# White Paper:
# Shaped Tip Fibers

A shaped tip on the end of an optical fiber allows for a wide variety of different outputs and inputs; they are most commonly in the medical field as laser scalpels [1,] to remove plaque buildup in arteries [2], to close varicose veins [3], and to couple diodes into multi-mode optical fibers. Shaped tips are also used to provide diffused outputs and as radial emitters, perpendicular to the face of the fiber.

A typical large-core, multimode optical fiber with a flat polish has an output that looks like a cone, as seen in Figure 1. The angle of the cone is defined by the numerical aperture (NA). Far away from the fiber tip, the size and shape of the fiber tip has very little impact on the size of the spot.

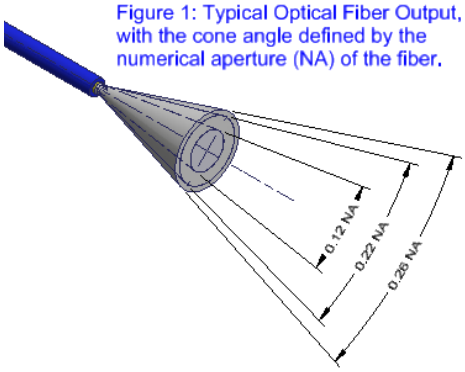

Figure 1: Typical Optical Fiber Output, with the cone angle defined by the numerical aperture (NA) of the fiber.

Shaping the tip of a fiber optic can allow for many different light configurations. One of the most common is the so-called "Sidefire" configuration, where the output of the fiber exits nearly perpendicular to the optical axis, as seen in Figure 2. This configuration is most commonly used for laser scalpels [1] and to couple diodes into an optical fiber in a space saving configuration, as seen in Figure 3.

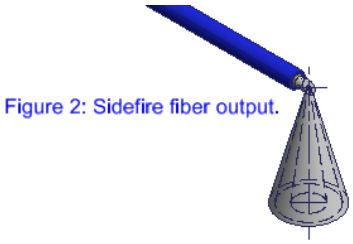
Figure 2: Sidefire fiber output.

Another common shaped tip configuration is the radiused or ball-end fiber; both are used for a similar purpose, namely to focus the output light of a fiber optic to a small spot with a corresponding increase in the output numerical aperture (NA).

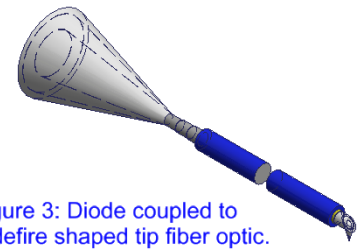
Figure 3: Diode coupled to Sidefire shaped tip fiber optic.

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The only difference is the travel distance of the light and the radius of curvature of the ball. These fibers have been typically used to remove plaque buildup in arteries and have been demonstrated to reduce incidences of cauterization and coagulation of nearby tissue when removing plaque. They also allow for coupling of light of different angles than are typically accepted by an optical fiber. Given the large divergence angles that can typically be achieved, it is possible to either collimate the output of a single fiber or to achieve a "large angle diffuser". These diffusers are typically used in intraocular surgery as an illumination source.

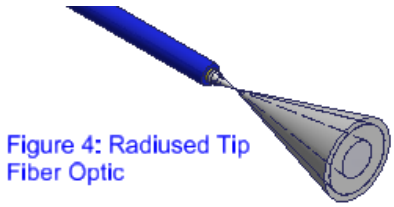

Figure 4: Radiused Tip Fiber Optic

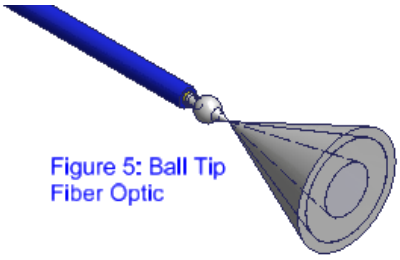

Figure 5: Ball Tip Fiber Optic

Other shaped tips include cone tips, which are used as beam homogenizers, radial diffusers, and many other applications. Cone tips are commonly used in the medical field both as a means of physically implanting the fiber in the tissue prior to treatment, as a means of radial diffusion, and as a means of a broad source diffuser. The output of the cone tip fiber can be controlled through careful selection of the cone angle-shaped glass.

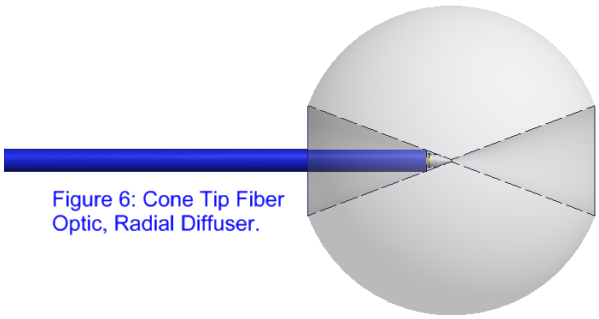

Figure 6: Cone Tip Fiber Optic, Radial Diffuser.

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Fiberguide offers a broad selection of shaped tips that are bare or encapsulated in a glass tube, to prevent fluids and other materials from impacting the shape of the light output from the fiber. We design and manufacture shaped glass to manipulate the light inside fibers.

References:

[1] Verdaasdonk, Rudolf M., and Cornelius Borst. "Ray tracing of optically modified fiber tips. 2: Laser scalpels." *Applied optics* 30.16 (1991): 2172-2177.

[2] Singleton, Donald L., et al. "Excimer laser angioplasty: tissue ablation, arterial response, and fiber optic delivery." *Quantum Electronics, IEEE Journal of* 23.10 (1987): 1772-1782.

[3] Chang, Cheng-Jen, and Jun-Jin Chua. "Endovenous laser photocoagulation (EVLP) for varicose veins." *Lasers in surgery and medicine* 31.4 (2002): 257-262.