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Fabrication of Carbon Micro Electrodes by Local Laser Pyrolysis

Emil Ludvigsen1, Nina Ritter Pedersen1, Xiaolong Zhu1, Rodolphe Marie2, David M.A. Mackenzie3, Dirch H. Petersen1, Anders Kristensen2, Jenny Emnëus2, Stephan Sylvester Keller1

1National Centre for Nano Fabrication and Characterization, DTU Nanolab, Technical University of Denmark, Kgs. Lyngby, 2800, Denmark
2Department of Physics, DTU-Physics, Technical University of Denmark, Kgs. Lyngby, 2800, Denmark
3Department of Materials Engineering and Nanosciences, DTU Nanoengineering, Technical University of Denmark, Kgs. Lyngby, 2800, Denmark
emillu@dtu.dk

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.

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.

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.

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.

References

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Presenting author

Emil Ludvigsen
Ph.D. Student
DTU Nanolab
emillu@dtu.dk

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.

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.

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.