Advances in Bioresorbable phosphate glass optical fiber fabrication

By

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Abstract

Bioresorbable phosphate glasses have emerged as a promising alternative to traditional silicate-based glass systems for biomedical applications. These glasses can be customized for their bioresorbability and mechanical properties and are transparent in a wide range of wavelengths (from 300 to 2600 nm), making them particularly suitable for biophotonic devices. Developing new and improved materials for innovative applications requires a multidisciplinary approach that involves glass-based photonics and advanced processing techniques for fiber optic research. Glass-based photonics plays a crucial role in pushing the development of new materials and advanced processing techniques for fiber optic research.

While extrusion is a powerful shaping method, extruding glass is rarely studied. The advantages of extrusion are the ability to vary the size and geometry of the extrudate, having excellent surface quality without any need for further treatments, fabricating complex preforms , and the ability to extrude different glass compositions. However, extrusion can result in distortion of the extrudates. In this thesis work, the soft glass extrusion process was optimized by studying the effects of various parameters on the glass billet and corresponding extrudate.

Preforms with low distortion and high surface quality enable the fiber drawing of microstructured optical fibers. The feasibility of fabricating microstructured bioresorbable optical fibers from phosphate glass with different compositions was investigated through melt-casting glass billets, extruding preforms, and using rod-in-tube and stack-and-draw assembly techniques. The resulting fiber

comprises one microfluidic channel for liquid delivery and one core-cladding section for guiding light. The fiber diameter dimension ranged from 125 to 250 μm. The performance of the fibers in guiding light and reducing attenuation loss was tested, and the microfluidic channel was evaluated for its ability to deliver liquid. Furthermore, by extruding preform with a very high outer-to-inner ratio diameter, we were able to fabricate single-mode fiber with a 7 μm diameter core size. On the other hand, by extruding preforms with a low outer-to-inner diameter ratio, it was possible to draw multi-mode fiber with a 220 μm diameter core size. These fibers are being studied to realize theranostic devices that can be used for targeted treatment within the body without the need for removal operations.

As an emerging technique for fabricating complex structural materials, FDM 3D printing was explored to study the possibility of using transparent bioresorbable phosphate glass in biomedical applications such as photodynamic therapy (PDT). The final part of this research examines the process of producing a new 3D-printed composite material made of bioresorbable glass and polymer. The process involves synthesizing the powder and producing final samples using a standard fused deposition modeling (FDM) 3D printer. After proper treatments, this composite material can offer the benefits of glass transparency, allowing for its use in PDT, while also functioning as a scaffold within the body and degrading at a controllable time frame.