

## RECONSTRUCTION OF REFRACTIVE INDEX PROFILE OF OPTICAL TELECOMMUNICATIONS FIBER

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### RESUMEN

En este trabajo se muestra que el perfil de índice de refracción de fibras ópticas se puede determinar analizando el patrón de campo cercano transmitido con el método de elementos finitos. Se presenta brevemente el principio del método y se evalúa comparando los resultados obtenidos con medidas experimentales con el método RNF en un fibras de núcleo de silicio puro y para una fibra LEAF.

**Palabras clave:** Caracterización de fibras ópticas, Campo cercano, Método de elementos finitos.

### ABSTRACT

In this work, we show that the refractive-index profile of optical telecommunication fibers can be determined by analyzing the transmitted near-field pattern with the finite element method. The principle of the method is briefly presented and evaluated by comparing the obtained results with experimental measurements obtained by the RNF and *m*-lines techniques on a pure-silica and LEAF single-mode .

**Key words:** Optical fiber characterization, Near field, Finite element method.

### INTRODUCCIÓN

Optical fibers are becoming the preferred physical carrier in telecommunications systems. Today in most applications is used single mode optical fiber, which operate in the second (around 1310 nm) and third (around 1550 nm) transmission windows. The main characteristics of telecommunication fibers, chromatic dispersion, spot size, single-mode propagation condition, and interfiber coupling coefficients are related to their refractive index profile (RIP). The recommended technique to measure the RIP of optical fiber is the refracted near field method (RNF) the details of which are given in . The method requires careful fiber preparation and periodical calibration of the refractive index scale.

Recently, the author shown(see reference[2]) that the RIP of 2-D index-profile waveguides can be reconstructed by analyzing the transmitted near-field pattern (TNF) with the finite element method (FEM) [2]. Here, we extend this method for evaluated optical fibers as a typical 3-D index-profile waveguides. Our interest in this methodology is based on the fact TNF is a

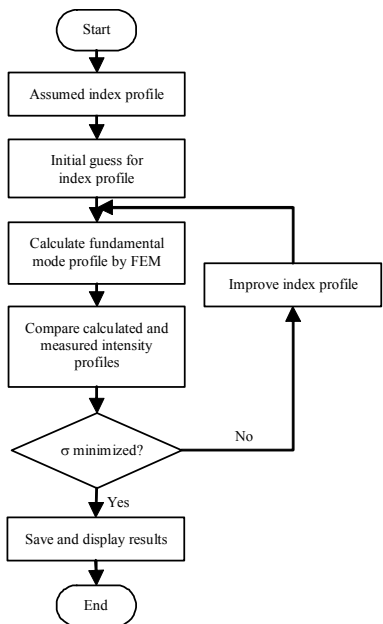
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nondestructive technique, it is applied at the operating wavelength and can be used also to multimode waveguides, requiring that only the fundamental mode is excited.

**THE TNF-FEM RECONSTRUCTION METHOD**

The methodology to reconstruct the fiber RIP by analyzing the TNF pattern with the finite element method follows the flow chart in Fig. 1. Briefly, the method consists in determine the

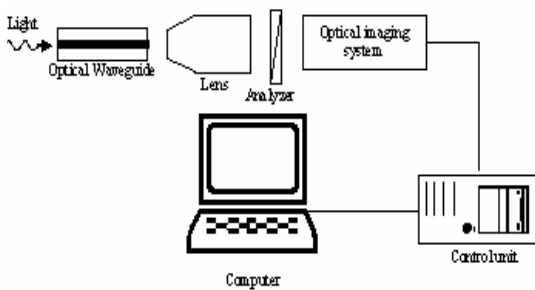


**Figure No 1.** Flow chart of the TNF-FEM methodology for the reconstruction of the refractive-index profile of optical waveguides.

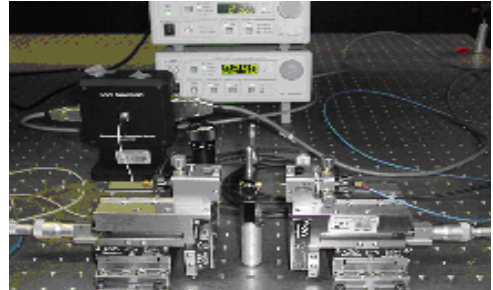
initial guess for waveguide RIP. The RIP that gives the TNF closest the measured one is chosen as the initial guess. Then, the selected guess is improved applying the reconstruction procedure with the finite element method. The main advantage of this procedure is, firstly, that the final result do not depend of the initial RIP as typically occur in this type of inverse problems [3] and, secondly, by the insensibility to high spatial frequency noise [2] where  $\Delta\Psi$  is the square error mean.

**EXPERIMENTAL SETUP**

The typical setup for measuring the TNF pattern is sketched in Fig. 2



**Fig.a**

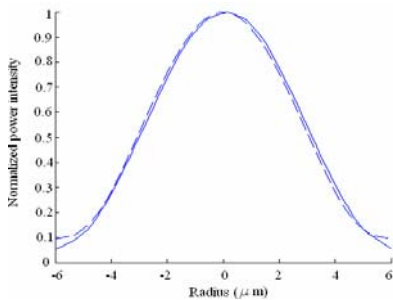


**Fig. b**

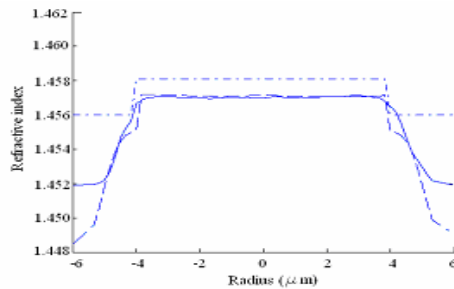
**Figure No 2.** (a) Schematic layout of a transmitted near-field measuring system; (b) implemented experimental setup

**RESULTS AND DISCUSSION**

The reconstruction by the TNF-FEM method (see reference [2]) of the 2- D index profile of a silica –pure core fiber is shown in the figure 3. The assumed index profile is taken to be step-index profile with index difference of  $5.3 \times 10^{-3}$  and core diameter of  $11 \mu\text{m}$ . The measured and optimal computed near-field intensity profiles of the fundamental mode are shown in Fig. 3(a). Fig. 3(b) shows a one-dimensional cross section through the axis of the measured and computed fiber index profile. It can be seen that the computed profiles are in good agreement with experimental ones. In particular, Fig. 3(b) shows to fit among the calc.



**Fig. a**



**Fig.b**

**Figure No 3** Transmitted near field and refractive index profile, of the analyzed fiber: (—) computed results, (--) experimental results and (-·-) initial guess

4a and 4b are shown the measured and optimal computed near – field intensity profiles of the undamental mode and the refractive index profile of the LEAF fiber. The assumed index profile was a sinc function. It can be seen that the computed profiles have the same form with experimental ones. Fig. 4(b) shows to fit among the calculate profile and measurement.

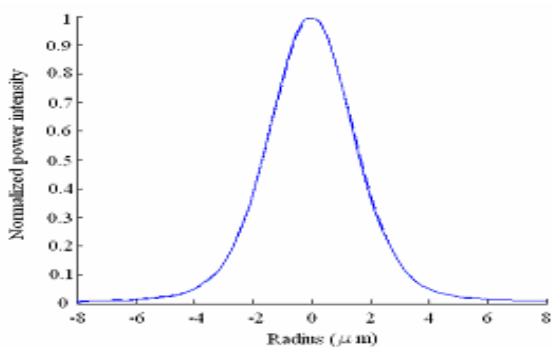


Fig.a

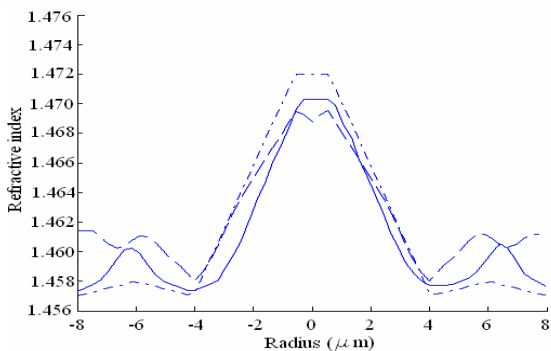


Fig.b

**Figure No 4** Transmitted near field and refractive index profile, of the analyzed fiber: (—) computed results, (--) experimental results.

**CONCLUSION**

In conclusion, in this work we have presented the TNF-FEM method for reconstructing the refractive index profile of a silica-pure core and LEAF single-mode fibers. This methodology can be constituted in a true alternative of low cost when it is compares with the conditions of maintenance that requires a RNFsystem

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