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Fabrication of Carbon Micro Electrodes by Local Laser Pyrolysis

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Motivation and Aim

Local laser pyrolysis (LLP) has previously been demonstrated as a method for writing carbon micro-electrodes in polyimide, to make flexible electronics and micro super- capacitors [1-3].

The aim of this study was i) To demonstrate LLP of absorber- modified SU-8. ii) To gain knowledge of the LLP process as a gateway to pyrolyse other polymers via direct laser writing.

Process overview of laser pyrolysis

SU-8, modified to absorb light at 800 nm wavelength, is spin coated onto a boron glass wafer. A collimated laser beam with a very narrow peak intensity at 806 nm is then used for locally pyrolysing the SU-8, essentially enabling direct writing of conductive carbon micro electrodes.

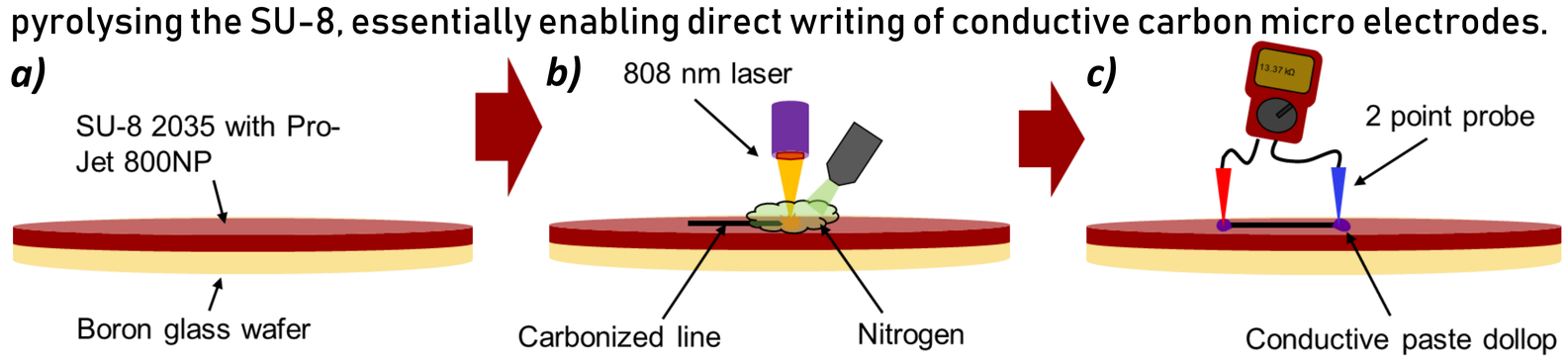

Fig 1. Overview of the laser pyrolysis process of absorber modified SU-8. **a)** SU-8 mixed with the absorber, Pro-Jet 800NP (FujiFilm), is spin-coated onto a boron glass wafer. **b)** A laser, operating at 806 nm, is used to locally pyrolyse the SU-8 under a nitrogen atmosphere. **c)** electrical evaluation of the written line.

Laser-written, pyrolysed structures

Various conducting, laser written structures. As can be seen, laser writing allows for very high design flexibility, but requires that the substrate can absorb the light.

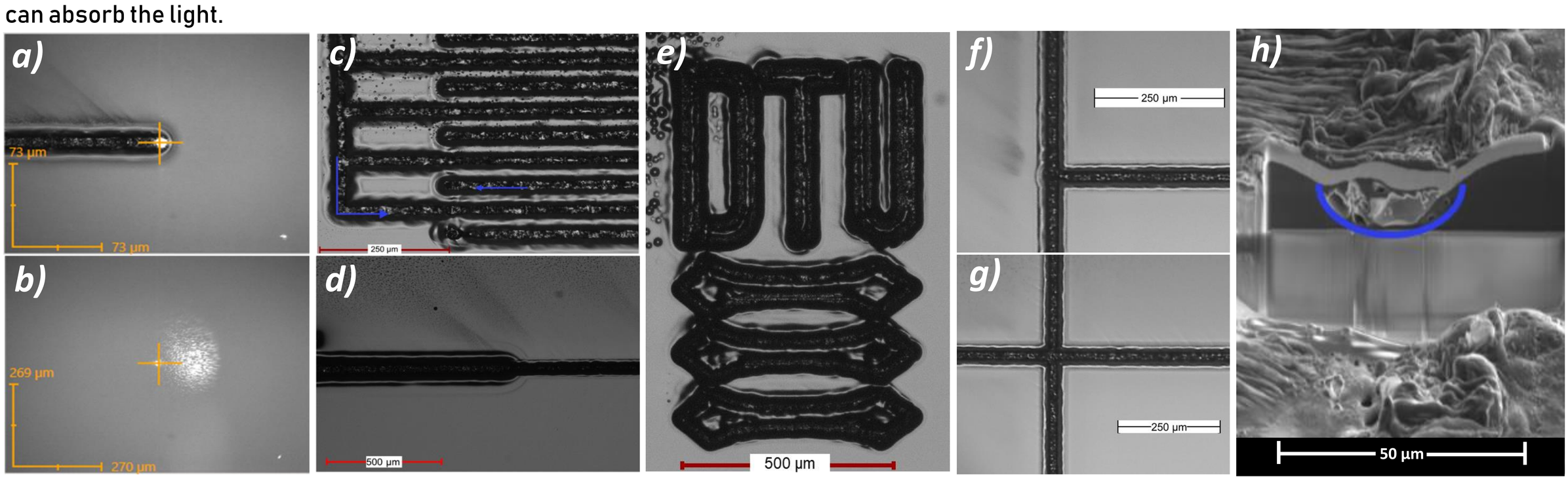

Fig 2. Laser writing in SU-8 with **(a)** and without **(b)** Pro-Jet added. **c)** Interdigitated electrodes written with 50 µm line-spacing during writing, the resulting line-spacing is about 15 µm. **d)** Attempt at writing a resistor. **e)** Carbonized DTU logo. **f)** and **g)** a node and an intersection, indicating seamless joining of lines. **h)** Cross-sectional FIB-SEM image of a laser-written, pyrolysed line. The conducting, carbonized part, is encircled within the blue half-ellipsis.

Electrical measurements

Electrical measurements on the written lines and structures. The degree of carbonization, evaluated through a resistivity measurement, can be seen to follow a declining power series with increasing laser power. The resistance is directly proportional to the path length but independent of the number of nodes and intersects on its way, confirming the seamless joining of lines.

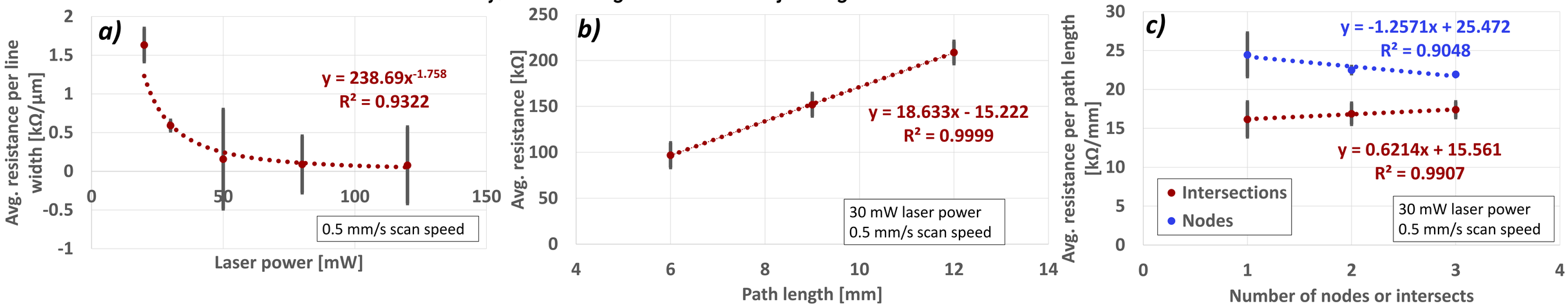

Fig 3. Effect of various parameters on the resistance through the line. **a)** Resistance per line width vs. laser power. The corresponding estimated conductance is about 2.26 ± 0.27 S/cm for the lines written at 80 mW laser power. **b)** Resistance vs. path length. As expected, the resistance increases linearly with path length. **c)** Resistance per path length vs. no. of nodes or intersects. As evident, intersecting or joining lines does not obstruct the current flow.

Conclusion

We have demonstrated localized laser pyrolysis by direct laser writing in absorber-modified SU-8. The SU-8 will not interact with the laser unless the absorber is added. The design flexibility is very high and lines can be joined together without added resistance. The highest, estimated conductance achieved is 2.26 ± 0.27 S/cm.

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