ABSTRACT

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| Title ofDissertation: | DIRECT LASER WRITING FOR SOFT ROBOTIC COMPONENTS |
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|  | Olivia Marie Young, Doctor of Philosophy, 2025 |
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| Dissertation directed by: | Associate Professor, Dr. Ryan D. Sochol, Department of Mechanical Engineering |

Soft robots have increased safety for human robot interactions compared to rigid robots because of the compliant materials used to fabricate them. As such they are excellent candidates for adding enhanced functionality to surgical tools such as guidewires for endovascular procedures. Conventional guidewires have no method of steering other than the surgeon pushing, pulling, and twisting the guidewire to navigate through vasculature to reach the intended target location. Introducing a pneumatically actuated soft robot to the guidewires can enable steering capabilities in a guidewire while requiring minimal additional equipment in the operating room. Unfortunately, some procedures, such as the treatment of cerebral aneurysms, would require the addition of soft robots on the microscale, which are difficult or impossible to fabricate using traditional fabrication techniques such as molding or layering, to navigate the small vasculature. The microscale additive manufacturing strategy Direct Laser Writing (DLW) offers unique capabilities that can be used to fabricate these complex structures. In this dissertation we explore the development of DLW printed soft robotic steerable guidewires. First, we examined the feasibility of using *ex situ* direct laser writing (*es*DLW) to fabricate soft robots by printing soft robotic components directly atop and fluidically sealed to microfluidic chips. We evaluated the integrity of the fluidic seal created by this fabrication strategy and the fluidic actuation capabilities of the soft robotic components. Next, we investigated the use of *es*DLW to fabricate a soft robotic steerable guidewire by printing a bidirectional soft robot atop dual lumen tubing. The introduction of vat two-photon polymerization allows for the *es*DLW printing of tall soft robots (5 mm in height), necessary for steering through vasculature, while still maintaining the microscale features necessary to create the thin-walled bellowed structure inherent to pneumatic soft robots. Finally, we developed a method of fabricating ultra-high aspect ratio (1300:1 or higher) DLW printed multilumen tubing enabling the fabrication of a monolithic soft robotic steerable guidewire. We characterized the bending characteristics of the guidewire and navigated a phantom to demonstrate the guidewire’s steerability. This work demonstrates the capabilities of using DLW to fabricate soft robotic structures and shows promise for the use of DLW printed soft robots as steerable guidewires. While the focus of this dissertation was on the development of endovascular surgical tools the strategies used can be employed in other fields such as organ-on-a-chip fabrication, micromanipulation, or drug delivery.

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