# Hollow-core optical fiber as a surgical laser scalpel with fluidic channels for site-selective drug delivery

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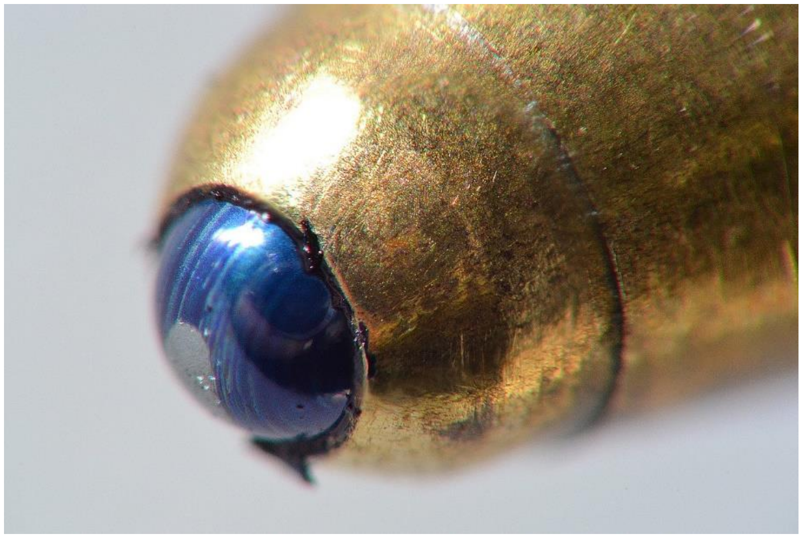
**Project description:** Optical fibers have played a significant role in the field of medical laser science. In the past years, the group has contributed to this field by producing new NIR pulsed lasers and fiber optic systems coupled to them. We are now working to target specific sites in the brain and in various tumors for surgical purposes such as ablating the tumor cells to treat cancer. Similarly, we can inject drug in the channel created by the optical fiber that delivers the NIR pulses to the target, a process that we now have evidence for its unprecedented complete non-invasiveness. To take things one step further, we have been exploring the idea of combining the fiber laser knife and injection cannula into a single compact system: A hollow-core optical fiber whose empty core can be used for site-selective drug delivery once the target area is reached.

To achieve the above goal, there are many interesting practical problems that need to be solved. Chief among them is terminating the hollow-core fiber, with typical diameters of a few hundred microns, with cones or spheres made of sapphire to make the ablation point of contact robust enough to sustain localized temperatures in excess of 2000 °C. The sapphire tip, however, cannot block the hollow core that is supposed to be the fluidic pathway once penetration by laser ablation is over. Consequently, proper fluidic channels must be incorporated in these tips for drug delivery. An alternative design, among several others, involves a mechanism such as the one used in a ballpoint pen. Another practical problem to solve here is to fix sapphire tips to the fibers using a suitable epoxy with minimal light absorption at the operating wavelength. We will also explore the problem of non-invasive insertion of the fiber in the brain through the skull bone: How can a 200-μm size pathway be created in the skull tissue without burning the surrounding cells? Other than adjusting the laser pulse parameters, integrating an irrigation mechanism to the fiber optic assembly is a possible route to explore.

**Required knowledge:** Basic E&M (e.g. Maxwell's equations). Basic optics (e.g. fundamental reflection and refraction phenomena). Familiarity with optical fibers and pulsed laser beams will be helpful. Familiarity with or willingness to independently learn to use engineering design software such as Autodesk and electromagnetic simulation packages as necessary is needed. Familiarity with microfluidics will be helpful.

**Learning outcomes:** The curious student dedicated to this project for the duration of the program is anticipated to be able to independently study and learn about the various scientific and engineering aspects of medical laser physics and fiber optics technology. The project is more suitable for students with an innovative mindset and keen interest in instrumentation design who want to gain experience in applied areas.



**Magnified tip of a ballpoint pen.** Is it possible to terminate a hollow-core optical fiber with a similar mechanism used as fluidic pathway for drug delivery? [Image source: Wikipedia]

**References:**

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[3] B. Girard, *et al.*, *"Bone surgery with femtosecond laser compared to mechanical instruments: Healing studies"*, Proc. Of SPIE 6261, 62612J-1 (2006).
[4] N. Jowett, *et al.*, *"Bone ablation without thermal or acoustic mechanical injury via a novel picosecond infrared laser (PIRL)"*, Otolaryngology – Head and Neck Surgery 150 (3), 385-393 (2014).