2.5D direct laser engraving of silicone micro-fluidic channels for stretchable electronics

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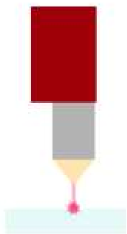
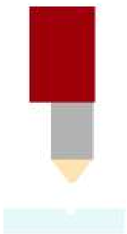
Concept.

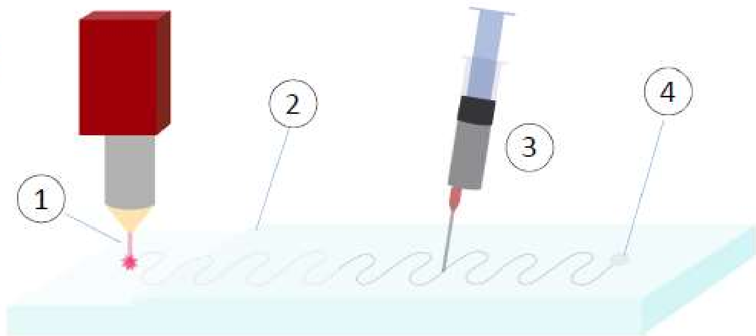


Laser ablation as a means of engraving microchannels in silicone rubbers.



Combine with **RT liquid conductor**. Stretchable conductive traces can be created within a single working day.

Stretchable electronics.



1. Laser engrave
2. Enclose channels
3. Fill with RT liquid conductor
4. **Encapsulate liquid**

2,5D.

Vary laser power or apply multiple passes during a single engraving production step. 2,5D structures are achieved.

e.g. capacitive pressure sensor

Further possibility: **buried vias**.

Stretchability.

Mostly limited by silicone material properties.

Necking induces resistance change.

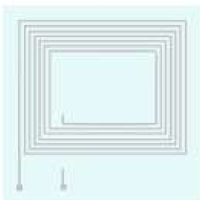
Self-healing capacity after channel pinch-off.

Use cases.

Whenever application calls for traces which are:

- single or few in number
- finely detailed
- low in resistance
- conformable
- self-healing

Component based solution not an integrated production method.

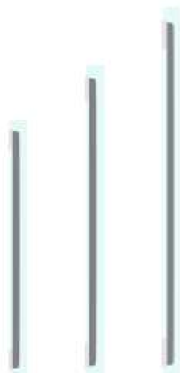


Applications.

Soft robotics

On-skin electronics

Wearables



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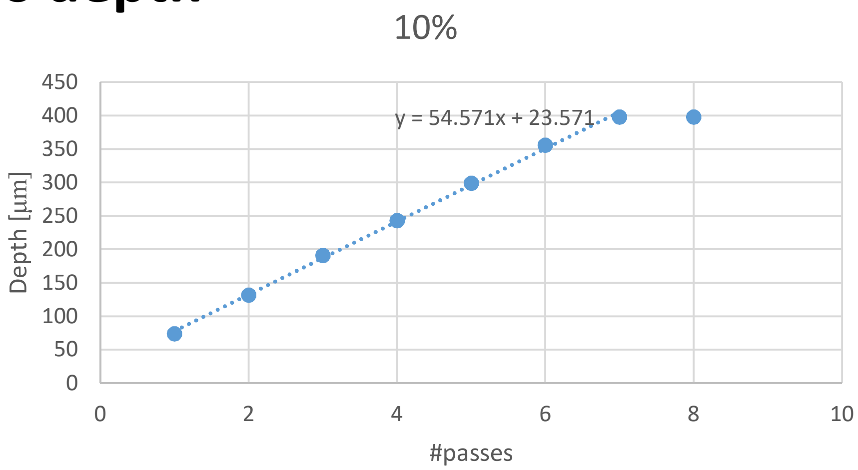
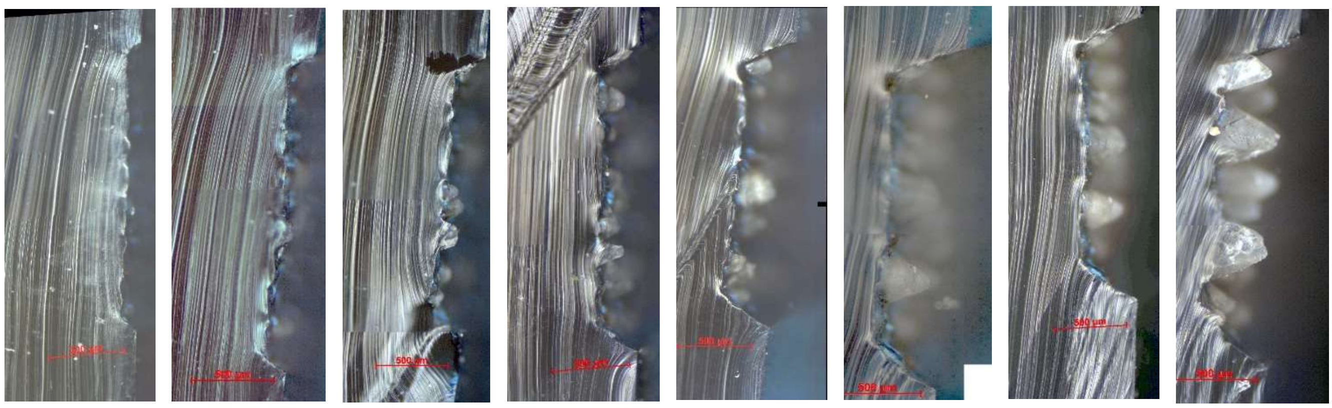
Scientific results

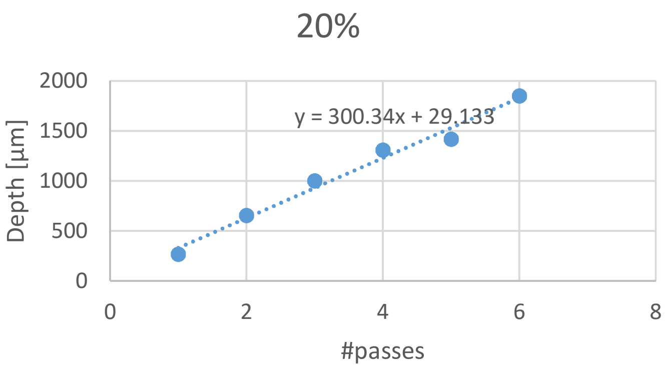
Laser P vs passes vs depth

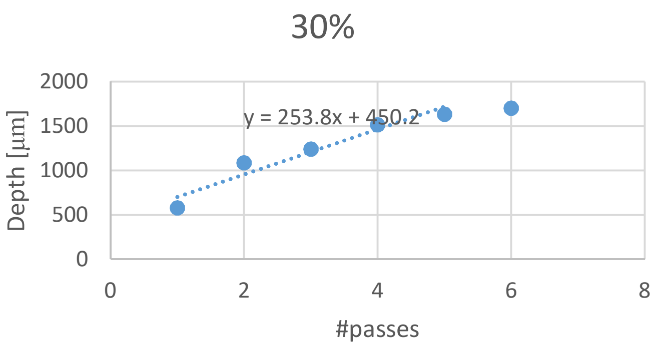
POWER SET TO 10%		
10x10xn	Depth	Calc depth
1	74	78.1
2	132	132.7
3	191	187.3
4	243	241.9
5	299	296.4
6	356	351.0
7	398	405.6
8	398	460.1





1 2 3 4 5 6 7 8





Conclusions:

- Laser gets out of focus with engravement depth
  - higher power = deeper cuts with each pass = faster roughness increase with each pass
- More or less linear correlation (ignoring roughness)
- First passes are in focus; nice and smooth
  - do not modulate engravement depth by number of passes

    ➔ directly use laser power to set engravement depth

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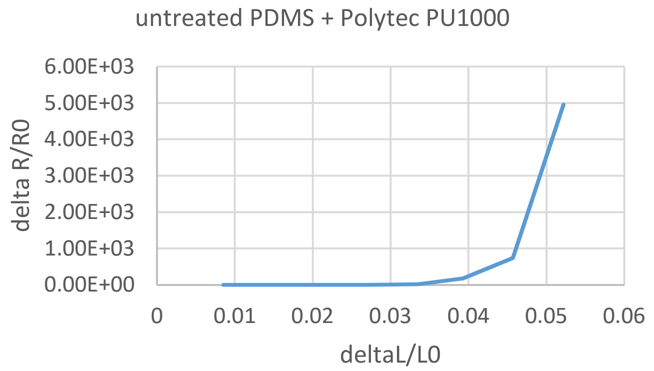
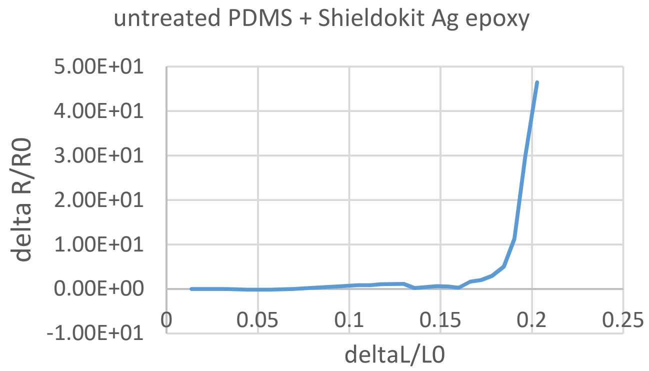
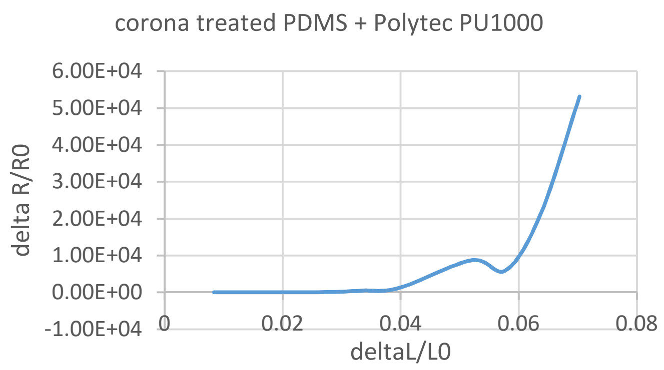
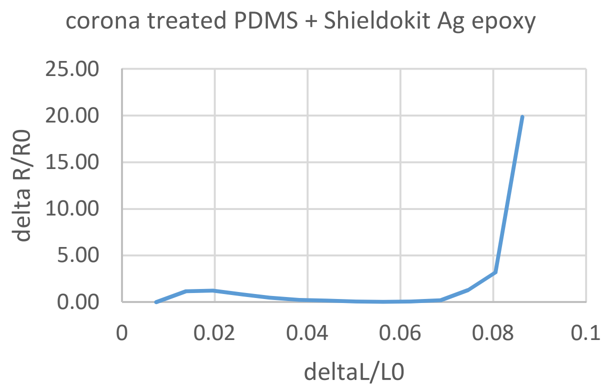
Scientific results

Mechanical characteristics of conductive encapsulant









Conclusions:

- Ag PU has a much lower starting resistance
- Ag PU does not adhere well at all
- Ag epoxy delaminates on untreated PDMS, explains 'favorable' measurement
- Ag epoxy makes for a stiffer match but adheres more or less ok when PDMS was pretreated with corona