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*Publication date:*
2021

*Document Version*
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

*Citation (APA):*
Bunea, A-I., Engay, E., Wetzel, A. E., & Taboryski, R. (2021). *Microrobots for biomedical applications: where does light come in?*. Abstract from 6th International Healthcare and Life Science & Entrepreneurship Workshop, Kgs. Lyngby, Denmark.

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**Microrobots for biomedical applications: where does light come in?**

Ada-Ioana Bunea, Einstom Engay, Alexandre Wetzel, Rafael Taboryski

Microrobots were pioneered two decades ago[1] and have already attracted significant attention among researchers because of their many interesting potential applications. Among these, biomedical applications are in high demand, and many valuable relevant studies *in vitro* or even *in vivo* have been reported so far.[2]

Different propulsion and control modalities are employed for microrobots, including biohybrid, optical, magnetic, chemical, thermal or acoustic propulsion. Various microrobot shapes, sizes, bulk materials and surface chemistries are being explored worldwide. Currently, designing and fabricating microrobots usually needs to be tailored to specific applications, which often requires an interdisciplinary team of highly-trained researchers.

Light is particularly useful for the fabrication of microrobots, and can also play an important role in their actuation. Two-photon polymerization (2PP) is a direct laser writing 3D printing technique which enables the fabrication of microrobots with sub-micrometer critical dimensions in both hard and soft polymers.[3] 2PP is arguably the best solution for fabricating microrobots with complex shapes, especially when it comes to using a single polymeric material. Multi-material structures are more challenging to produce using 2PP, but nevertheless achievable.

When it comes to actuation, our group focuses on the use of optical forces generated by manipulating highly focused near-infrared light beams. Another approach to light-based microrobotic actuation involves the use of smart light-responsive materials, which change shape in controlled fashion when exposed to certain wavelengths.[4] Light is typically considered a biocompatible actuator, but is only suited for applications in superficial tissues of the human body because of the limited tissue penetration depth.[5] Despite this challenge, light-controlled microrobots can be employed for various biomedical studies at the laboratory level, such as cellular or even intracellular manipulation, fluid viscosity characterization, or drug delivery. Additionally, supplementing the use of light with that of a second actuator with better compatibility with the human body, such as magnetism, could eventually enable tasks in the human body.[6]

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