

MAIN PUBLICATIONS

Wiederhecker GS, Cordeiro CMB, Couny F, Benabid F, Maier SA, Knight JC, Cruz CHB, Fragnito HL. 2007. Field enhancement within an optical fibre with a subwavelength air core. *Nature Photon.* **1(2)**:115-118.

Boggio JMC, Marconi DJ, Bickham CR, Fragnito HL. 2007. Spectrally flat and broadband double-pumped fiber optical parametric amplifiers. *Optics Express.* **15(9)**:5288-5309.

Cordeiro CMB, Franco MAR, Chesini G, Barretto ECS, Lwin R, Cruz CHB, Large MCJ. 2006. Microstructured-core optical fibre for evanescent sensing applications. *Opt. Express.* **14(26)**: 13056-13066.

Chillcce EF, Rodriguez E, Neves AAR, Moreira WC, Cesar CL, Barbosa LC. 2006. Er³⁺-Tm³⁺ co-doped tellurite fibers for broadband optical fiber amplifier around 1550 nm band. *Opt. Fiber Technol.* **12(2)**:185-195.

Dainese P, Russell PSJ, Joly N, Knight JC, Wiederhecker GS, Fragnito HL, Laude V, Khelif A. 2006. Stimulated Brillouin scattering from multi-GHz-guided acoustic phonons in nanostructured photonic crystal fibres. *Nature Phys.* **2(6)**:388-392.

Hugo E. Hernández-Figueroa, Michel Zamboni-Rached, and Erasmo Recami. 2008. *Localized Waves*. Book published by J. Wiley publishers. ISBN: 978-0-470-10885-7369.

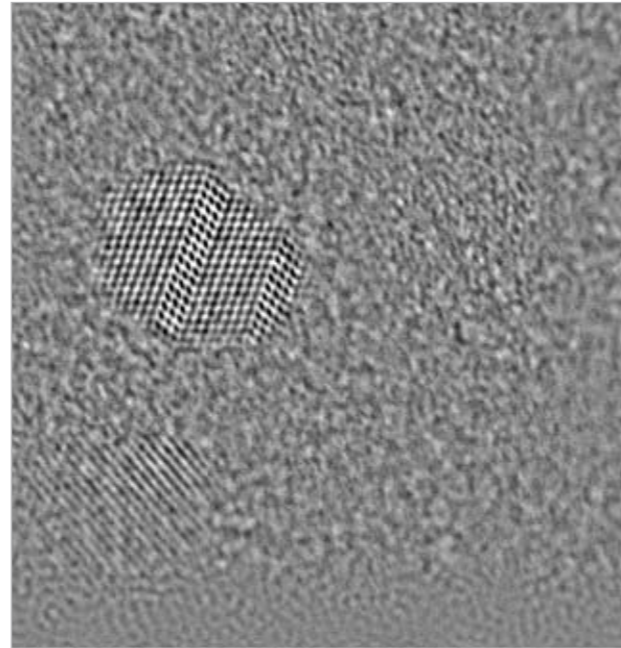
Ferreira OP, Souza AG, Mendes J, Alves OL. 2006. Unveiling the structure and composition of titanium oxide nanotubes through ion exchange chemical reactions and thermal decomposition processes. *J. Braz. Chem. Soc.* **17(2)**:393-402.

Fontes A, Ajito K, Neves AAR, Moreira WL, Thomaz AA, Barbosa LC, de Paula AM, Cesar CL. 2005. Raman, hyper-raman, hyper-rayleigh, two-photon excited luminescence and morphology-dependent-modes in a single optical tweezers system. *Phys. Rev. E.* **72**:012903 (1-4).

Bachmann L, Diebold R, Hibst R, Zezell DM. 2005. Changes in chemical composition and collagen structure of dentine tissue after erbium laser irradiation. *Spectrochim. Acta A-Molec. And Biomolec. Spectrosc.* **61(11-12)**:2634-2639.

Padilha LA, Neves AAR, Rodriguez E, et al. 2005. Ultrafast optical switching with CdTe nanocrystals in a glass matrix. *Appl. Phys. Lett.* **86(16)**:161111.

Stowe MC, Cruz FC, Marian A, Ye J. 2006. High resolution atomic coherent control via spectral phase manipulation of an optical frequency comb. *Phys. Rev. Lett.* **96(15)**:153001.



HRTEM image of a Si substrate prepared at CePOF, showing the atom's chemical interactions

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- **Exploratory Photonics**

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Confocal laser scanning biological microscope at the biophotonics lab

CePOF-Unicamp is a multidisciplinary center for research, technology transfer, and education and dissemination of optics and photonics. The center gathers researchers from the Physics Institute, Electrical and Computing Engineering School, Chemistry Institute, Biology Institute, and School of Medical Sciences at the State University of Campinas (Unicamp), the Energetic and Nuclear Research Institute (IPEN), and the Special Laboratory for Lasers in Dentistry (LEO, University of São Paulo).¹

The center congregates expertise in optical fibers, glass materials, nonlinear fiber optics, femtosecond physics, optical metrology, quantum optics, waveguide modeling, and optical communication systems and devices.

CePOF missions are:

- To develop fundamental and applied research, integrating cross-disciplinary expertise to explore advanced applications of optics and photonics;
- To disseminate optics and photonics to the general public, thus promoting science at all levels of education;
- To promote innovation in the industry through technology transfer, small business incubation, and continued education programs.

CePOF organizes R&D activities into well-defined projects that require the contributions from groups with complementary expertise. This teamwork and leadership development atmosphere stimulates our young researchers to go deeper into the theoretical details and measurement techniques that are necessary for technological developments. The center also encourages students and post-docs to travel abroad, thus strengthening external collaborations, bringing back new variants for research, and assimilating state-of-the-art methods and techniques.

¹ Further information on the Center organization and participants is available from CePOF-Unicamp web pages: www.ifi.unicamp.br/foton

MAIN RESEARCH TOPICS

The research activities include fundamental studies in optical communication (devices and systems) and exploratory photonics (materials sciences, photonics in life sciences, optical metrology and quantum optics), as well as applied projects on industry's demand.

Research Topics

Biophotonics
Fiber Optics Parametric Amplifier (FOPA)
KyaTera Project
Optical Fibers
Optical Metrology
Photonic Waveguide Devices
Quantum Dots
Rare Earth Doped Fiber Optic Amplifier (REDFA)
Semiconductor Optical Amplifier(SOA)
Silicon Photonics

Optical Communication Laboratories

Non-linear optics and optical processing, high-capacity WDM systems, and advanced optical amplifiers.

- Laboratories and Research Activities

Optical Communication Lab
Fiber optics parametric devices
Stimulated Brillouin Scattering (SBS) in optical fibers
Photonic Crystal Fibers (PCFs)
Modeling waveguides using finite elements
WebLab on Optical Communication
- **LapCom Prof. Atilio José Giarolla**
Semiconductor Optical Amplifiers (SOAs)
Automatic gain control for Erbium Doped Fiber Amplifiers (EDFA)

Exploratory Photonics Laboratories

In this program we explore new and advanced applications for photonics. The research projects are divided in the areas:

- Advanced materials and structures

Researches on new materials and structures with applications in optical communication, sensors, and bio-photonics

- Photonics in life sciences:

Researches on new techniques using optical tweezers combined with micro-spectroscopy, nonlinear optics, and colloidal quantum dots; researches on lasers and materials with applications in dentistry and medicine

- Optical metrology:

Fundamental and applied research using femtosecond combs

- Quantum Optics:

Quantum processes for theoretical studies



Institutions connected at KyaTera Project



Optical Communications Lab

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

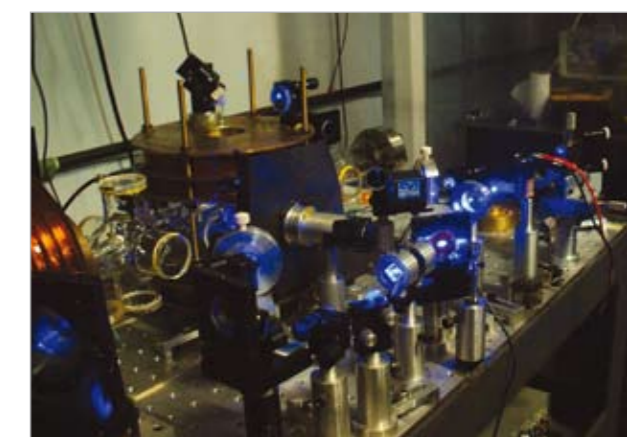
Our R&D projects are organized within two main Programs: Optical Communication and Exploratory Photonics.

The Optical Communication Program covers fundamental and applied aspects of materials, devices, and systems. In this program, we explore advances in physics that may lead to significant improvements in the transmission and networking capacity of optical communication. In order to explore the ultimate limits of fiber optic systems, new ultra-broadband optical amplifiers and all-optical optical routers are necessary. To this end, we investigate Fiber-Optic Parametric Devices (amplifiers, wavelength converters) Semiconductor Optical Amplifiers, and special Rare Earth Doped Fiber Amplifiers. Our program covers waveguide and fiber modeling and manufacturing, device development and system studies. In a special project within this program, called KyaTera², we developed a dark fiber optical testbed in the State of São Paulo (over 4,000 km of fibers, presently), with the fibers reaching directly the walls of every laboratory. This Fiber-to-the-Lab network is ideal for field trials of photonic devices and optical networks, and offers essentially unlimited bandwidth for the development of future Internet applications. Telefonica and Padtec are our main industrial partners in this project.

In the Exploratory Photonics Program we explore advanced applications of photonics, mainly in Life sciences, sensing and metrology. We develop new biophotonics techniques using optical tweezers combined with micro-spectroscopy, nonlinear optics, and colloidal quantum dots (home produced), optical coherent tomography, and photodynamic therapy. Most of the lasers that we use in our clinical dentistry studies are developed within the center, using crystals grown also in the center. For sensing applications we develop special Photonic Crystal Fibers (PCFs) and methods to laterally access the holes in these fibers. In Optical Metrology, we develop femtosecond frequency combs by using (home developed) Ti:Sapphire lasers, and next generation atomic clocks with ultra-stabilized cw lasers and alkaline-earth atoms (Calcium or Ytterbium).

Our R&D facilities include: optical fiber drawing towers for Photonic Crystal Fiber and specialty fibers (e.g., erbium doped telluride fibers); micro fabrication facility (semiconductor amplifiers, micro-disk and stadium lasers, erbium-doped amorphous silicon waveguides, ion-exchange glass waveguides); laser ablation facilities – ns and fs; high-performance computer cluster facility for waveguide modeling; high-capacity DWDM systems; KyaTera dark fiber testbed facility; optical tweezers/micro-spectroscopy with CARS

(Coherent anti-Stokes Raman Scattering), 6.7 fs laser with carrier-envelope-phase stabilization control, 0.5 TW 5 Hz 30 fs amplified system, crystal growth facility, diode pumped solid-state laser development facility, micro-FTIR spectroscopy, fast infrared thermography, optical coherent tomography systems; LELO – Special Laboratory on Lasers in Dentistry facility ; laser-cooled optical atomic clock system; and glass fabrication facility.



Ti:Se laser in operation at Lasers and Application Lab

2. The name KyaTera comes from "Kya" ("net" in Tupi-Guarani, the language of the native Brazilian people) and "Tera" ("monster, marvel" in Greek).