

≫ 研究所紹介

Introduction of FETI

〈概要〉

Furukawa Electric Technológiai Intézet Kft., (FETI, ブダペスト：ハンガリ) は、古河電気工業(株)の研究開発事業に貢献している。FETIは、主として材料工学、機器開発および製造工程に関連した新技術の開発と既存技術の改善を目的とした様々な種類の研究開発プロジェクトに取り組んでいる。FETIは、Hungarian Research Institute の電工学関連部門を原点として1990年に設立された。この時以来、FETIはその活動分野を広げ科学者の雇用を増やしている。研究者および技術者は、4つの主要グループに従事している。シミュレーショングループは3人の初期メンバーで2000年に設立、自動車部品研究グループは2003年研究開始、発泡製品開発グループは2009年にTrocellen との協力から成長し、光デバイスグループは2014年に設立された。現在、35名の技術者と研究者がFETIに在籍していて、そのうち概ね50%が博士号の保有者である。またFETIは、ハンガリー科学アカデミーの固体物理光学研究所、Szeged 大学、ブダペスト工経大学、Pázmány Péter カトリック大学などの複数の学術機関と、研究開発活動の協力関係がある。

1. INTRODUCTION

Furukawa Electric Technológiai Intézet Kft., Budapest, Hungary (FETI), supports the research and development activities of Furukawa Electric Co. Ltd., Tokyo, Japan. FETI is participating in many different types of R&D projects in order to develop new or to improve existing technologies mainly related to material sciences, device developments and manufacturing processes.

FETI was established in 1990 originating from a department of the Hungarian Research Institute for Electrical Industry. Since then, FETI has grown in its activity as well as in the number of the employed Scientists. Researchers and Engineers are working in four main groups: the Simulation Group which was established in 2000 with three initial members, the Automotive Research Group which started investigations since 2003, the Foam Development Group which thrived from a cooperation with Trocellen in 2009 and the Optical Devices Group which has been in existence since 2014. Nowadays, 35 Engineers and Researchers are working permanently in FETI and approximately 50% of them are holding a PhD degree.

FETI cooperates with academic institutes to support its R&D activity. Our academic partners include the Research Institute for Solid State Physics and Optics of the Hungarian Academy of Sciences, the University of Szeged, the Budapest University of Technology and Economics, the Pázmány Péter Catholic University and some others.



Figure 1 The building of FETI in Budapest, Hungary where all the offices and laboratories are located.

2. SIMULATION GROUP

Computer simulation may result in a faster progress on product design by calculating several scenarios without significant investment in real prototypes. The aim of the Simulation Group is to provide technical support in certain development, improvement and optimization tasks solving physical and engineering problems with well-established physical and numerical models. What follows are some examples of this type of work.

2.1 Mechanically Stressed Optical Fibers

Coated and ribboned optical fibers are exposed to external stress of the coating materials, which may induce additional birefringence in the fiberglass. Changing the cross-sectional geometry of the fiber ribbon may lead to significant stress and PMD reduction in the optical

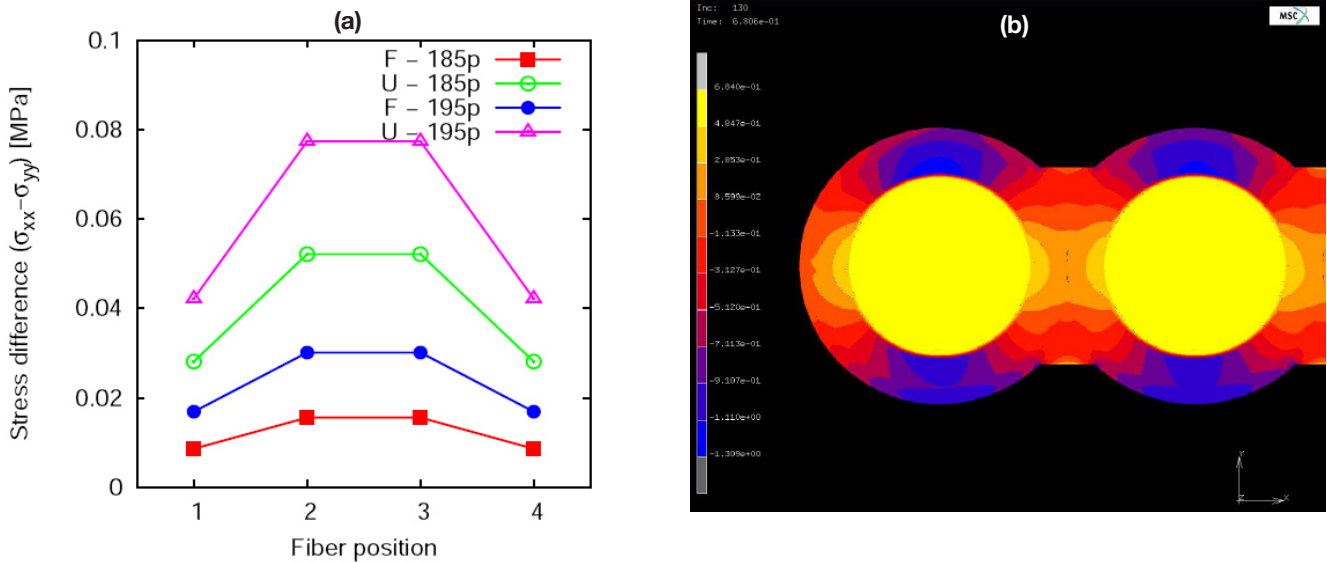


Figure 2 (a) Relation between the fiber position and the stress difference in the fiber core in case of different materials and primary coating thicknesses in a fiber ribbon and (b) a typical calculation result of the stress across an investigated fiber ribbon geometry.

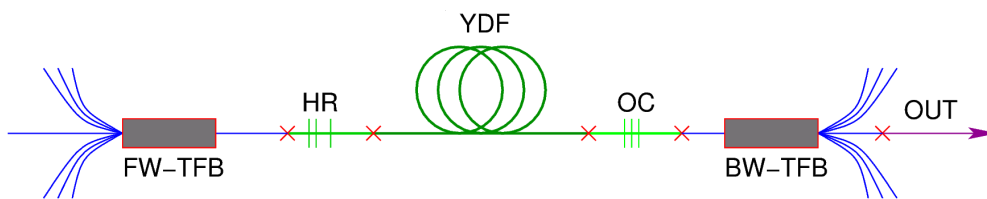


Figure 3 A typical arrangement of a fiber laser oscillator with forward and backward pumps. FW-TFB: forward tapered fiber bundle (for forward pumps), BW-TFB: backward tapered fiber bundle (for backward pumps), HR: high reflector (mirror), OC: output coupler, YDF: Ytterbium doped fiber.

fibers¹). Changing the thermal and mechanical parameters of the different components may also yield stress reduction according to our finite element (FE) analyzes¹. FETI optimized stress caused PMD in fibers by modifying the geometry and the material properties of the ribbon.

2.2 Optical Fiber Laser and Amplifier Simulations

We developed softwares to simulate the light propagation in optical fibers²), doped optical fibers^{3,4}) and fiber based optical systems^{5,6}). These solvers are tested with signals in various power ranges which are investigated experimentally. Our softwares are capable of optimizing the parameters of certain optical components such as the saturable absorber parameters in the Ytterbium or the Erbium doped fiber oscillators⁵). We investigated, for instance, the changes of the pulse energy and the pulse width as a function of the modulation depth of a saturable absorber in an Ytterbium fiber ring oscillator.

2.3 Absorbing Clamp Method

An efficient numerical simulation tool based on a finite element method is proposed, by which the electromagnetic compatibility (EMC) shielding effect characteristics of power cables can be predicted in the 30–1000 MHz frequency range⁷). This is done the same way as if it was measured by the Absorbing Clamp Method⁷).

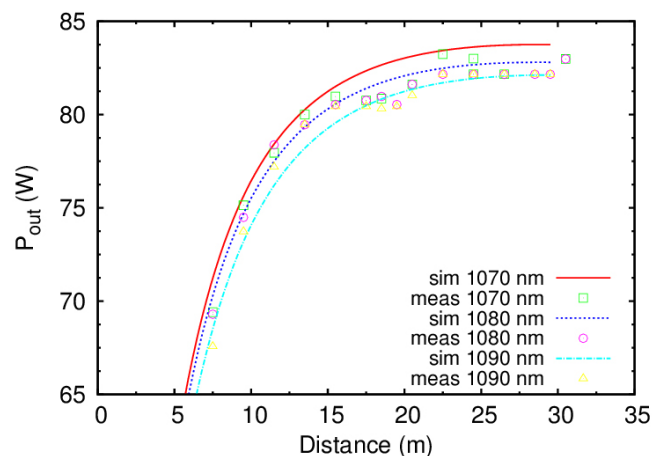


Figure 4 Measured and simulated output power as a function of the fiber length from a high power fiber amplifier at three different wavelength regions. Measurements are done by cutting back the length of the gain fiber.

This simulation tool can be applied in the design and the optimization of braided cable shields to be used in the automotive industry.

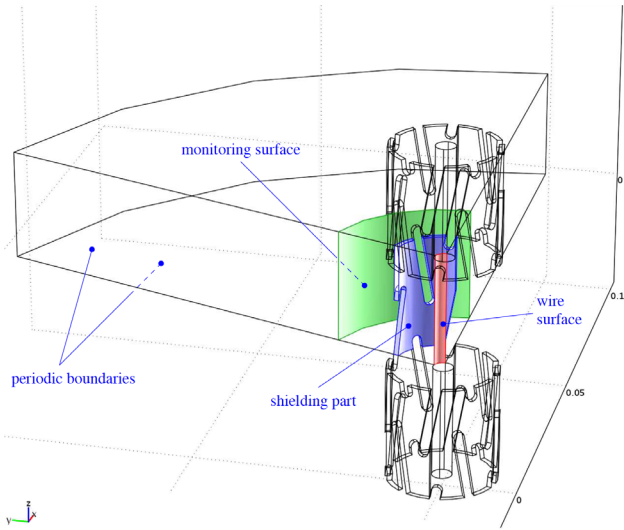


Figure 5 3D finite element model for simulating the shielded wire to obtain the shielding effect at different frequencies.

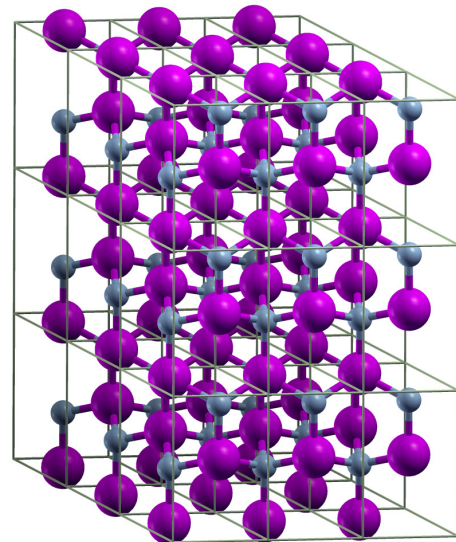


Figure 6 An optimized structure from the Quantum Chemical computations.

2.4 CVD Simulation

Based on Quantum Chemistry, we can compute the material (thermal and transport) and reaction properties (rate coefficients) of compounds for chemical vapor deposition (CVD) in order to make the Reactive Flow simulations possible. This leads to detailed, predictive models of CVD, which can be used to optimize the reactors, to compute and to explain trends⁸⁾.

3. OPTICAL DEVICES GROUP

The main focus of the Optical Devices Group is on the numerical simulation of semiconductor light-emitting devices and the optically generated sub-THz communication systems. Past topics include opto-electro-thermal modeling of distributed feedback lasers, vertical-cavity surface-emitting lasers and signal propagation in multi-mode optical links.

3.1 Three-Dimensional VCSEL Simulation

A self-consistently coupled three-dimensional dynamical model has been presented for the first time to simulate noncircular vertical-cavity surface-emitting lasers (VCSELs)⁹⁾. The full-vectorial treatment enables us to determine the polarization characteristics of these lasers.

A new honeycomb design has been proposed to increase the single-mode current range of low threshold current photonic crystal VCSELs⁹⁾. Simultaneous confinement of the fundamental mode within the central cavity and the shift of higher modes toward outer trapping defects can lead to stable single-mode operation^{10),11)}.

3.2 Simulations of Laser Modules

Furukawa Electric has a strong market presence in narrow linewidth full-band tunable laser modules based on a distributed feedback (DFB) laser array. A working group was established from FEC and FETI members to design next-next generation module providing larger output

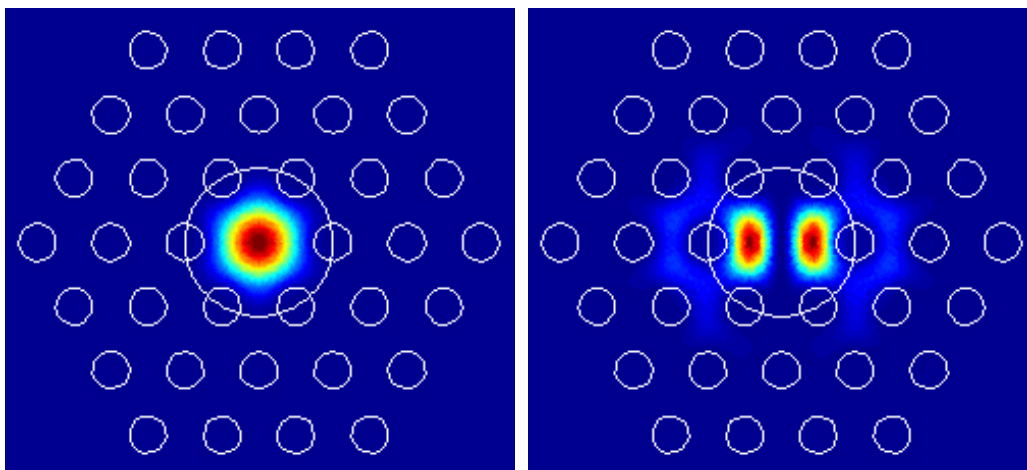


Figure 7 Calculated mode profiles of the fundamental (LP01) and first order (LP11) modes in a photonic crystal VCSEL.

power and reduced linewidth in a versatile and compact design at a reduced cost. FETI performs optical and laser simulations using in-house developed solvers for evaluation and continuous improvement.

4. AUTOMOTIVE RESEARCH GROUP

The Automotive Research Group of FETI is supporting the development of various products for automotive applications.

4.1 Radar Sensors

In recent years, Advanced Driver Assistance Systems (ADAS), became popular. These systems, equipped with sensor devices that can help to avoid vehicle accidents by detecting objects in the surroundings. Furukawa Electric has developed a multi-mode radar, based on pulse radar technology which is in compliance with radio equipment specifications for low power radio stations or for mobile detection sensors. The radar sensor is suitable for various applications in the automotive and the infrastructure businesses. Such applications require tracking of the objects and the base algorithm to do so was established in FETI.

4.2 Reference Measurement Tool for Radar Validation

Since the preventive safety system is consisting of the radar itself, in order to confirm the validity of the radar measurement during the development process, a reference measurement system was developed by FETI. This system can indicate and record not only the detection results of the target on a real-time basis but also the detection results of the synchronized reference sensors. As the reference sensors, Light Detection And Ranging (LIDAR); (Laser scanner, Detected data for distance and orientation) and a camera (confirming the scenes which are assessed) were used¹²⁾.

4.3 Battery Sensor

FETI is involved in the development of the algorithms for sensors estimating the battery internal state.

By attaching a sensor to the negative pole of a lead battery, it precisely monitors the charging and discharging current, voltage and temperature of the battery.

Using these data, a sophisticated algorithm can calculate battery information important for power management of vehicles. In this way, the product helps to boost mileage and reduce CO₂ emissions by avoiding dead battery as well as charge controlling and idling stops.

5. FOAM Group

5.1 MCPET & MCPOLYCA - Reflective Technology

MCPET and MCPolyca sheets are suitable for lighting applications because of their high diffuse reflectivity and other advantageous optical properties. The existing aluminum reflectors can be replaced by these micro-cellular foams. Both MCPET and MCPolyca can be thermoformed easily but the deformation of micro-cells can degrade the optical properties of the material. Cell elongation, thinning the sheet and the residual stress after forming may cause defects in the final product. FETI has patented several thermoforming methods keeping the original cell structure and the optical property of the material. Several technological parameters of the thermoforming process can be studied by FETI's experimental thermoforming device.

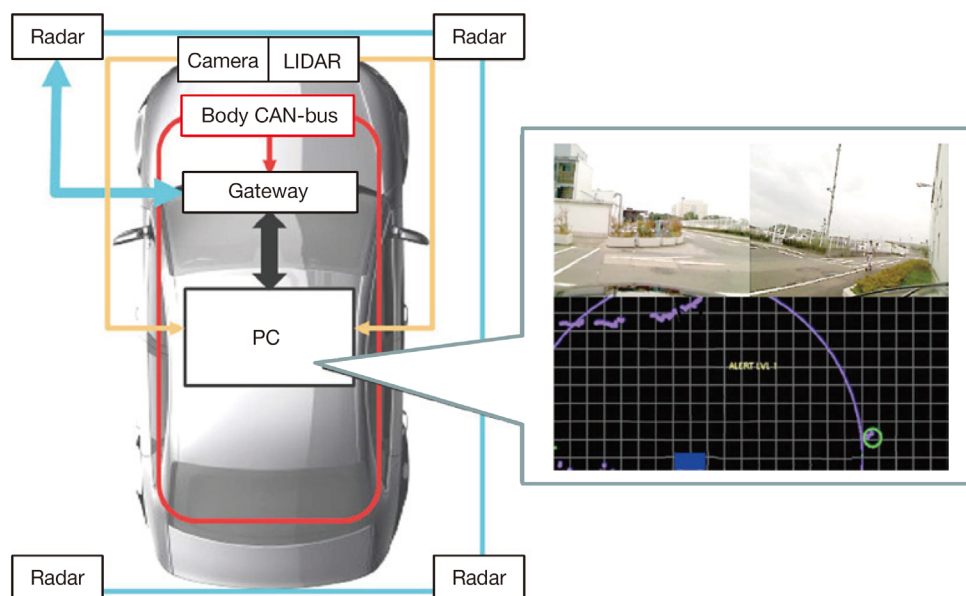


Figure 8 Arrangement of the measurement in a car and the processed data.

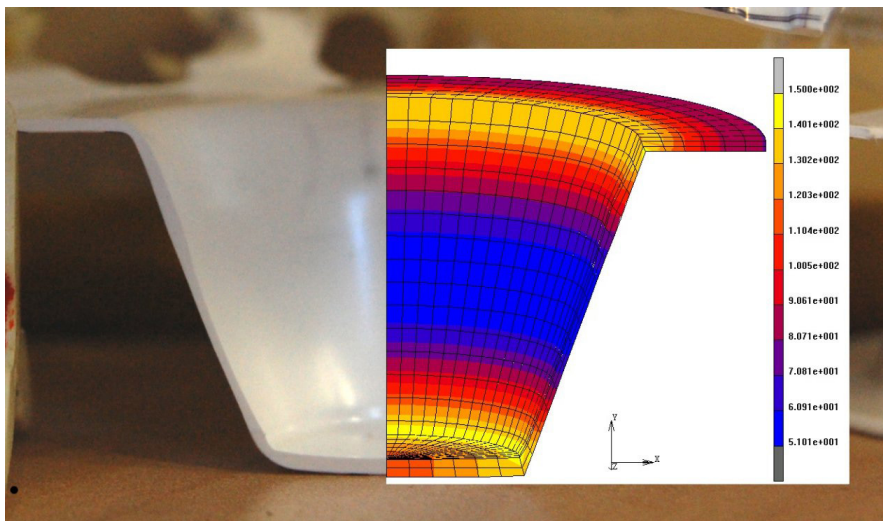


Figure 9 Thermoformed MCPET sample for the purpose of light reflector and its thermo-mechanical simulation result in order to compare the wall thicknesses.

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