Femtosecond Laser Direct Writing (FLDW) is a viable technique for producing photonic devices in bulk materials. This novel manufacturing technique is versatile due to its full 3D fabrication capability. Typically, the only requirement for this process is that the base material must be transparent to the laser wavelength. The modification process itself is based on non-linear energy absorption of laser light within the focal volume of the incident beam.

This thesis addresses the feasibility of this technique for introducing photonic structures into novel dielectric materials. Additionally, this work provides a deeper understanding of the light-matter interaction mechanism occurring at high pulse repetition rates. A novel structure on the sample surface in the form of nano-fibers was observed when the bulk material was irradiated with high repetition rate pulse trains.

To utilize the advantages of the FLDW technique even further, a transfer of the technology from dielectric to semiconductor materials is investigated. However, this demands detailed insight of the absorption and modification processes themselves. Experiments and the results suggested that non-linear absorption, specifically avalanche ionization, is the limiting factor inhibiting the application of FLDW to bulk semiconductors with today's laser sources.