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Two-photon polymerization for 3D printing light-controlled microrobots

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Two-photon polymerization (2PP) enables the microfabrication of structures at a resolution of about 100 nm by using femtosecond laser pulses. Microrobotic structures that allow optical manipulation can be fabricated with the aid of 2PP in a suitable photoresist. This is particularly interesting for the emerging field of Light Robotics[1], which combines the most recent technologies in microfabrication and nanobiophotonics.

Optical trapping has been employed in the past 30 years for e.g. single molecule studies, microrheology measurements or even subcellular delivery and sampling. Complex sculpting of the light for different types of optical trapping and manipulation experiments has been thoroughly explored. However, most optical trapping experiments make use of simple microbeads, which have limited functionality. An important step forward in the field of Light Robotics is the use of 3D printed microrobotic structures instead of microbeads. Including bead-shaped "handles" in the microrobot structures allows optical manipulation in a similar manner to that of simple microbeads. By using Generalized Phase Contrast (GPC) or Holographic GPC (Holo-GPC) as beam shaping techniques, multiple optical traps can be simultaneously generated and thus a microrobot with multiple "handles" can be controlled with full spatio-temporal freedom.

Sculpting the object[2], in addition to sculpting the light, allows incorporating specific features into the design. Our group has previously reported microrobots equipped with a syringe function[3]. Here, we show the optical manipulation of a disk-tip based optical microrobot (Figure 1). In the future, the disk-tip feature will be employed for inducing local perturbations of biological samples, such as mucus biobarriers, lipid bilayers or even cell membranes. This could facilitate e.g. DNA transfection in plant cells or to burst open bacteria cells. By incorporating different features into the microrobot design we are working towards developing a series of microrobotic "surgeons" that would represent a valuable toolbox for surgical precision at the microscale.

Combining the full 3D design freedom of 2PP with the full volume control freedom facilitated by the use of 3D real-time light shaping represents a significant step towards the development of a new generation of microrobotic tools that have the potential to revolutionize biomedical research at the smallest scales.

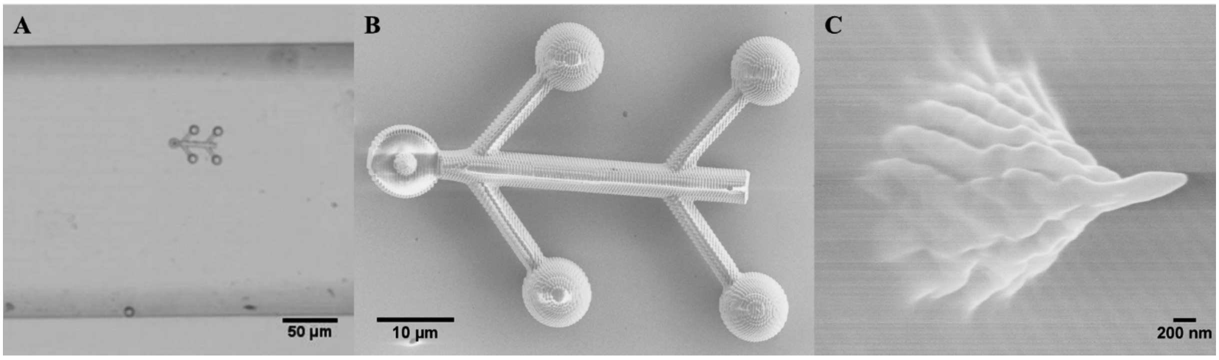

Figure 1: 3D-printed microrobot using two-photon polymerization. A: Optical microscopy image of the microrobot in the optical trapping cuvette. B, C: SEM images of microrobot (B) and tip feature (C).

References

1. J. Glückstad and D. Palima, "Light robotics: Structure-mediated nanobiophotonics" in *Technology & Engineering*, Elsevier, 2017, ISBN 978-0-7020-7096-9
2. J. Glückstad, *Nature Photonics*, **5**, 7–8 (2011).
3. M. Jayson Villangca, D. Palima, A. R. Bañas, J. Glückstad, *Light: Science & Applications,* **5** (2016).