Technical Brief #1

Fiber Evanescent Field Technology

This note is one of a series of technical briefs developed from customer FAQs and intended to answer the majority of questions concerning the operation of Phoenix products. They are targeted at engineers to assist in incorporating Phoenix products into designs. Any detailed technical questions should be forwarded to Phoenix support.

What is the evanescent field in an optical fiber?

To meet the guiding conditions for an electromagnetic wave propagating in a dielectric waveguide the field decays exponentially away from the core -cladding boundary. The **evanescent tail** is an integral part of the guided wave and its characteristics are determined by the guiding parameters of the wave. Therefore modification of the evanescent field modifies the guided wave.

Interaction with the evanescent field gives the potential to modify the guided wave without impinging the core of the waveguide.

Benefits of component fabricated by this technology

- Non-invasive to the fiber core, the core remains untouched and therefore undamaged
- Functionality achieved through modification of the guiding conditions giving control over parameters such as power dissipation.
- Level of interaction with the field is controlled by the depth of cladding removed and length of fiber from which cladding is removed.
- Fabrication on any fiber type
- Complete matching to fiber system
- All-fiber and hybrid integration capability
- Low cost manufacturing
- Multi-functionality integration within a small footprint

Principle of evanescent field components

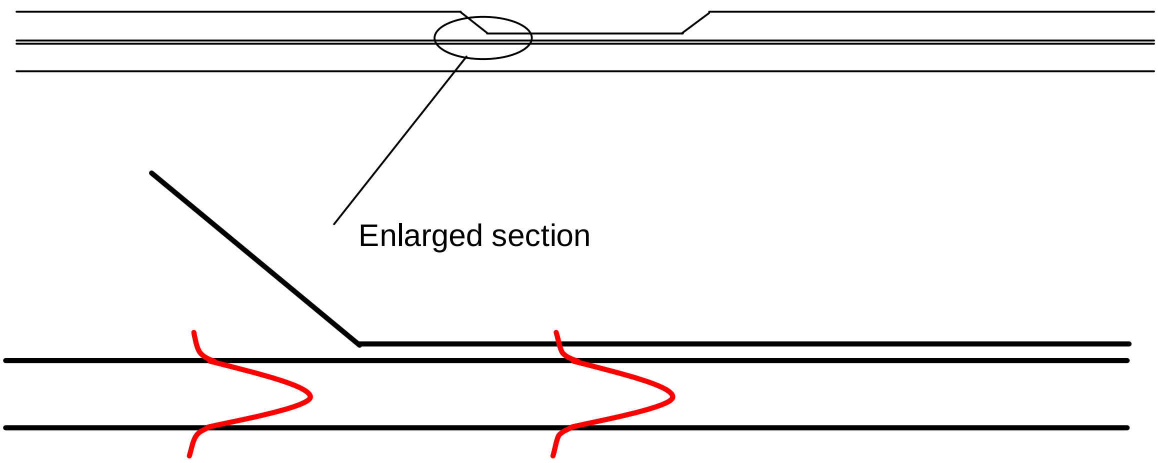
To access the evanescent field of an optical fiber the cladding is reduced to within a few microns of the core-cladding boundary. There are essentially three methods to achieve this:

- Etching
- Tapering in a flame
- Grinding and polishing

Phoenix devices use the latter to provide a robust substrate, which can be tailored to optimize the device characteristics.

By **side polishing** the fiber, a section of cladding of the desired length can be removed and the optical functionality required built onto the exposed core region.

This all-fiber technique provides, through a single process, an optical waveguide on which the required functionality can be built requiring no pigtailing and no intrusion into the core.



A 'side-polished' fiber provides access to the evanescent tail of the propagating wave.

Evanescent field component groups

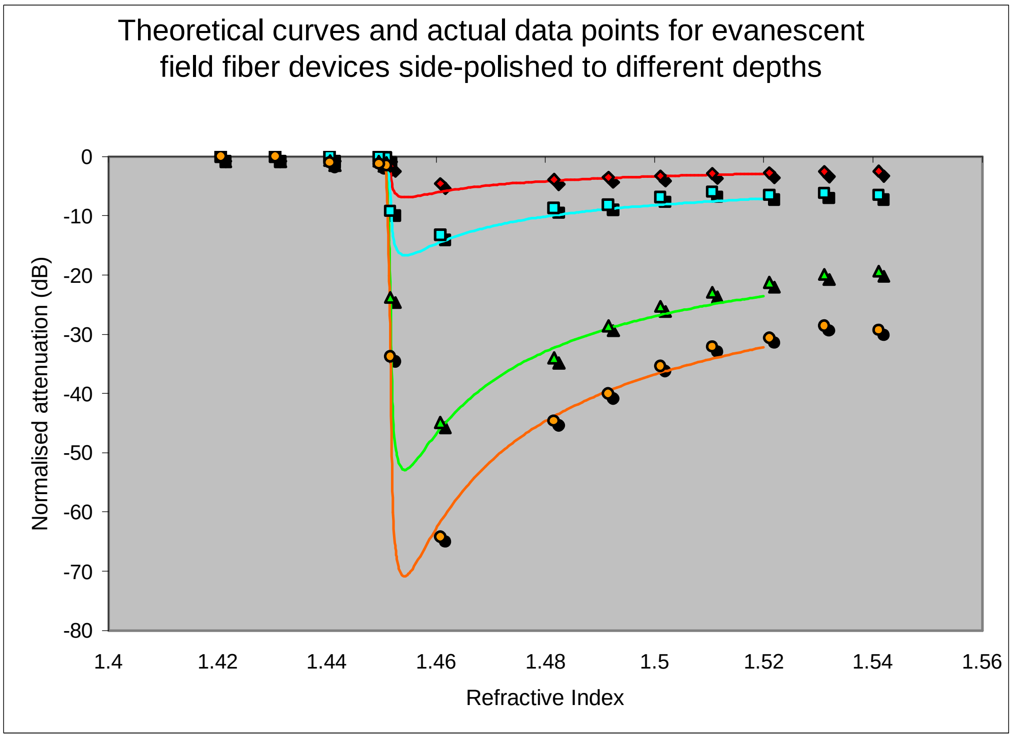
Three broad groups of component type can be defined:

1. Cladding replaced by a thick 'bulk' layer of material. In this case the properties of the overlay material determine the functionality of the components. Examples of components in this group are polarizers, VoA's and shutters.
2. Multi-layer waveguide fabrication. Thin films are layered over the exposed region to produce a multi waveguide. The properties of the materials in the layers and the thickness of the layers determine the guiding conditions through the region and the functionality of the component. Examples of components in this group are filters.
3. Two side-polished fibers brought into close proximity will couple light between the two cores. This essentially creates a dual core waveguide. An example of a component of this type is the coupler.

Exposing a length of fiber core by side-polishing the optical fiber provides a basic waveguide substrate which can be utilized to realize a range of functionality by manipulating the propagating wave without impinging the fiber core, making this potentially an extremely powerful technology.

Characteristics of side-polished fibers

The depth to which the cladding is removed from the fiber gives control over the level of interaction with the evanescent field. Replacing the cladding with a material of differing refractive index changes the insertion loss of the fiber section. The series of curves below show the insertion loss for a single mode Corning SMF28 fiber for different levels of cladding removed.


Theoretical curves and actual data points for evanescent field fiber devices side-polished to different depths
Normalised attenuation (dB)
0
-10
-20
-30
-40
-50
-60
-70
-80
1.4
1.42
1.44
1.46
1.48
1.5
1.52
1.54
1.56
Refractive Index