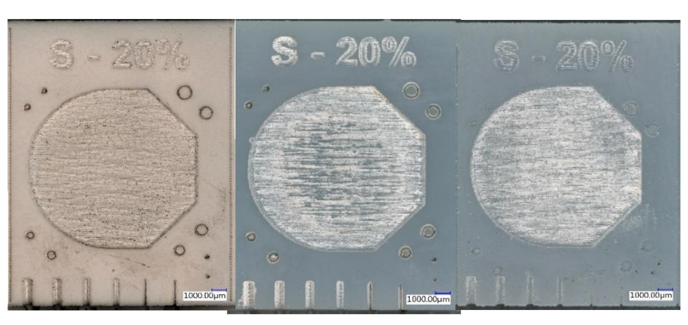



*Fig 3: Engravings for Power 50% and speed 20% on Elastosil (left), Dragonskin (midle) and Ecoflex (right)*

## PRELIMINARY ANALYSIS

As shown in *fig 3*, the softer the silicone the smaller the engraving depth and incision. The harder materials often cut to a higher precision producing less silicone dust in the process.

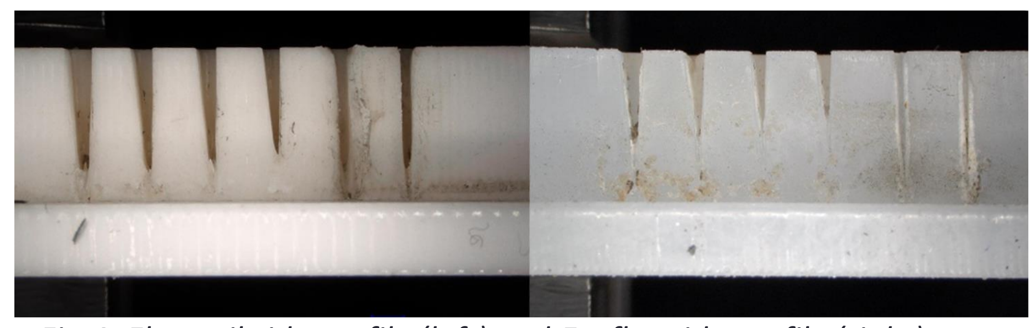


*Fig 4: Elastosil side profile (left) and Ecoflex side profile (right)*

*Fig 4* shows the cutting of hard Elastosil compared to very soft Ecoflex for 50% power and 1% speed.

## PROGRAMMABLE TEXTILES AS A MATERIAL

Textile-based material has also recently been used in seamless pneumatically actuated systems to achieve a wide array of geometric articulation. By introducing asymmetry into the knitted material by varying the stitch length or choice of thread, and inserting it around an elastic inner tube, the motion behaviour of the system to achieve the desired bending behaviour can be characterised (Ahlquist, S et al. 2017). The thread, manufacture, and fabrication strategies can all be varied to attain complex motions through combinations of differentially knitted textiles. The development of this method negates the use for conventional multi-step moulding in the fabrication process of the Thin Soft Layered Actuator demonstrated in *fig 1,* simplifying the overall design and minimising waste.

Using knitting as the fabrication technique means that continuously varying the stitch pattern can create multi-axis movements in a single sheet of material. The differentiated surface elasticity property can deform and change in dimensions until the locking point in the knit structure is reached (at which point all loops are fully extended).

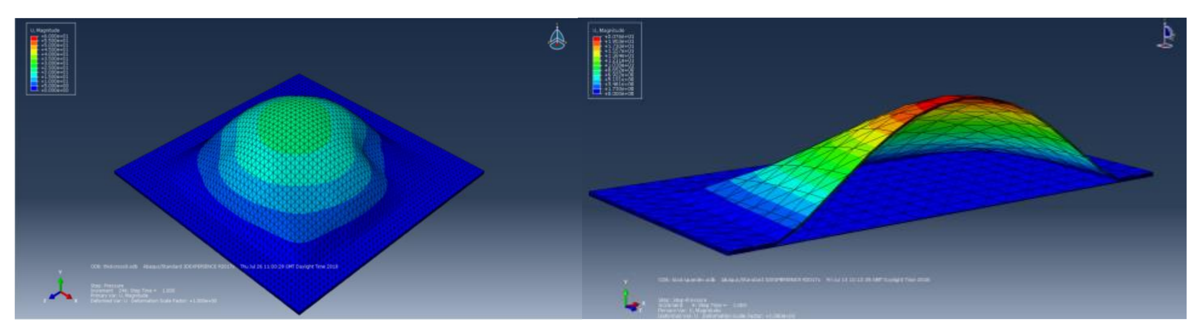


*Fig 5:* Preliminary designs of different knit patterns modelled using Finite Element Analysis Software.


## References:

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Galloway et al. 2013. "Mechanically Programmable Bend Radius for Fiber-Reinforced Soft Actuators."

Jones, D, et al. 2017. *A soft multi-axial force sensor to assess tissue properties in RealTime.* 2017. IEEE , pp. 5738-5743.

Kow, JW et al (2018) *Fig 2:* Thin soft layered actuator based on a novel fabrication technique. 2018. IEEE , pp. 176-181.

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