INTERFIBER ANALYSIS, LLC

Optical Fiber Measurement Specialists

IFA100

Optical Fiber Analyzer

A New Direction for

Fiber Refractive Index Profiling

IFA-100

Optical Fiber Analyzer

The IFA-100 Optical Fiber Analyzer uses transverse interferometry to sample. The IFA-100 consists of four components: (1) the system unit, also termed the interferometer; (2) the motion control module; (3) the lightsource; and (4) the desktop personal computer. Graphical user interface (GUI) software executing on the computer permits the operator to conveniently control the system unit, measure fibers, and analyze data.

A fiber sample containing a short region of bare (uncoated) fiber is loaded into the system unit. Depending on the settings of the GUI, the system unit will measure the refractive index and/or the residual stress and/or fiber geometry of the fiber sample.Measurements obtained with the IFA-100 can be saved as ascii data files that can by imported into a wide variety of other software packages and programming environments. Measurements can also be save in a proprietary binary format that can subsequently be reloaded into the GUI. In addition, Interfiber Analysis also offers an optional Computational Module that permits refractive index data acquired by the IFA-100 to be used to compute properties of the guided mode(s) of the fiber sample.

Standard Features

- Dimensional, 2-D, and even 3-D Fiber Index Profiles
- No costly instrument purchase
- Rapid turnaround
- Experienced measurement staff
- Any fiber type (telecom, PM, EDF, etc.)
- Any fiber material (silica, non-silica, plastic)
- Any fiber diameter from 40 µm to 750 µm
- Any measurement wavelength from 450 nm to 1000 nm
- Sub-µm fiber geometry measurements
- Sample lengths can be as short as cm's
- Measure splices, tapers, couplers

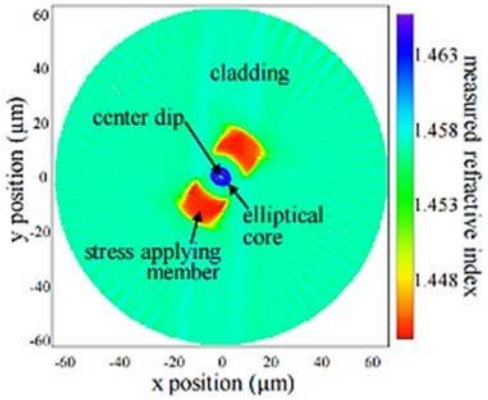


Figure 1. Tomographic measurement of commercially available PM fiber index profile at 546 nm.

IFA-100 Specifications

Refractive index accuracy	0.0001
Spatial resolution	~500 nm
Measurement wavelength	Anywhere from 370 nm to 2050 nm
Fiber diameter	10 µm to 500 µm
Fiber material	Silica glass, non-silica glass, plastic
Concentricity error measurement	200 nm
Core non-circularity measurement	0.4%
Fiber type	Single mode, multimode, micro structured, PM, rare-earth doped, cladding pumped, large-mode-area, high-delta, etc.

Measurement Technology

A schematic of the experimental setup appears in Figure 1 and is a modification of the Transverse Interferometric Method (TIM) in which a fiber is placed in the sample arm of a Mach-Zehnder interference microscope. The fiber was inserted into refractive index matching oil and imaged by a high-NA (up to 1.4) oil-immersion objective lens that permitted sub-µm spatial resolution. A tungsten-halogen lamp with a visible-light blocking filter was combined with an identical unfiltered lamp to yield a high-brightness spatially incoherent wideband optical source, which avoided coherent noise effects that otherwise plague spatially resolved interferometry the present method uses an optical wedge phase shifter to uniformly shift the optical path length of the reference arm, thereby generating a distinct interferogram for each spatial position (pixel) in the image as a function of applied phase shift. General advantages of phase-shifting (or phase-stepping) interferometry (PSI) over spatial fringe detection include: (1) robustness to fringe spacing or orientation; (2) insensitivity to illumination inhomogeneities; and (3) the opportunity to expand the field of view by stitching multiple frames together.

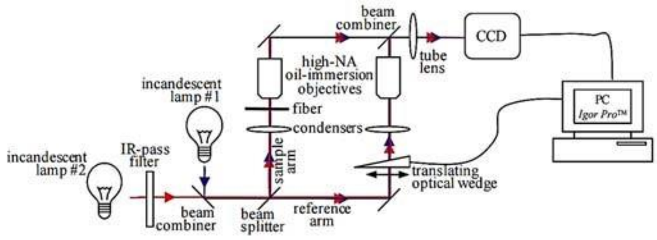


Figure 1. Schematic of experimental apparatus

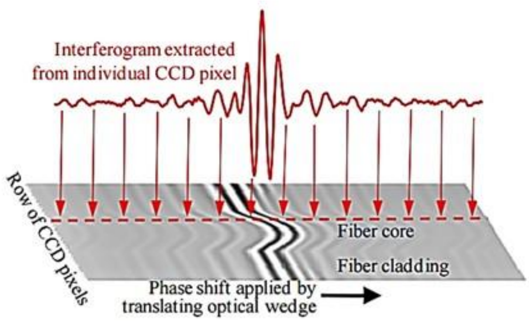
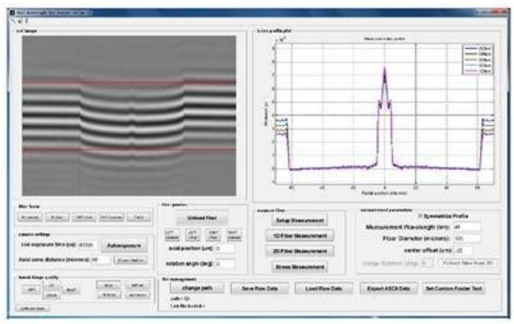
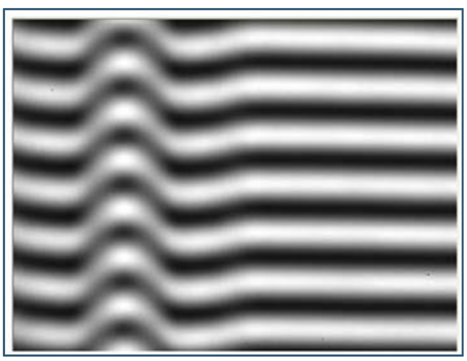


Figure 2. Sample interferograms acquired for a graded index multimode(GI-MMF) optical fiber

Software Interface

The operator interacts with the IFA-100 primarily via the graphic user interface (GUI) software provided with the Windows desktop PC. The controls for this interface are substantially intuitive, however, it is imperative that all operators be formally trained in the correct use of the software and hardware before attempting to operate the IFA-100.



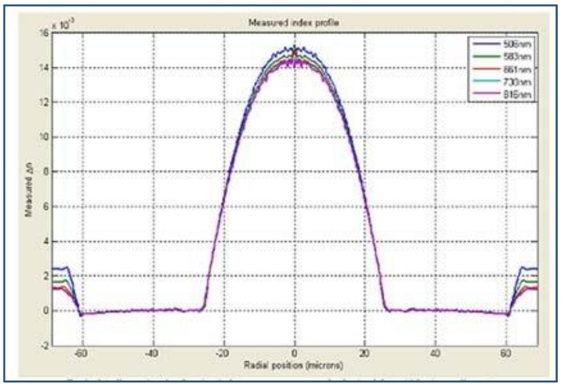


Typical image

Typical image of a fiber immediately after loading showing how the fiber is not centered on the screen and is not well focused. 1-dimensional fiber measurements should never be initiated with a fiber out of position and out of focus as in this example. Instead, always ensure that either the fiber and fringes are setup automatically with the Setup Measurement button or using the manual controls.

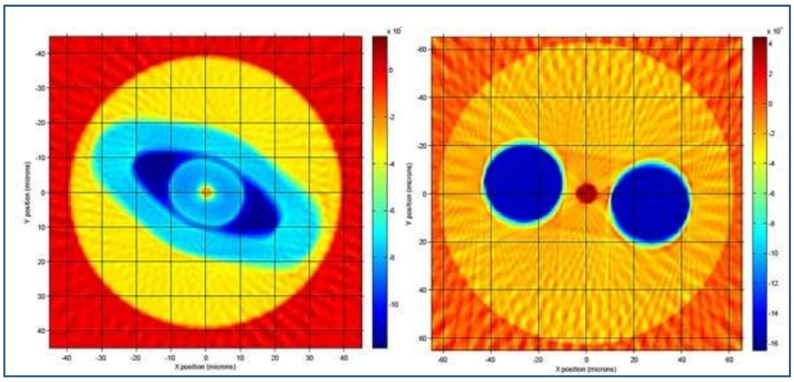
1-Dimensional Fiber Measurement

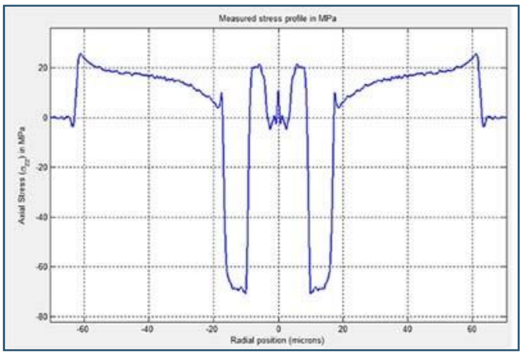
In a 1-Dimensional Fiber Measurement, the interference fringes are first scanned past the fiber and then subsequently scanned past the background without the fiber present. The data acquired from these two scans is then analyzed to provide the axisymmetric refractive index profile in the top right of the GUI window. This measurement typically requires about 3 minutes to execute once the fibers are loaded.



2-Dimensional Fiber Measurement

In a 2-Dimensional Fiber Measurement, data is acquired at many different angles of fiber rotation to provide a full 2-Dimensional view of the fiber's internal refractive index profile. Because many scans must be taken (36 every 5°) and because each scan requires the fiber to be rotated, repositioned, and refocused, this measurement is time consuming, between 15 and 45 minutes depending on the measurement parameters. However, this technique provides accurate data for non-axisymmetric fiber samples, including PM fibers, fibers with polygonal or gear shaped claddings, and fibers in which the core and cladding are not concentric.





Stress Measurement of Fiber

In addition to measuring the refractive index of a fiber, suitably equipped IFA-100 systems can also measure the residual stress in a fiber by measuring the refractive index at two orthogonal polarizations. Stress measurement is currently only available as a 1-dimensional measurement for axisymmetric fibers and is not available for PM fibers or other non-axisymmetric fibers. A sample fiber stress measurement performed on standard SMF is shown left.

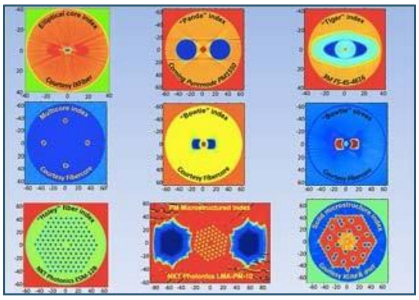
Mode Computations

The Computational Module (CM) is an optional additional graphic user interface (GUI) software that computes the properties of guided modes based on refractive index profiles measured by the IFA-100. Furthermore, if they are put into the correct file format, then this computation module can also be used to analyze optical fiber refractive index profiles obtained from other measurement instruments or synthetically generated.

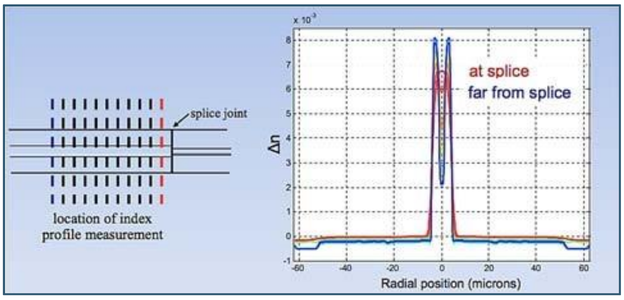
IFA100 applications

Interfiber Analysis uses sophisticated numerical codes to model optical fiber waveguide properties. Critical performance parameters such as mode fields, group and phase propagation constants, and fiber dispersion can all be computed based on optical fiber designs, or even from measured optical fiber index profiles. These numerical codes can be applied to resolve difficult problems such as predicting non-linear optical effects, interconnecting dissimilar optical fibers, or predicting multipath interference.

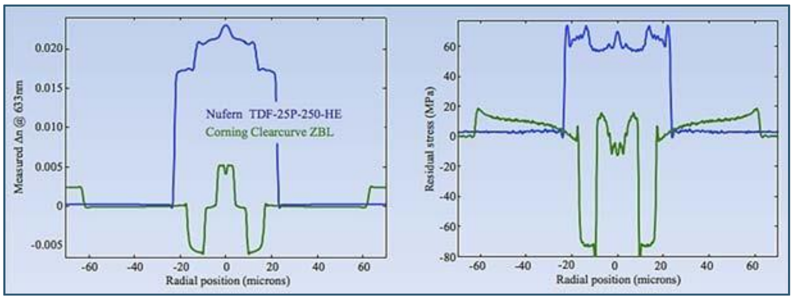
- Refractive Index and Geometry Measurement of fiber



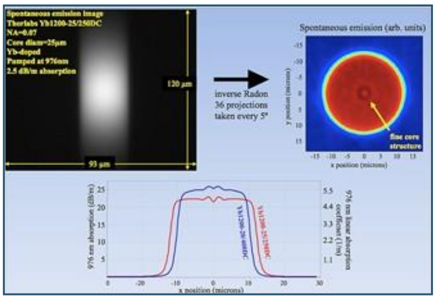
- Refractive Index Measurement of splices, tapers or couplers



- Stress Measurement of Fiber



- Gain profile Measurement of YDF



Optical Fiber Failure Analysis

Both catastrophic optical fiber failure and subtle degradations of optical fiber performance have become more common and also more important with the development of high-power optical fiber technologies.

Interfiber Analysis has the measurement tools, the analytical skills, and the experience to diagnose the source of optical fiber failures and develop strategies to help mitigate or eliminate them.

Optical Fiber Parameters Analysis

The modal effective area (A_{eff}), the phase index (n_{phase}), the group index (n_{group}), and the dispersion are provided for all of the guided modes.

The mode field diameter (MFD) and the M^2 of the LP_{01} mode.