



**FIRST SYMPOSIUM  
OF THE PHOTONICS SOCIETY OF POLAND**



# **Photonics and optical technologies in Poland**

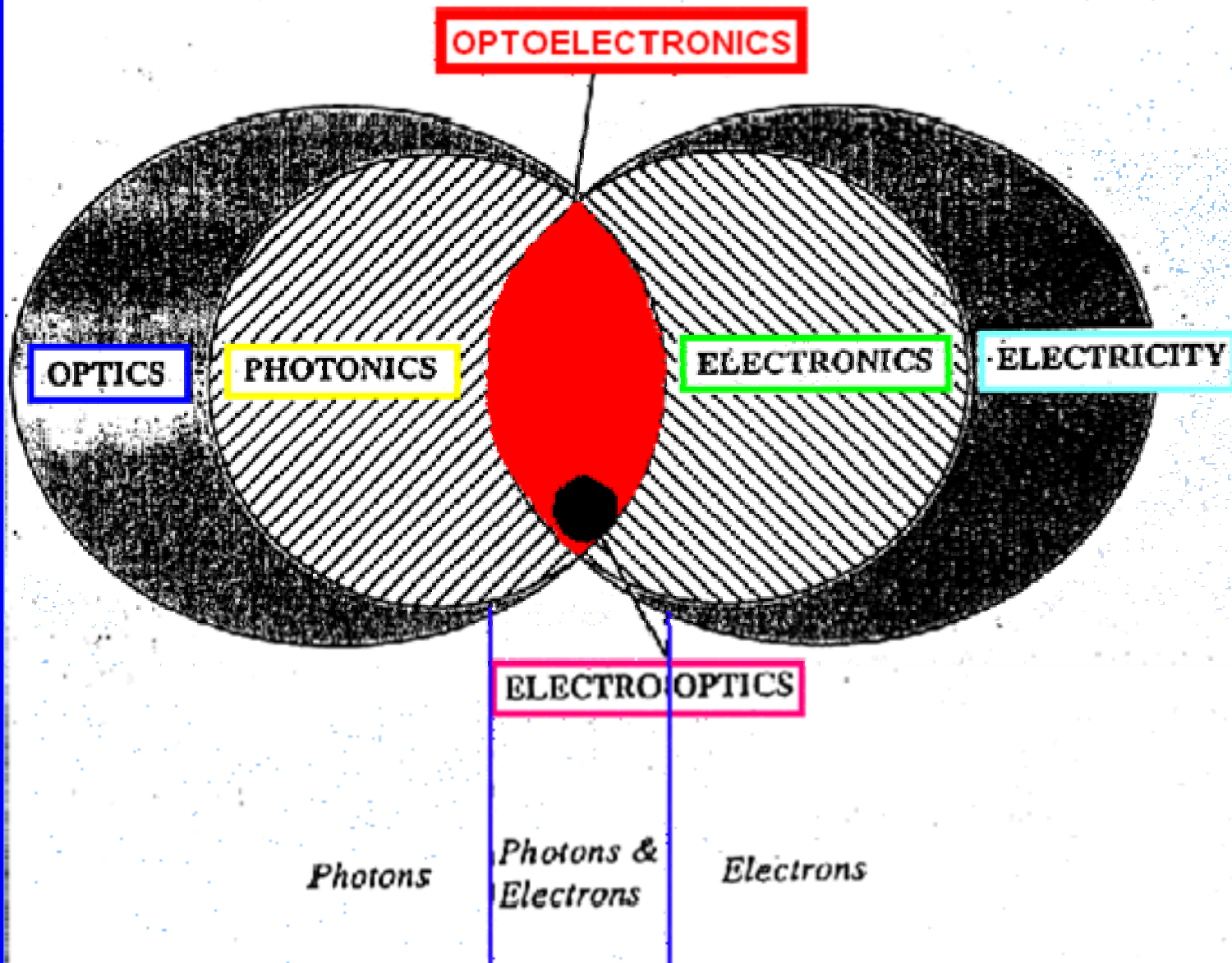
**Tomasz R. Woliński**

*Photonics Society of Poland President  
Faculty of Physics, Warsaw Univ. of Technology*

Warszawa, 31 May 2008



# Overlap of Optics and Electricity



# Photonics

- Technology of generating and harnessing light and other forms of radiant energy: *quantum unit*

## ➤ Photon

- Science: light emission, transmission, deflection, amplification & detection by optical components & instrumentation, lasers & other light sources, electro-optical instruments, hardware & electronics

## ➤ e.g. Fiber optics

- Applications: energy generation & detection, communications, information processing

## ➤ e.g. Photonic sensors

# Outline

- Motivation
  - Ostsee-Stammtisch
  - Asia Interprise LEAP, Berlin-Beijing 2007
  - NCBiR, Warszawa 15.01.2008
- Polish Photonics Market
- Examples of technology achievements
- Survey
- Survey analysis – presented on 29.04.2008 (KEiT PAN)



THE INTERNATIONAL SOCIETY FOR OPTICAL ENGINEERING  
POLAND CHAPTER

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# OPTICAL TECHNOLOGIES IN POLAND

## Ostsee-Stammtisch Meeting

25th January 2006, Hamburg



THE INTERNATIONAL SOCIETY FOR OPTICAL ENGINEERING  
POLAND CHAPTER

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# Poland Chapter of SPIE and Polish Photonics Market

Asia Interprise  
Linking Europe and Asia in Photonics Meeting

Beijing, Nov. 2007



# Polish Photonics Market

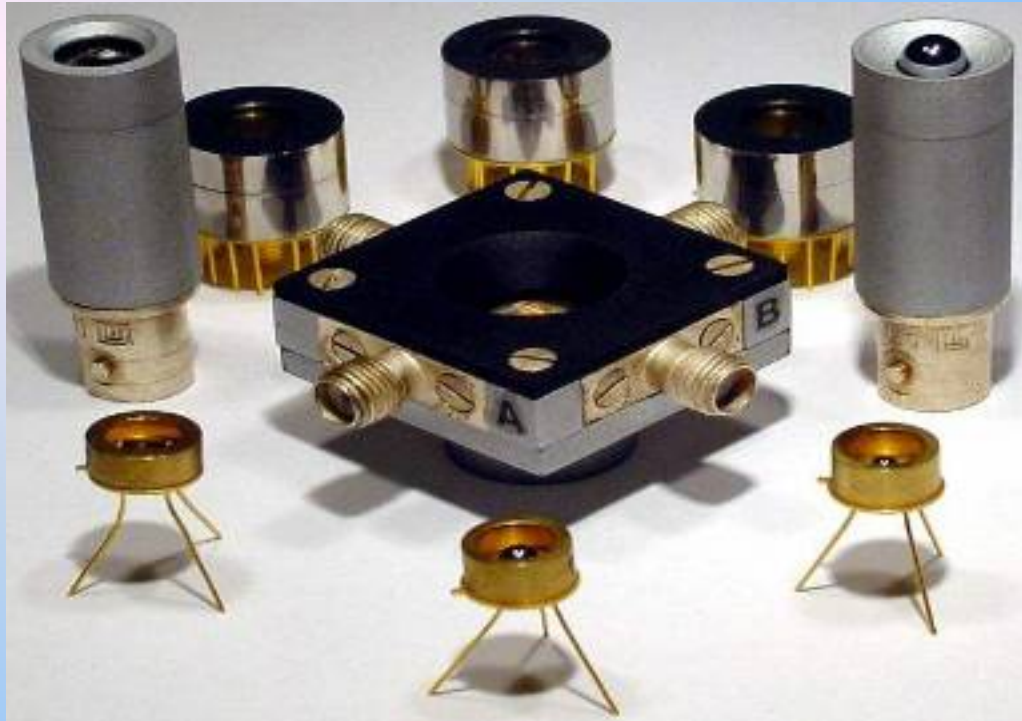
- **~ 60 companies and research institutes**

e.g.

- VIGO and Solaris Group
- LASERINSTRUMENTS (CTL)
- Optical Coherence Tomography- UMK and OPTOPOL S.A.
- UNIPRESS and TOPGUN Co.



# VIGO System Ltd



- Examples of uncooled and thermoelectrically cooled single element **photodetectors**  
(manufactured by Vigo System, Warsaw)

# VIGO System Ltd-Infrared camera



# CTL's Lasers for Medicine



- **Low Power Lasers** - transdermal, non-invasive and non-chemical treatment
- **High Power Diode Lasers** – precise microsurgery, endodontics and aesthetic applications
- **CO<sub>2</sub> Surgical Lasers** – the most delicate laser scalpels for non-contact and bloodless cutting, vaporisation and coagulation of soft tissues

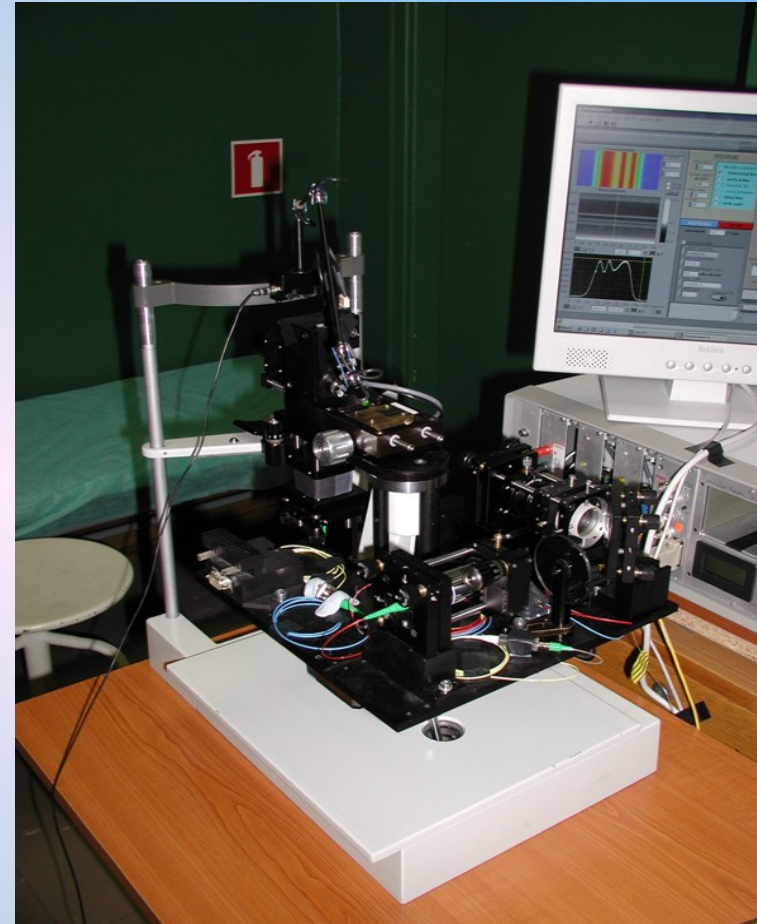


- **Er:YAG Lasers** – hard tissue preparation in dentistry; skin resurfacing in dermatology
- **Nd:YAG Lasers** – endodontics, periodontology and aesthetic medicine



# Spectral OCT– licence sold to OPTOPOL S.A.

- Compact and portable high-speed, high-resolution Spectral OCT
- **designed and constructed at Nicolaus Copernicus University**
- Light source  $\lambda_0 = 830 \text{ nm}$ ,  $\Delta\lambda = 70 \text{ nm}$
- Axial resolution (in tissue): **< 3  $\mu\text{m}$**
- Transversal resolution
  - at the retina: **15 –20  $\mu\text{m}$**
  - at the cornea: **5-10  $\mu\text{m}$**
- Acquisition rate: **40  $\mu\text{s/A-scan}$**
- High sensitivity:  $S/N = 98 \text{ dB}$
- Optical power: **700  $\mu\text{W}$  at cornea**



# Examples of Technology achievements

- **Liquid Crystals** (MUT and AWAT Co)
- **Photonic Crystal Fibers** (UMCS, ITME)
- **Optical fiber sensors and displays**  
(WUT, PWr, MUT, PG ...)



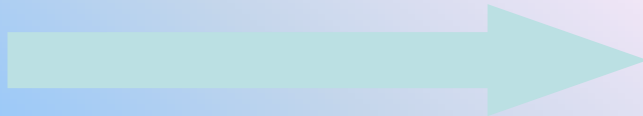
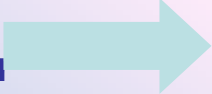
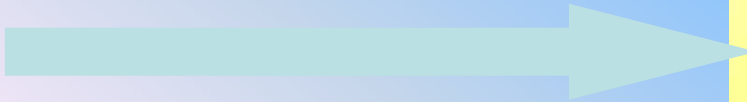
# New **Liquid Crystals** materials (MUT)

licencies sold to Germany, Korea, Japan, US

1. **Low-birefringence** nematic compounds and mixtures:  
with  $n_o < 1.459$
2. **Stable single LCs** with nematic phase in the range  $10^\circ - 45^\circ\text{C}$  :  
**6CHBT** – positive anisotropy  $\Delta\epsilon > 0$   
**7CP5OBC** – negative anisotropy  $\Delta\epsilon < 0$
3. **High-birefringence** nematic compounds and mixtures:  
 $\Delta\epsilon > 0, \Delta n = 0.3 - 0.5$
4. **Ferroelectric and antiferroelectric compounds** and mixtures:  
low tilted and high tilted ( $45^\circ$ ) ferroelectric and orthoconic  
antiferroelectric (**LCDs**)

# Specific liquid crystals applications (MUT):

- ↪ helmets for light protection (welders helmets)
- ↪ liquid crystals displays for many applications e.g. cockpit information display for Polish glider PW5
- ↪ thermographic foils with cholesteric liquid crystals
- ↪ Ultrafast LC light valves
- ↪ liquid crystals by donors for dynamic holography and LC based image recognition

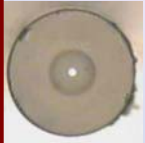




# Optical Fibers Technology at MCSU, Lublin

since 70'

## Standard fibers



Single mode SM  
 $\phi$  125  $\mu$  m



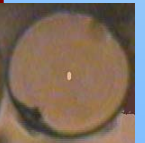
Graded Index GI  
 $\phi$  125  $\mu$  m



Side-hole SH-HB  
 $\phi$  125  $\mu$  m



Holey fibers HF  
 $\phi$  125  $\mu$  m



Single Mode Polarization  
 Maintaining SMPM  
 $\phi$  125  $\mu$  m



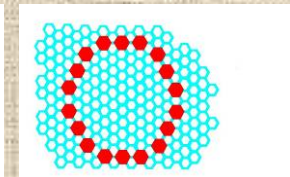
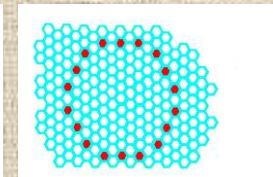
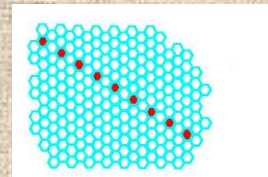
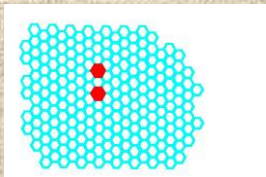
Double Clad rare  
 earth doped  $\phi$  125  $\mu$  m



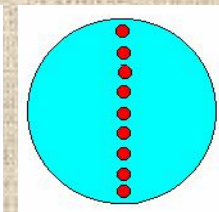
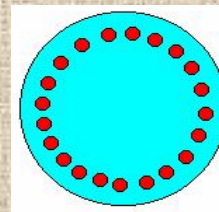
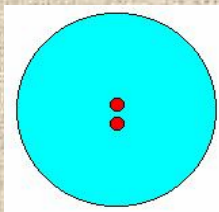
Plastic Clad Silica  
 PCS  
 $\phi$  100 - 1000  $\mu$  m

and another special fibers as D-shape fibers or capillaries  
 with elliptical hole e.g. 4 x 18  $\mu$  m

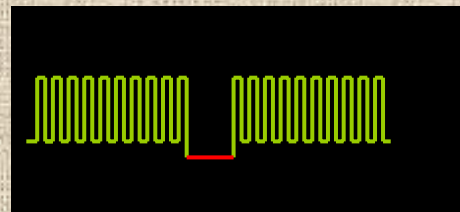
## Microstructured fibers - multicore hole fibers



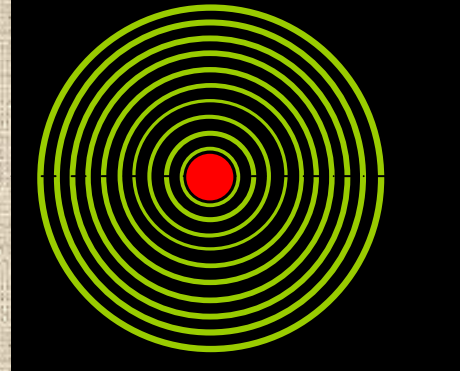
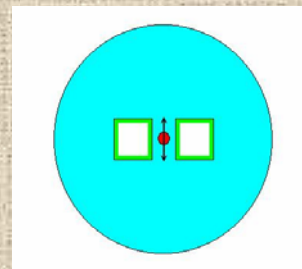
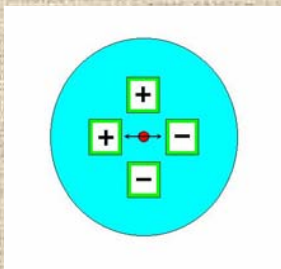
## -multicore fibers



## -Bragg fiber

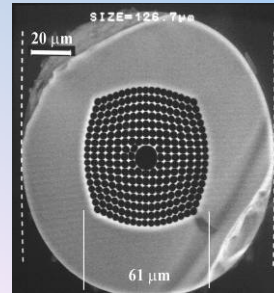
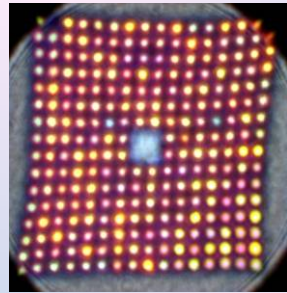
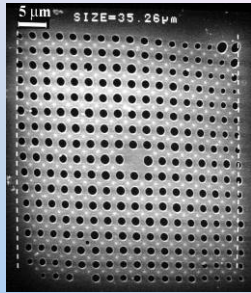


## -another microstructural fibers

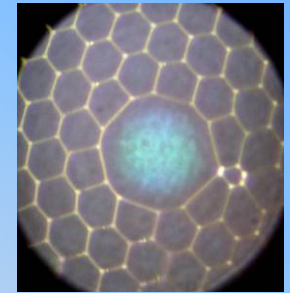
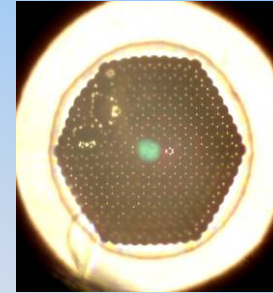


# PCFs made of multicomponent glasses

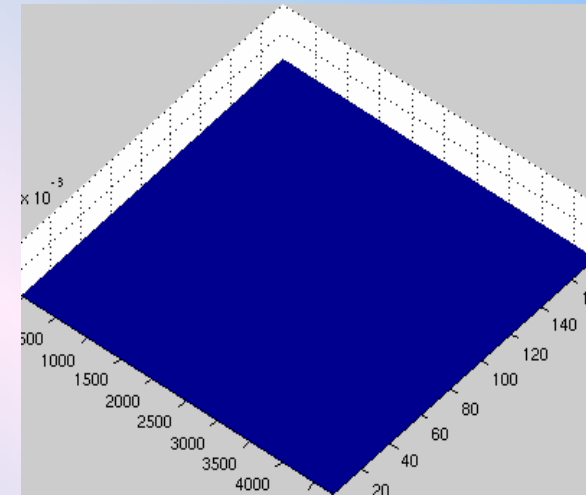
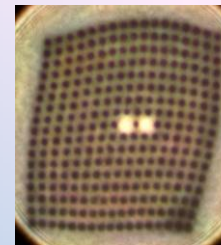
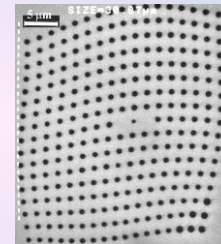
## All solid PCFs



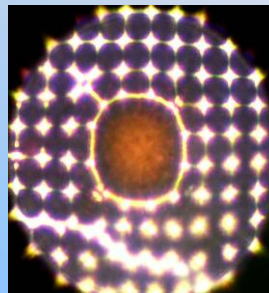
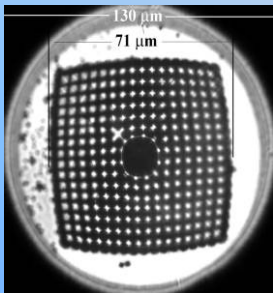
## Hollow core PCFs



## Double core PCFs



## Double lattice PCFs with air holes and glass rods



# FIBER OPTICS Lab.

**Fac. of Physics**  
**WUT**



PhD and MSc STUDENTS

## Research activities:

- polarization and coherence of light
- photonic crystal fibers filled with liquid crystal
- nonlinearly optical phenomena - supercontinuum
- polarimetric fiber optic sensors
- polarization mode dispersion in telecommunication
- optical coherence tomography
- depolarization effects in liquid crystals
- m-line spectroscopy



**Prof. Tomasz R. Woliński** (left)

*Head of Optics Divisions*

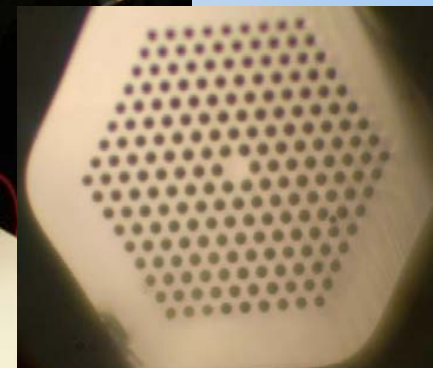
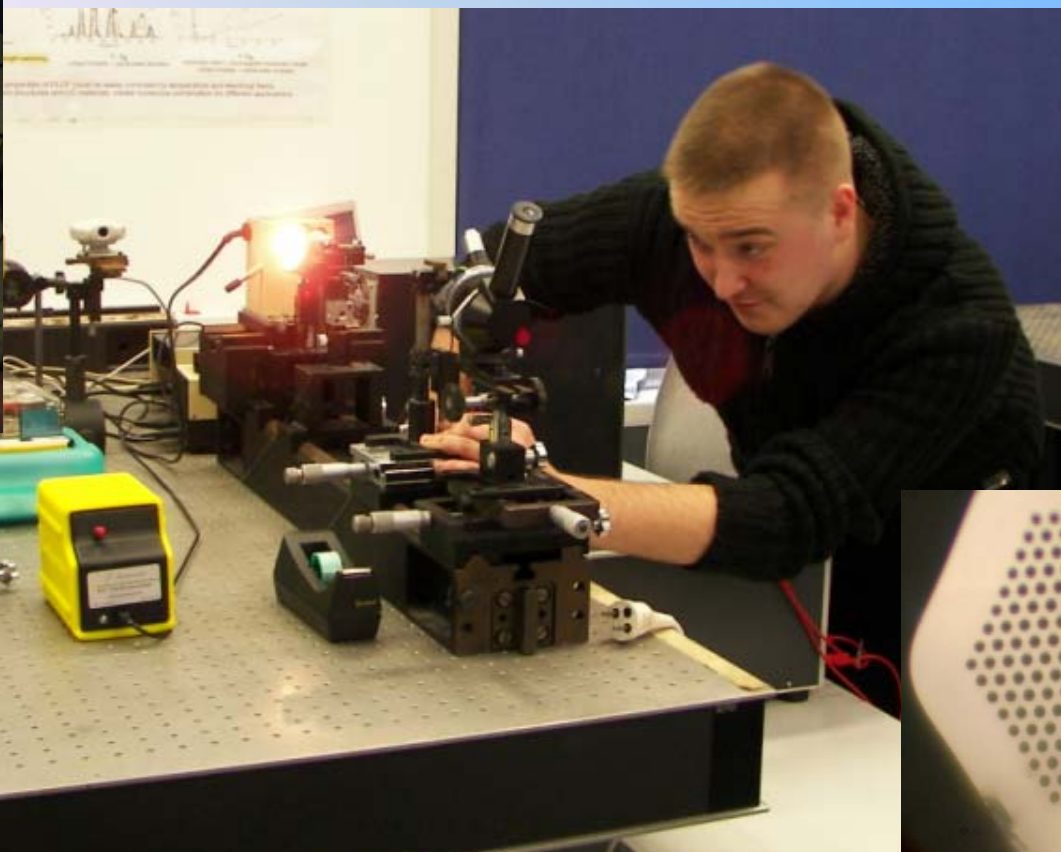
**Prof. Andrzej Domański** (right)

*Head of Fiber Optics Laboratory*





# Photonic Crystal Fibers (PCFs) and Liquid Crystals (LCs)



# Collaboration

since 90'

## Faculty of Physics, WUT

Prof. T. Woliński

Prof. A. Domański

Prof. M. Karpierz

Dr. P. Lesiak

Dr. T. Nasiłowski (VUB)

Dr. K. Rutkowska (Brzdąkiewicz)

Dr. M. Sierakowski

Dr. K. Szaniawska (NCBiR)

Dr. A. Szymańska (EWUT)

### PhD students:

D. Budaszewski, A. Czapla

S. Ertman, U. Laudyn, K. Jaworowicz

M. Chychłowski, M. Tefelska

## Institute of Chemistry MTU

Prof. Roman Dąbrowski  
& Co-workers

## Institute of Physics MTU

Dr. E. Nowinowski-Kruszelnicki  
& Co-workers

## UMCS Lublin

Dr. Jan Wójcik  
& Co-workers

## Faculty of Mechatronics WUT:

Prof. M. Kujawińska  
& Co-workers

## NTU, Singapore:

Prof. Ping Shum  
& Co-workers

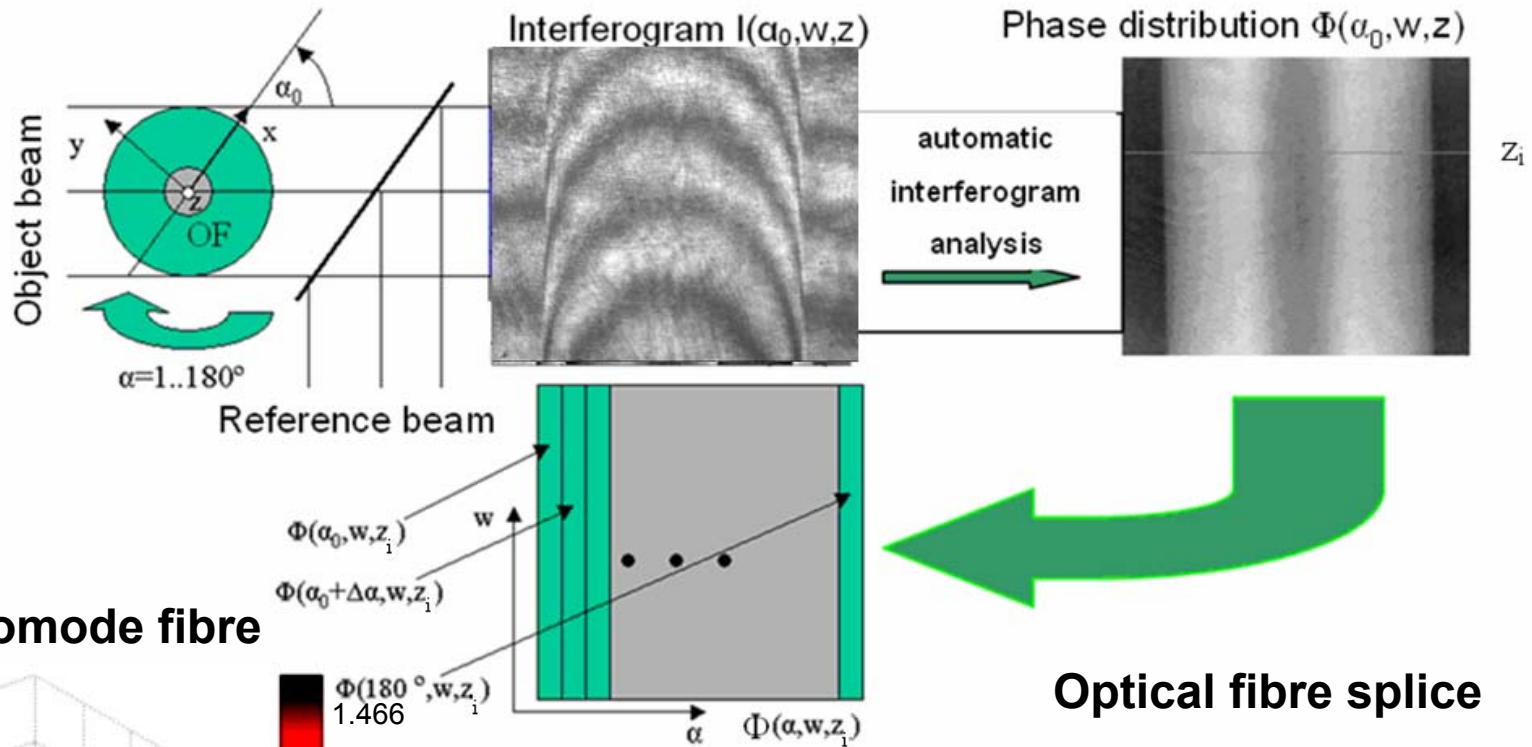
## UQO, Canada:

Prof. Wojtek Bock  
& Co-workers

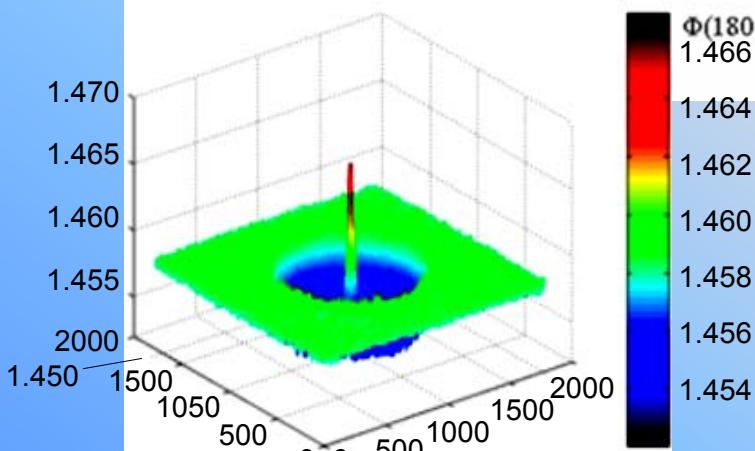


# Microinterferometric tomography for 3D refractive index determination in photonics elements (MWUT)

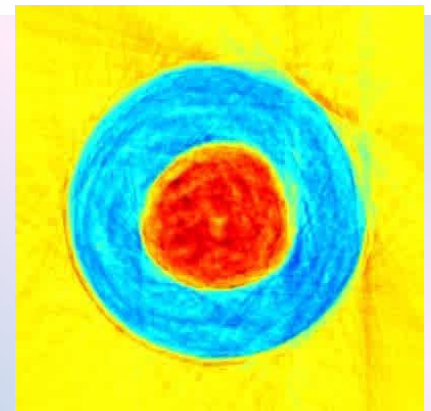
Mach-Zehnder Interferometer



n in monomode fibre

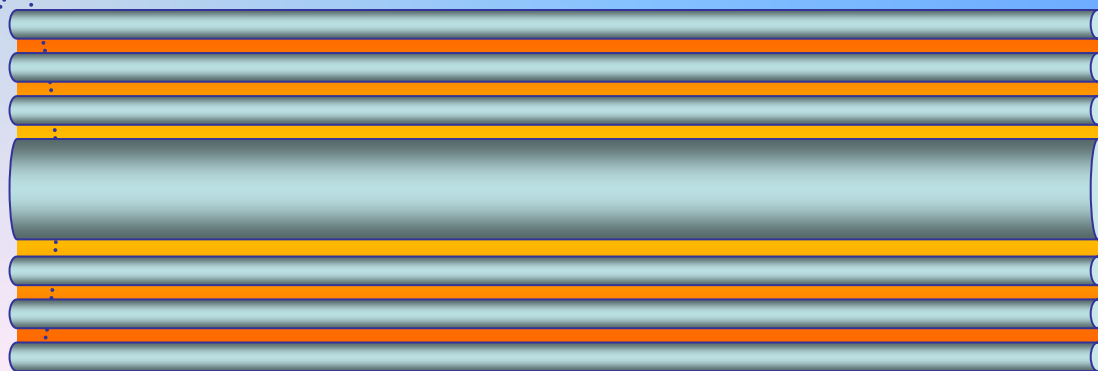
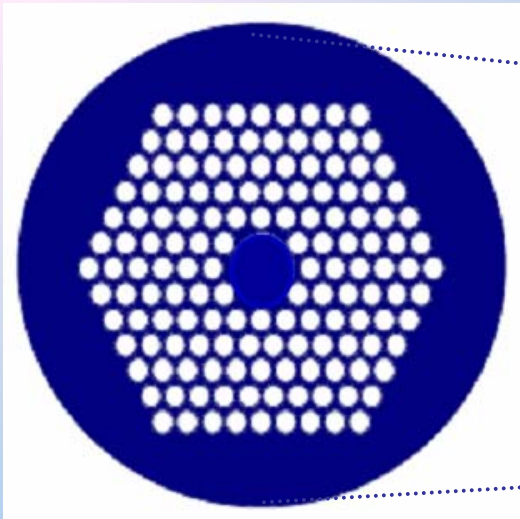
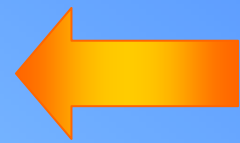


Optical fibre splice



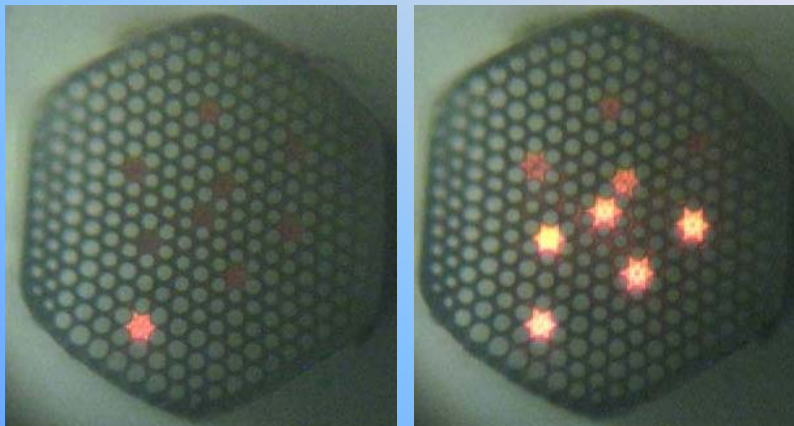


PCF filled with liquid crystal

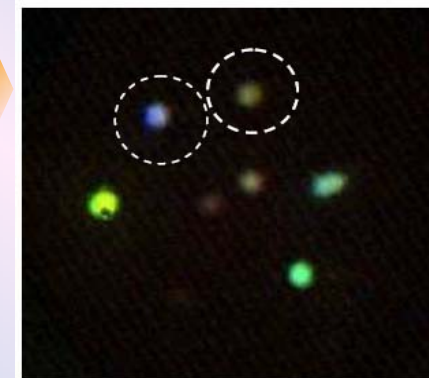
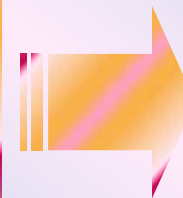


The effect of filling PCF with LC for example:  
**Multicore PCF**

**Empty:** propagation of all wavelengths

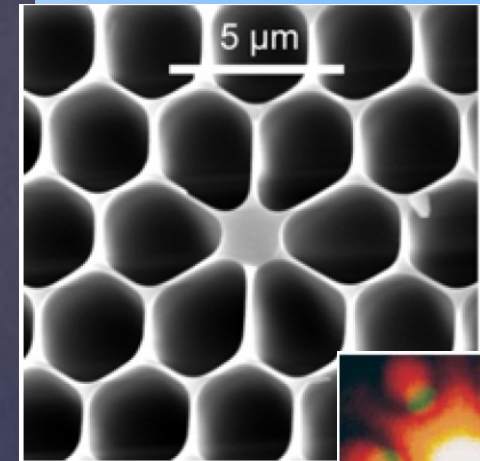


**With LC:**  
propagation of  
selective  
wavelengths

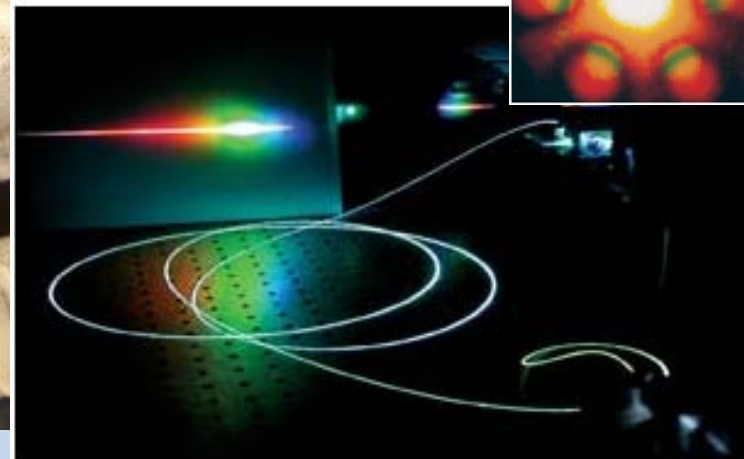
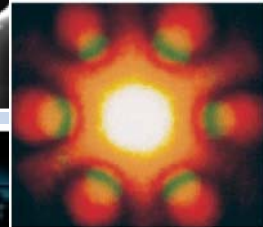




# Supercontinuum (SC)

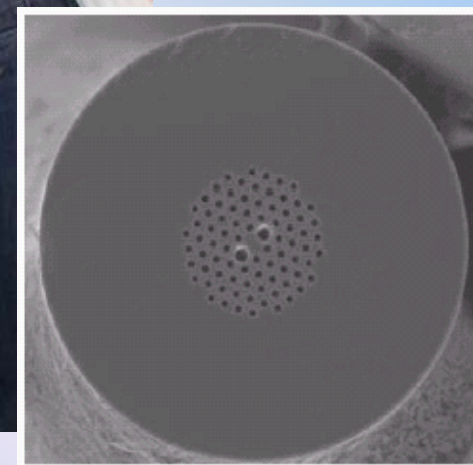
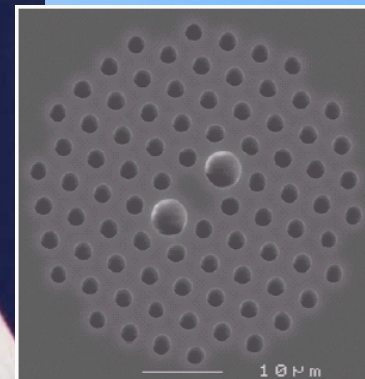
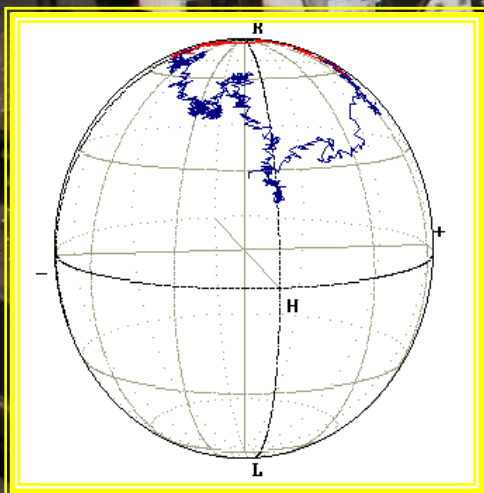
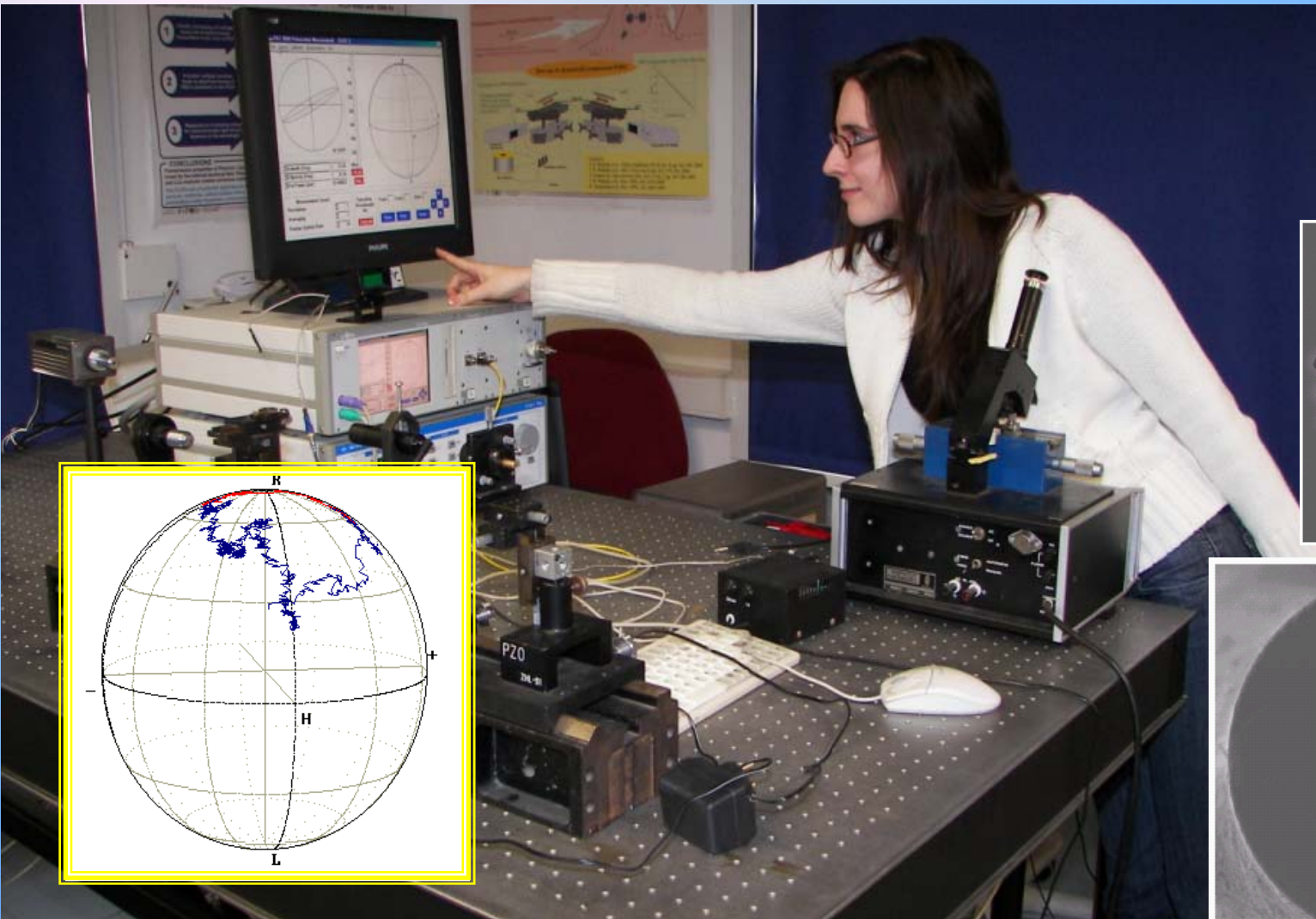


(\*)



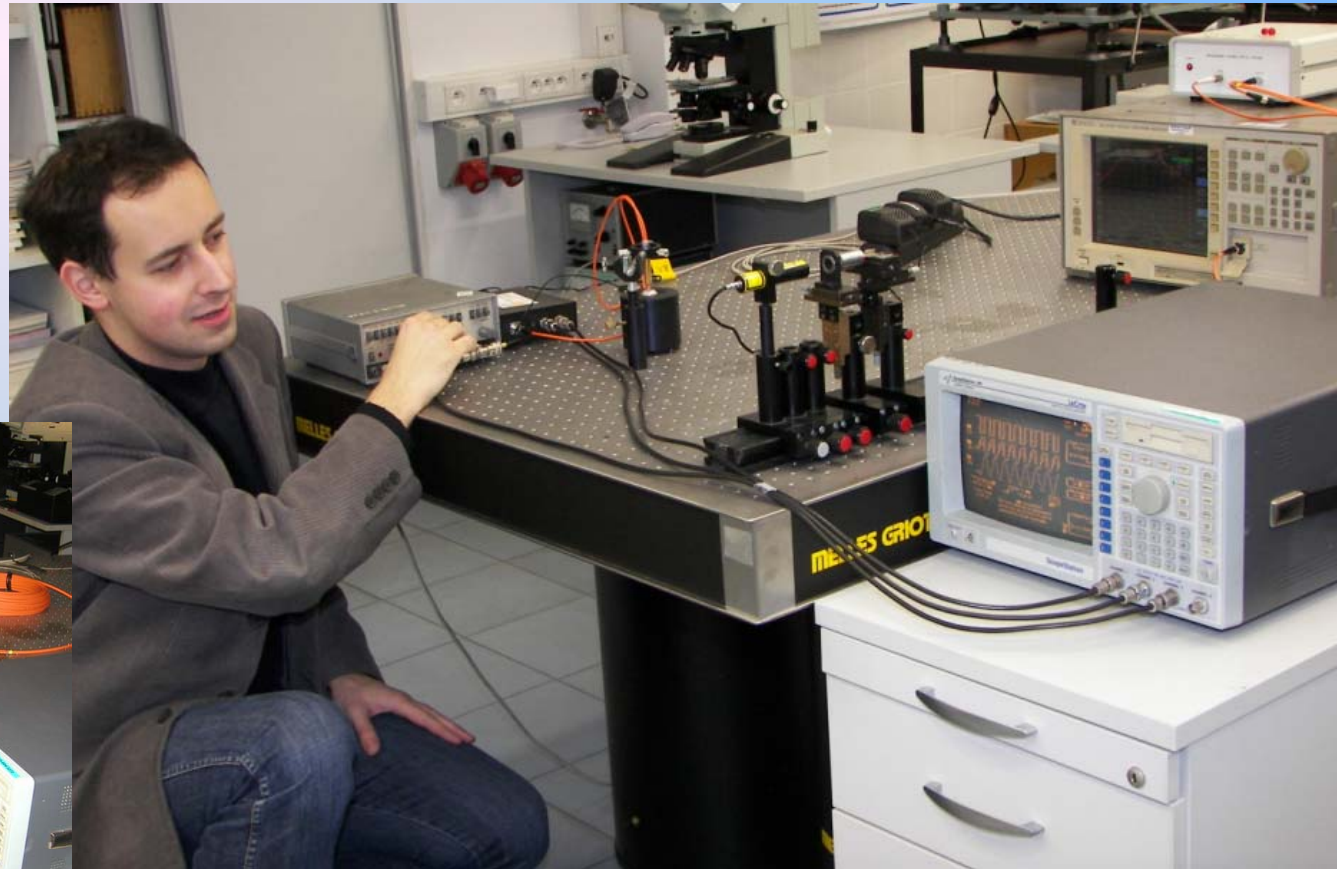
(\*) [http://fibers.org/articles/news/6/3/27/1/fspho2\\_4-04](http://fibers.org/articles/news/6/3/27/1/fspho2_4-04)

# Polarization properties of PCFs





# Fiber optic sensors

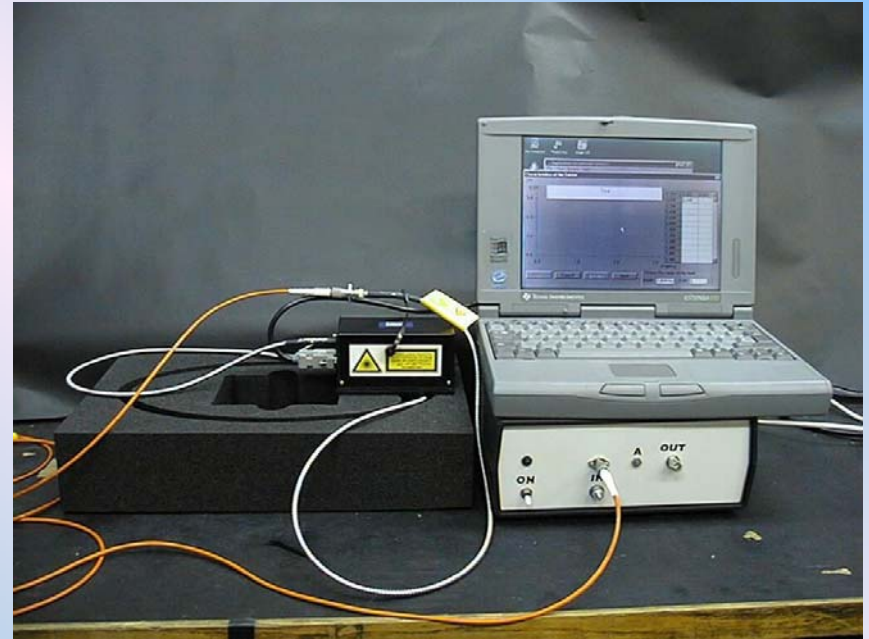




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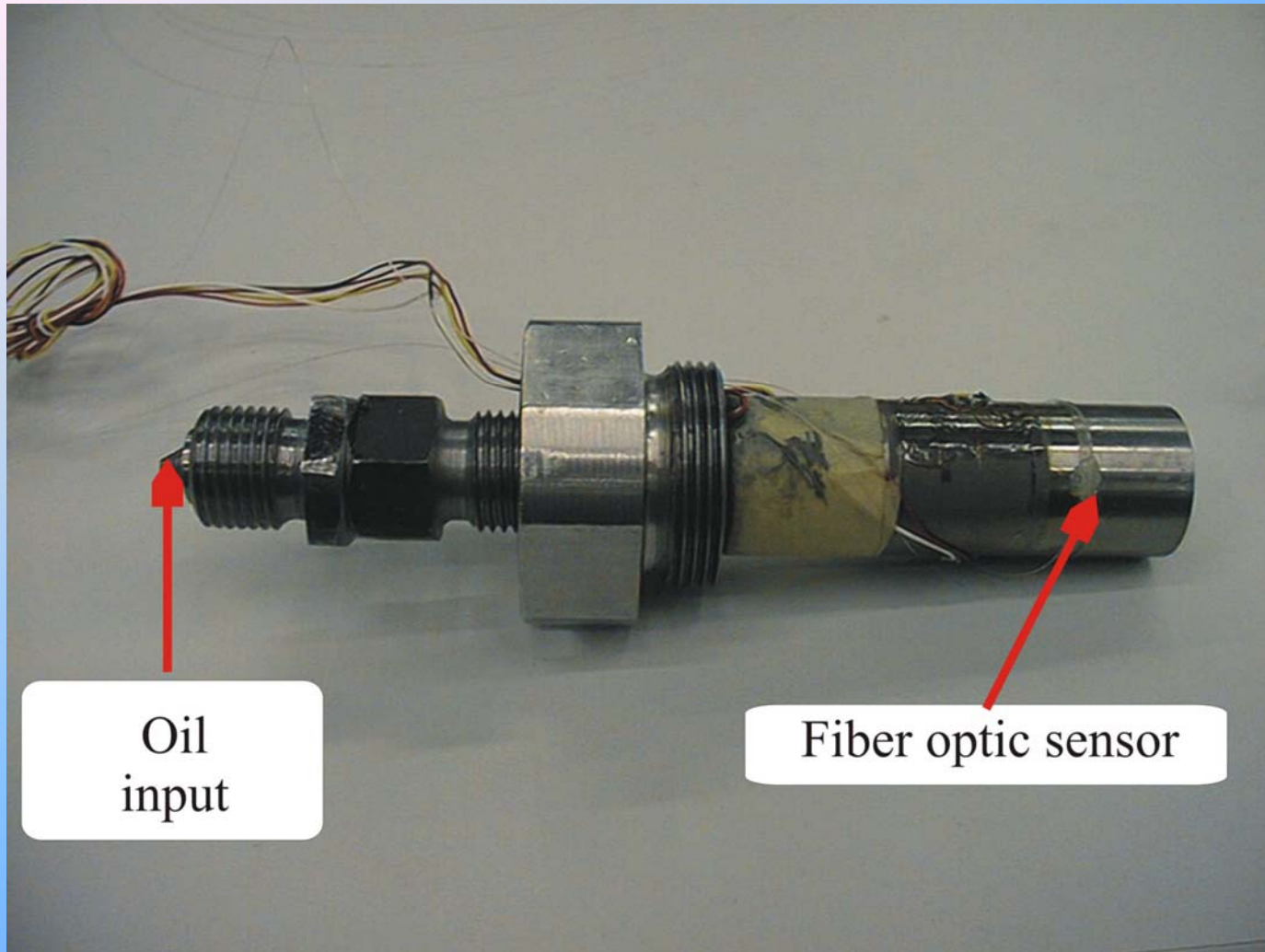
# Prototype modular fiber-optic sensor

## PKN ORLEN





# Fiber-optic strain gauge

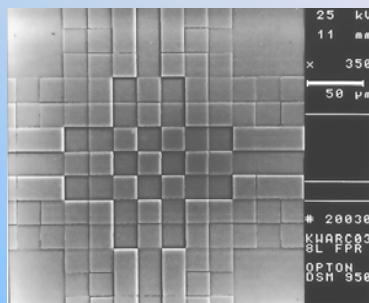


HB fiber wounded around the pressure transducer

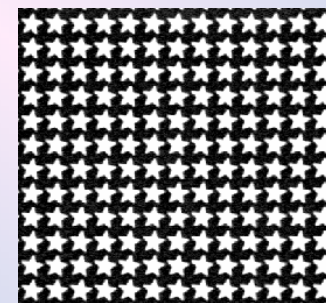
## OPTICAL PROCESSING RESEARCH GROUP

### Design of **Diffractive Optical Elements** and **Computer Generated Holograms** for various applications:

- **BEAM SHAPING AND WAVE-FRONT TRANSFORMING**
- **PRECISE POSITIONING AND ALIGNMENT**
- **OPTICAL INTERCONNECTORS (e.g. DIFFRACTIVE BEAM SPLITTERS, DAMMAN GRATINGS, TALBOT ARRAY ILLUMINATORS)**
- **LASER PROCESSING OF MATERIALS**
- **NONCONVENTIONAL IMAGING (e.g. IMAGING WITH EXTENDED DEPTH OF FOCUS, UNIFORM MULTIPLE IMAGING)**
- **DIFFRACTIVE AND HEAD-UP DISPLAYS**

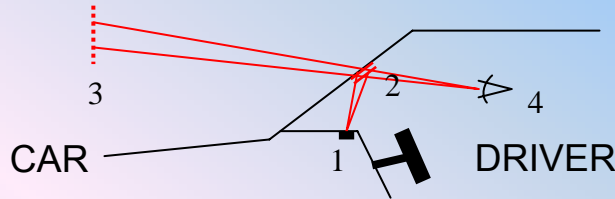


**PHASE SAMPLING FILTER - DIFFRACTIVE STRUCTURE  
DESIGNED FOR MULTIPLE IMAGING FABRICATED BY THE  
ELECTRON LITHOGRAPHY**



**MULTIPLE OUTPUT IMAGES FORMED  
BY THE FABRICATED FILTER**

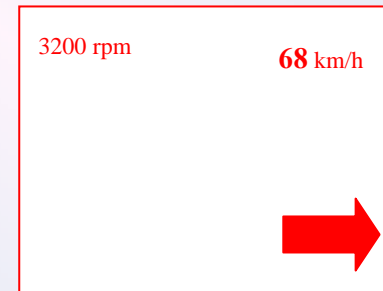
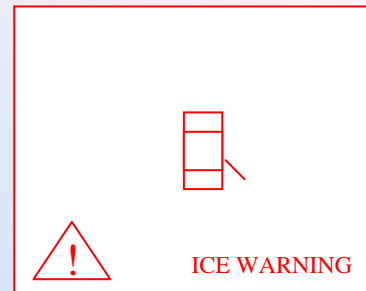
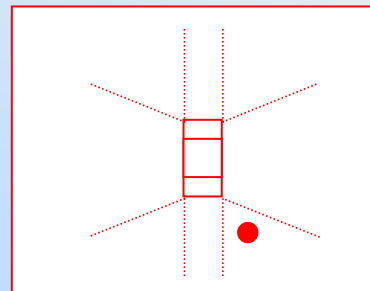
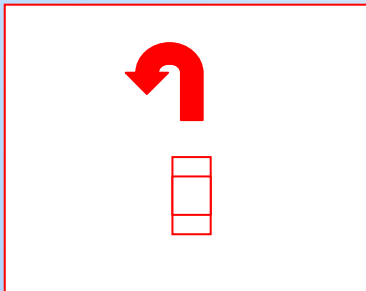
# Holographic HUD display for use in car industry



## Motivations

- Driver no longer needs to take his eyes off the road
- Information signs placed in large distance behind the windscreen – no need for accommodation of the eye
- Signs are adaptively brightened during the day and dimmed in the night
- Signs are transparent

Example signs to be displayed by HUD:





# SURVEY QUESTIONS

1. Presentation of the Research Group (RG)
2. RG main achievements in 2005-2008

## **Optoelectronics / Photonics / Applied Optics**

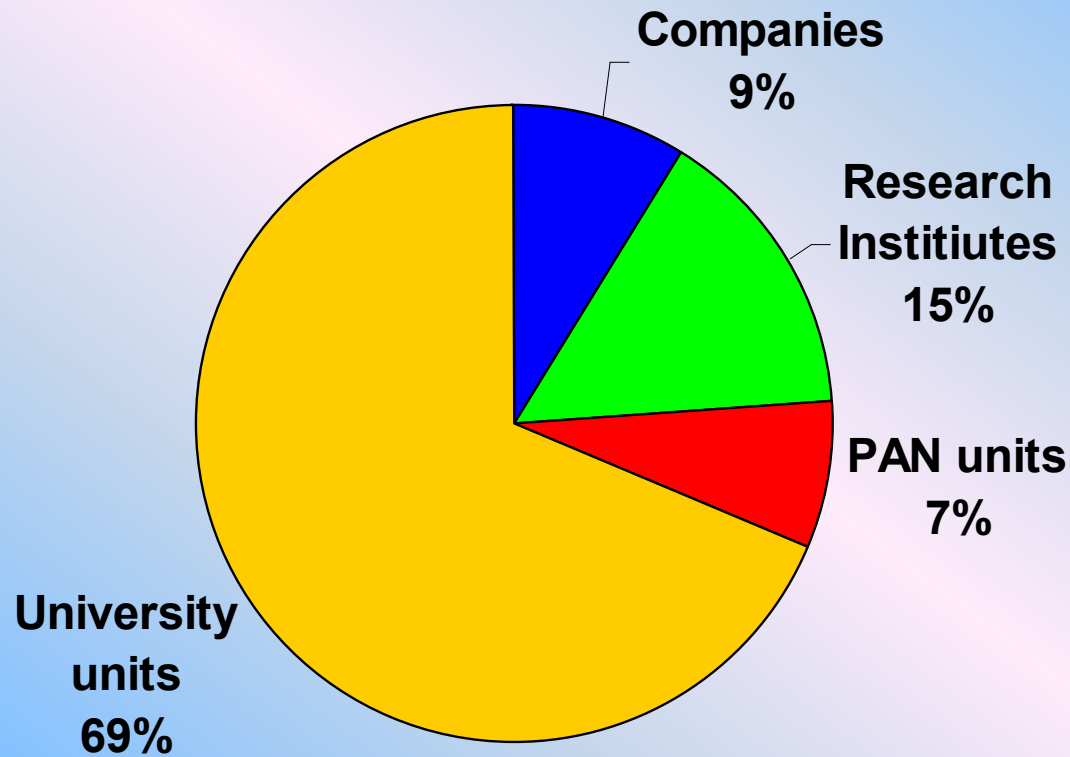
Main publications (Thompson ISI inc.)  
Implementations/studies  
Patents

3. Grants obtained and grants applications in 2005-2008

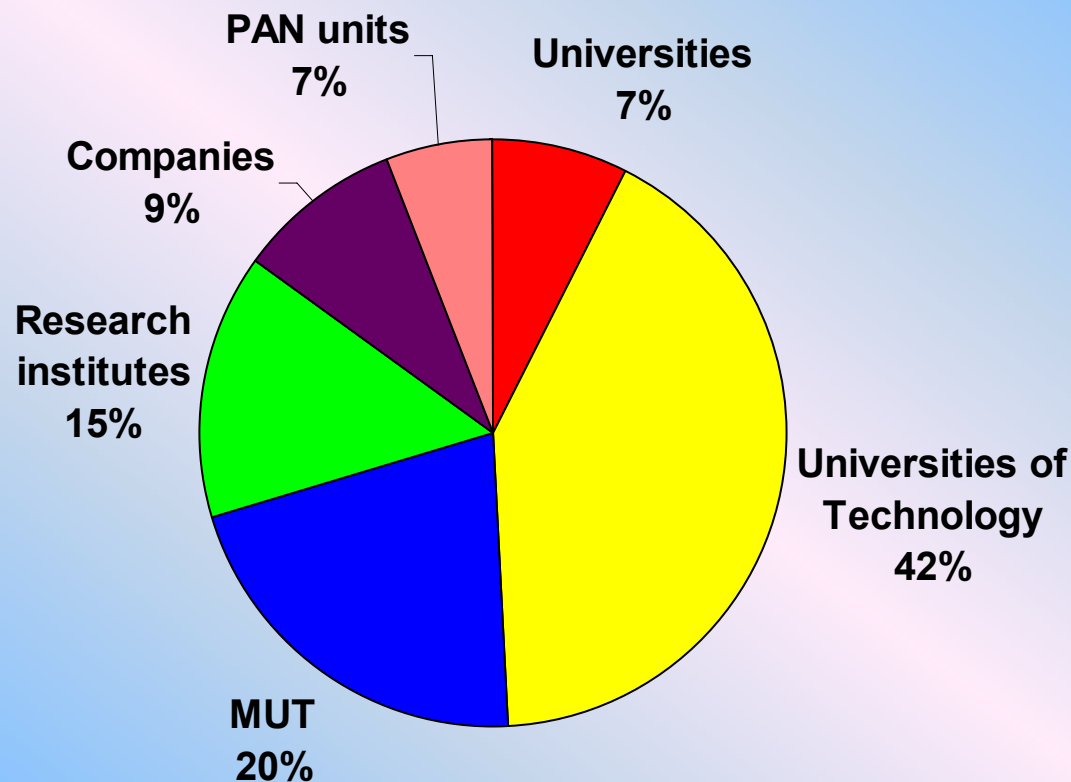
National  
European (EU)  
International

4. Scope of research that might be realized, in the years 2008-2010, by the RG, with potential applications in industry/economy - expected End-users

# Organizational Structure of Research Groups dealing with optoelectronics and photonics



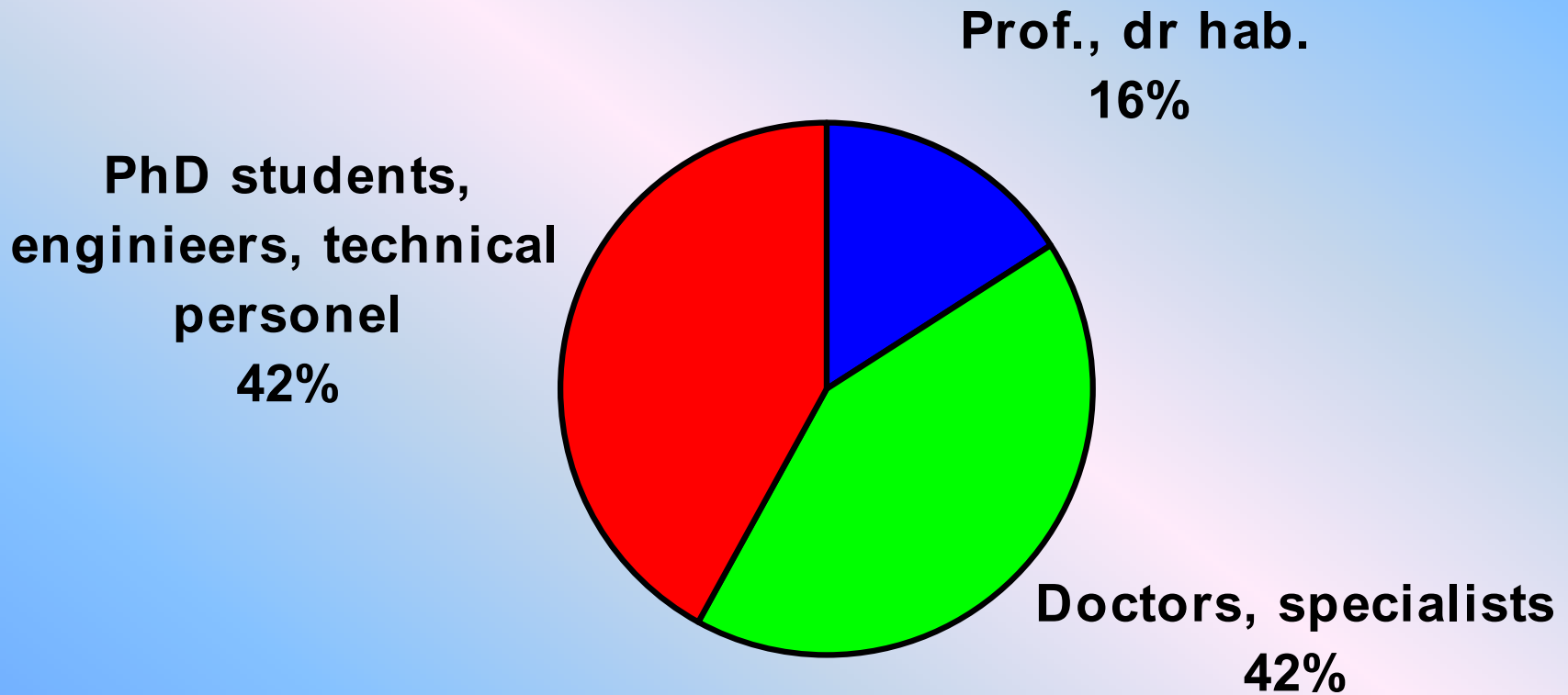
# Organizational Structure of members of RGs dealing with optoelectronics and photonics



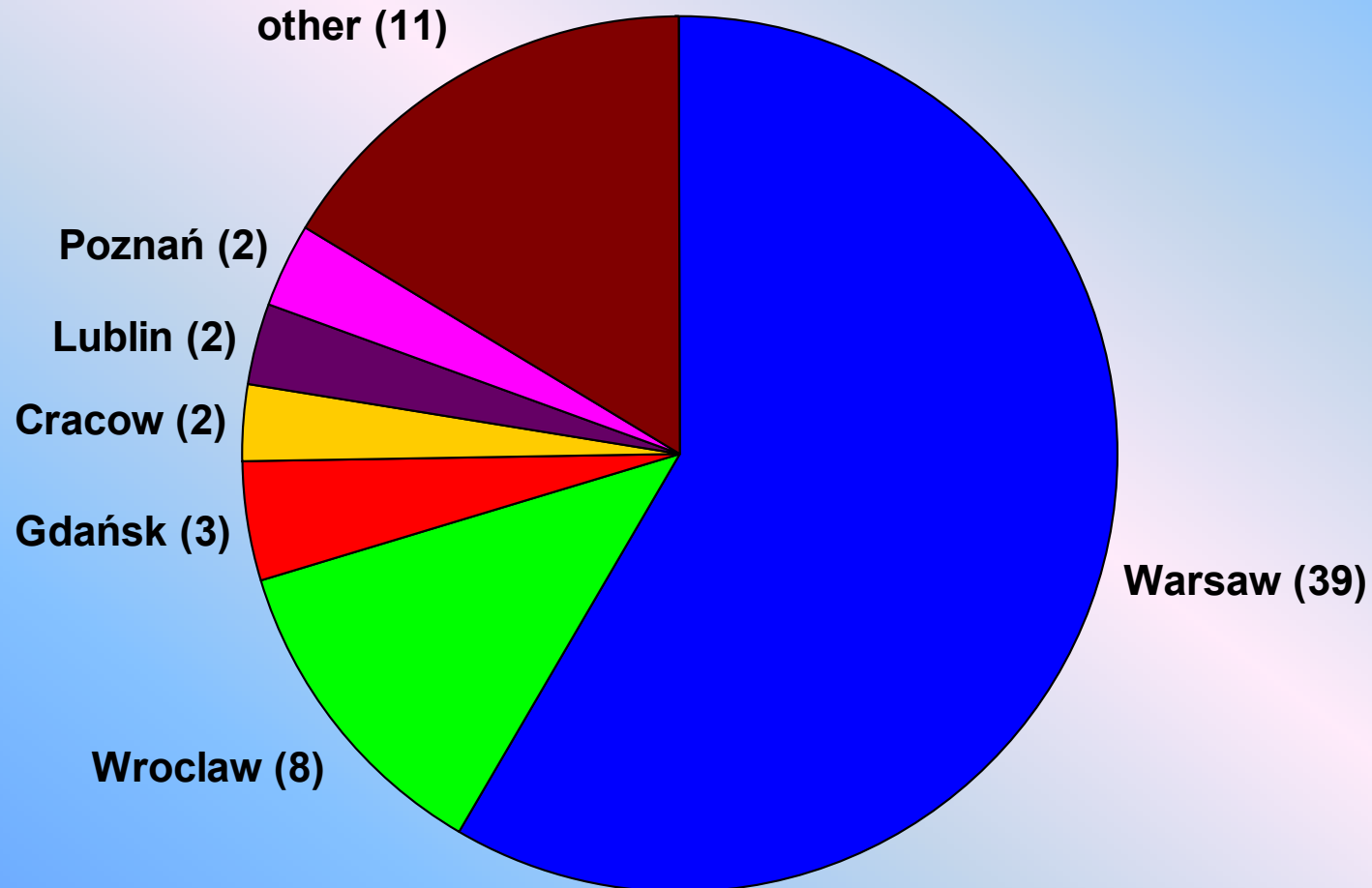
# Organizational Structure of members of RGs dealing with optoelectronics and photonics

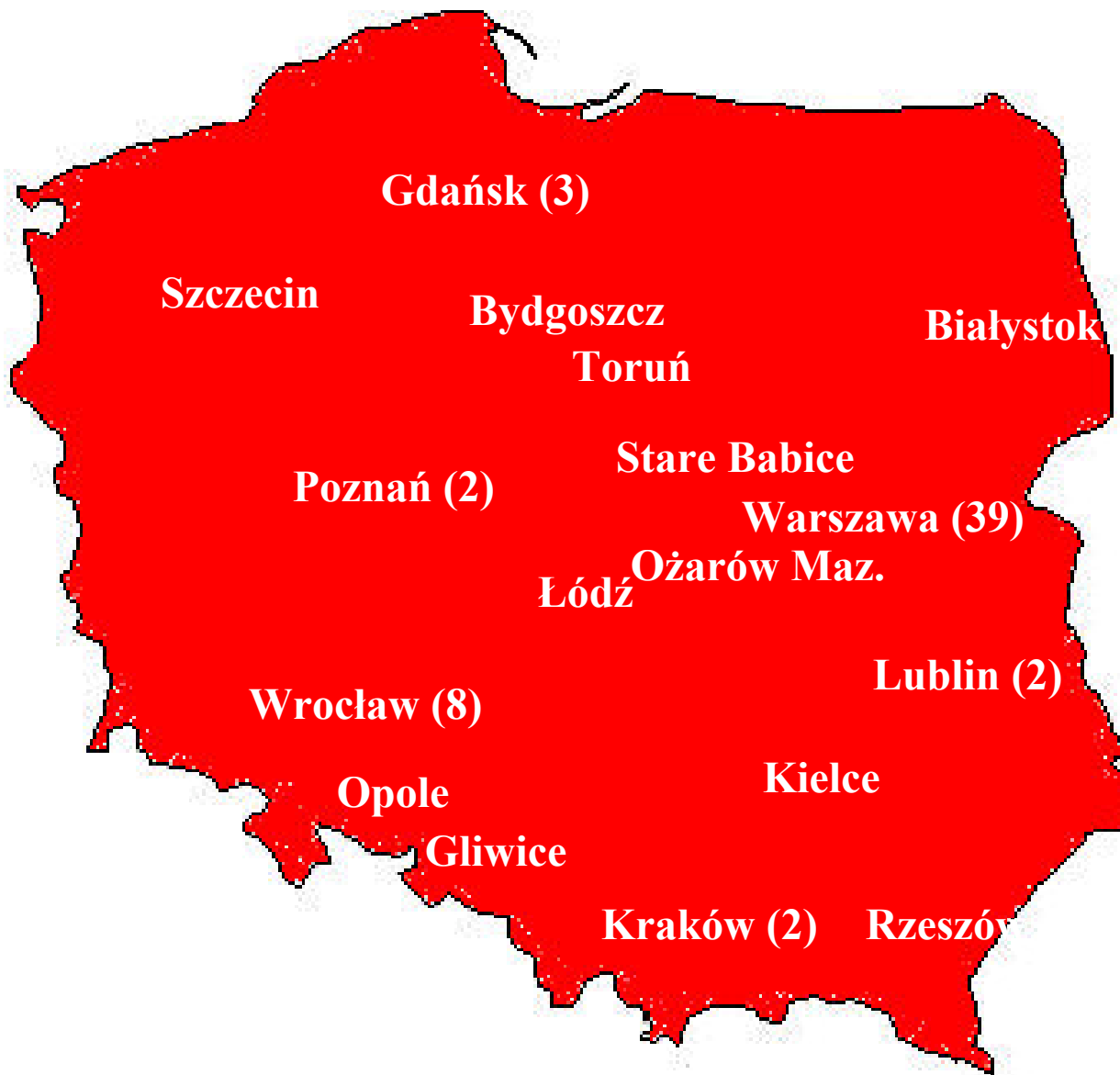
Universities	Universities of Technology	MUT	Research Institutes	Companies	PAN units
<b>5</b>	<b>28</b>	<b>14</b>	<b>10</b>	<b>6</b>	<b>4</b>
<b>UJ</b> <b>UMCS</b> <b>UMK</b> <b>UW</b> <b>UTP</b>	<b>PW (8)</b> <b>PWr (6)</b> <b>PP, PG</b> <b>PŚ, PRz,</b> <b>AGH, PŁ,</b> <b>PL, PŚ,</b> <b>PSz, PB</b>		<b>ITME</b> <b>IOS</b> <b>ITE</b> <b>ITRT</b>	<b>CTL</b> <b>VIGO</b> <b>PIRS</b> <b>Lasertex</b> <b>TopGaN</b> <b>Inframet</b>	<b>IMP PAN</b> <b>IWĆ PAN</b> <b>IBIB PAN</b> <b>INTBS</b> <b>PAN</b>

# Academical Structure of members of RGs dealing with optoelectronics and photonics



# Locations of Research Groups dealing with optoelectronics and photonics



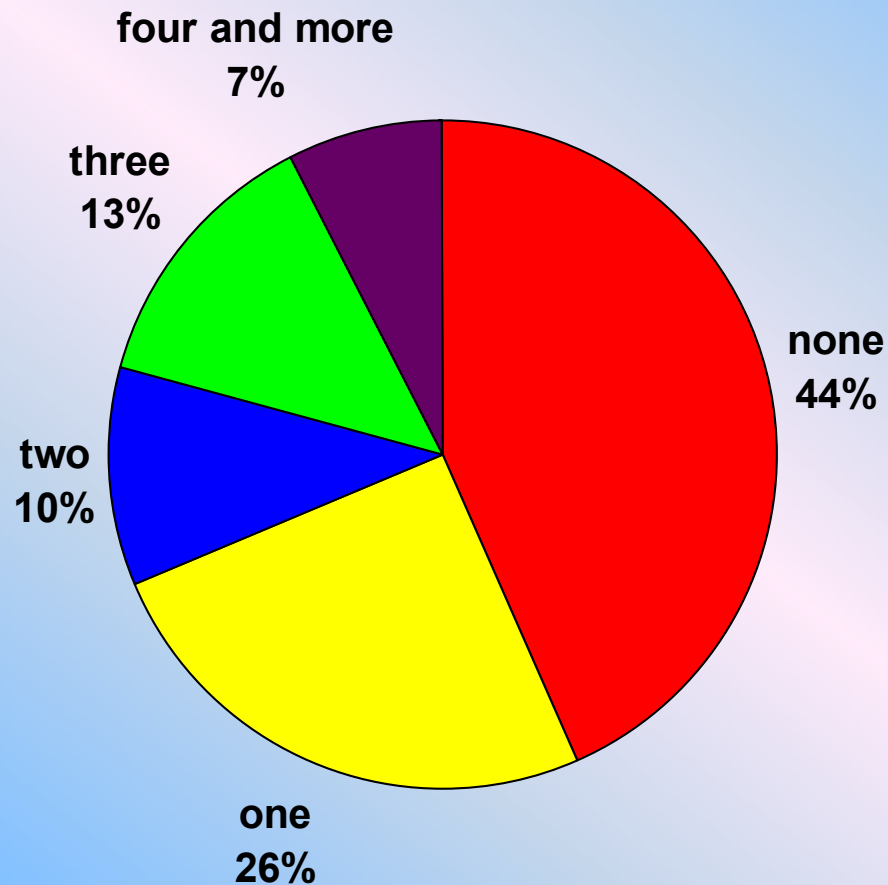




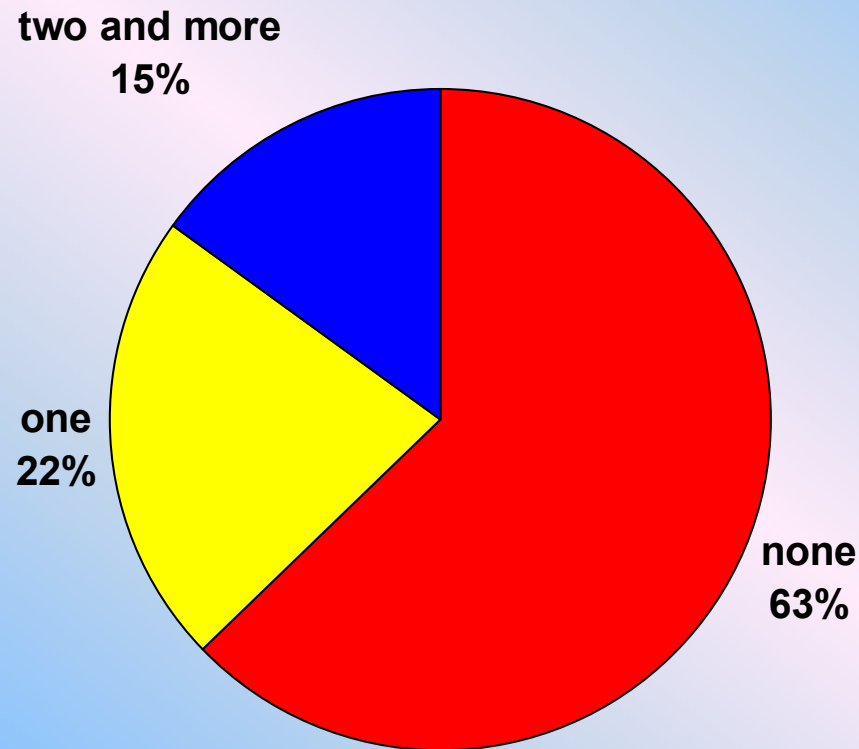
# Number of national grants in RG



# Number of European (EU) grants in RG



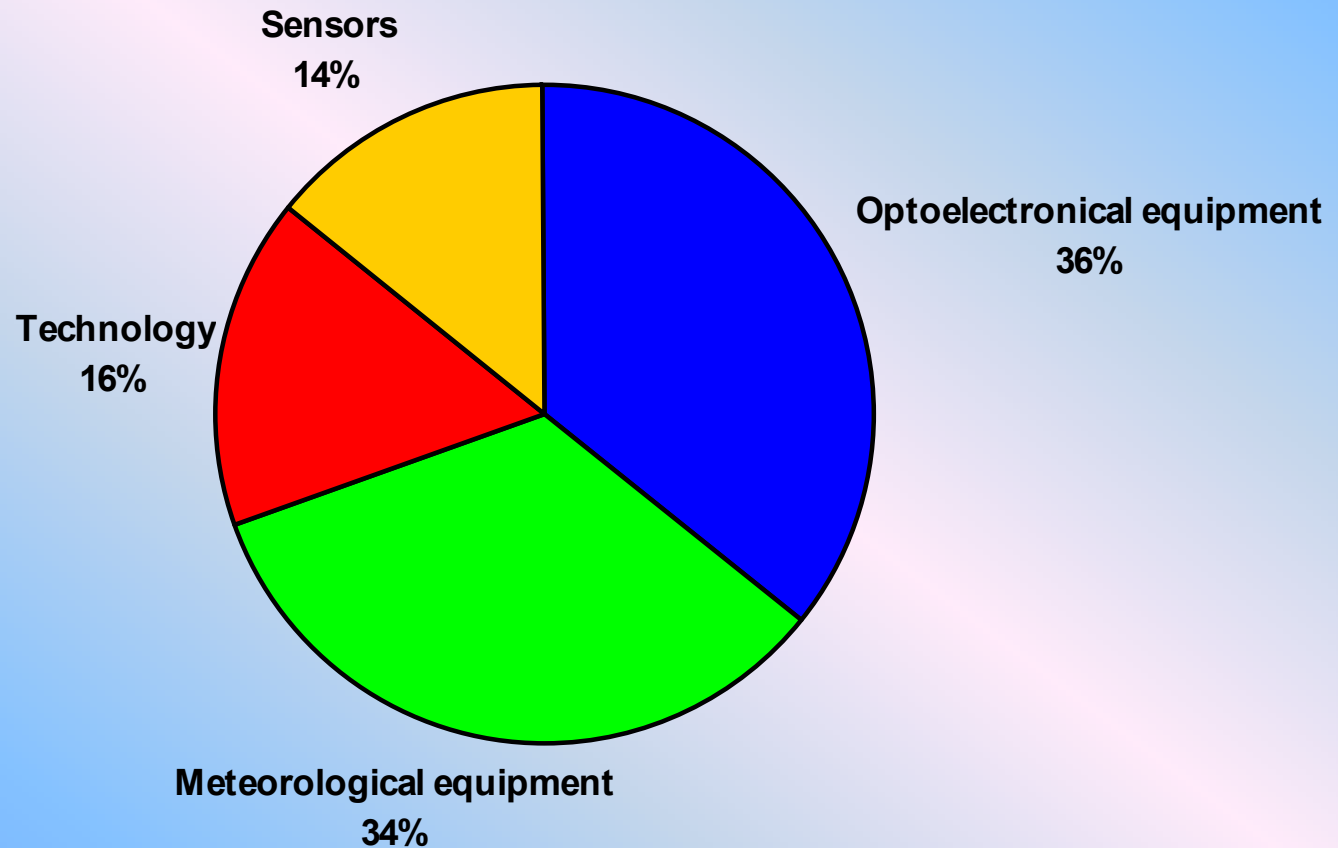
# Number of non-EU grants in RG



# Patents (P) and Implementations (I) of RGs in optoelectronics and photonics

Universities	Universities of Technology	MUT	Research Institutes	Companies	PAN units
<b>P-7</b> <b>I-5</b>	<b>P-28</b> <b>I-31</b>	<b>P-18</b> <b>I-27</b>	<b>P-8</b> <b>I-14</b>	<b>P-5</b> <b>I-19</b>	<b>P-2</b> <b>I-5</b>
<b>UMCS</b> <b>UMK</b>	<b>PW</b> <b>PWr</b>		<b>ITME</b> <b>IOS</b>	<b>CTL</b> <b>VIGO</b> <b>PIRS</b> <b>Lasertex</b> <b>TopGaN</b> <b>Inframet</b>	<b>IMP PAN</b> <b>IWC PAN</b>

# Proposed research activities of RGs with potential implementations



# CONCLUSIONS

- Scientific and technical potential of Poland allows for realization of important **NICHE** activities in **advanced technologies and constructions of OE/ME**
- Primary scope (70%) of RG:
  - **Optoelectrical Equipment (OE)**
  - **Meteorological Equipment (ME)**

- National need for modern photonics meteorological equipment justifies the need to initialize a **National Research Program (NRP)** tentatively entitled:

***Photonic and Optoelectronic  
equipment for modern  
medecine, environmental  
protection and innovational  
economy***

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Aleksandra Czapla  
Sławomir Ertman



# PSP Conferences 2008

- **Optical Fibers and Applications**  
Białowieża 30 Jan - 2 Feb 2008

<http://we.pb.edu.pl/~swiatlowody/>

- **Wilga**, 30 May – 1 June 2008

<http://wilga.ise.pw.edu.pl>

- **COE**, Poznan, 20-25 June 2008

<http://coe2008.et.put.poznan.pl/index.htm>

- **Polish-Czech-Slovak: Optics for New Technologies**,  
Polanica 8-12 Sept 2008

<http://pcsoc.if.pwr.wroc.pl>