Eidgenössische
Technische Hochschule
Zürich

Institute of Quantum Electronics

Nonlinear Optics Laboratory

Annual Report 1996

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*The picture illustrates the writing of ferroelectric domains on the nanometer scale with scanning force microscopy. The "IQE-NLO" logo was written into a prepolarized sqared region surroundet by naturally grown domains in $BaTiO_3$. The resulting line width of individual ferroelectric domains measures about 700 nm.**(see page 29)*

Nonlinear Optics Laboratory

Annual Report 1996

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Prof. Dr. Marko Zgonik	Institute Jozef Stefan, Ljubljana, SLO

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Dr. Daniel Fluck	Dr. Ye Tao (interimistic)

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Lotti Nötzli	50%	Ute van Aartsen	(NEFF, 10%)
Brigitte Spaenhauer	50%		

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RESEARCH SUMMARY

Research topics of the Nonlinear Optics Laboratory in 1996 were

- *Molecular Crystals and Polymers*
- *Photorefractive Effects and Applications in Optical Parallel Processing*
- *Integrated Optics and Optical Frequency Conversion*
- *Molecular Beam Epitaxy of Organic and Inorganic Thin Films*
- *Investigation of Organic Molecules at Interfaces using Nonlinear Optics and Atomic Force Microscopy*
- *Magnetic Resonance Spectroscopy.*

One of the highlights of the 1996 activities in the field of organic nonlinear optics was the development of a new type of molecular crystal based on short hydrogen bond induced self-assembly of merocyanine dye molecules, one of the molecules with the largest optical nonlinearities and which could not be crystalized in good quality before. High quality acentric crystals could be synthesized by designing a co-molecule of phenolic derivatives which leads to the formation of short and strong hydrogen bonds between the phenolic derivatives and the merocyanine molecule. Out of the 79 synthesized molecules, five different new crystals with large nonlinearities could be grown. They all crystallize in an optimized structure for 2nd and 3rd order nonlinear optics with almost perfectly aligned molecules. One of these materials can be grown in two different forms which show different optical and nonlinear optical properties but which have crystallographic structures which cannot be distinguished by x-ray diffraction. The investigation of the physical properties of this new class of organic crystals and the further optimization of the nonlinear optical properties will be one of the main topics in the near future.

Within the photorefractive team a series of breakthroughs has been achieved in 1996. We were able to extend the wavelength range of photorefractive activity in $KNbO_3$ from about 800 nm up to the telecommunication wavelength range around 1600 nm by H^+-implantation. In addition the photorefractive response in the wavelength range from 600 to 1000 nm was drastically increased by Rh-doping and suitable reduction treatment. The fundamental physics of charge transport in these materials is now much better understood so that materials for applications in the red-infrared wavelength range of laser-diodes can be tailored. For the first time "photorefractive soli-

tons" at low incident laser power have been produced and investigated theoretically and experimentally in $KNbO_3$.

In the integrated optics team a prototype of a 40 mW blue compact laser (wavelength 491 nm) with very stable intensity, based on optical frequency doubling in $KNbO_3$, has been built. A tuneable, compact, all-solid state laser source pumped by two laser diodes with cw output power of up to 65 mW and tuning range between 431 and 438 nm was also completed using sum-frequency mixing in $KNbO_3$.

Some new activities in the field of ferroelectric domain switching by a scanning force microscope allows a new type of information storage. We demonstrated, for the first time to our knowledge, that ferroelectric domains with lateral dimensions of less than 700 nm can be switched in the opposite direction and can be used for writing a text as a switched polarization pattern. In addition a new method, SMM (Scanning Maxwell Stress Microscopy), has been developed which allows the measurement and mapping of the electric field distribution on a nanometer scale in both lateral directions as well as in the direction normal to a ferroelectric surface. This new method will now be applied to the investigation of the dynamics of domain switching in ferroelectrics with molecular resolution.

In 1996 Dr. F. Gitmans, Dr. Th. Marty and Dr. R. Schlesser have left our laboratory after completing their PhD thesis and Dr. Th. Dietrich, and Dr. I. Poberaj finished their post-doctoral work and started their new professional activities in industry and in the home University respectively. We thank all these colleagues for their successful work and pleasant cooperation. During 1996 we could welcome Dr. Ch. Cai as a new post-doctoral fellow and M. Bösch and P.Cereghetti as new PhD students.

Prof. P. Günter completed his sabbatical with interesting and motivating stays in the USA, in Japan and France. In January / February he was a "Distinguished Visiting Lecturer" at the Center for Research in Electro-Optics and Lasers (CREOL) of the University of Central Florida in Orlando. In March / April he stayed as a visiting professor at the "Institute for Physical and Chemical Research" (RIKEN, Japan) where he interacted with colleagues active in organic nonlinear optics, in organic photorefractive materials and nanotechnology. Finally in May/June he completed his sabbatical as a visiting professor at the "Institute d'Optique Théorique et Expérimentale" of the "Université Paris-Sud", Orsay (F).

Activities of members of the Nonlinear Optics Laboratory in Conference Committees and Editorial Boards

During and after the sabbatical Prof. Günter continued to be active in a series of international committees and as editorial board member of scientific journals in the fields of optics, nonlinear optics, quantum electronics, solid state physics of ferroelectric, organic and polymeric materials. He is a member of the editorial board of the following scientific journals:

- *"Ferroelectrics"*
- *"Ferroelectrics Letters"*
- *"IEEE Journal of Quantum Electronics"*
- *"Nonlinear Optics"*
- *"Optica"*
- *"Optics Communication" (starting 1997)*
- *"Photonics Science News"*
- *"Pure and Applied Optics": Journal of the European Optical Soc. A*

and was/is a member of the advisory or program committees of the following international conferences:

- *"Conference on Lasers and Electro-Optics" (CLEO Europe '96)*
- *"Congress of the International Commission for Optics" (ICO '96)*
- *"Electrical and Related Properties of Organic Solids" (ERPOS-7)*
- *"European Conference on Applications of Polar Dielectrics" (ECAPD) (Chairman of the European Steering Committee)*
- *IEEE Ferroelectrics Committee of the "Ultrasonics, Ferroelectrics and Frequency Control Society"*
- *"International Conference on Organic Nonlinear Optical Materials" (ICONO-3)*
- *"International Symposium on Lasers and Nonlinear Optical Materials" (IS-LNOM '97)*
- *"Materials for Nonlinear Optics"*
  (European Optical Society Topical Meeting 1997)
- *"Nonlinear Frequency Conversion: Materials, Devices and Applications" (SPIE 1996 Symposium)*
- *"Organic Thin Films for Photonic Applications"*
  (1997 Topical Joint Meeting of the Optical Society of America and the Chemical Society of America)

- *OSA Topical Meeting on "Photorefractive Effects and Applications"*
- *World Ceramics Congress on "Electronic, Magnetic and Optical Ceramics".*
  (CIMTEC'98: 9th International Conference on Modern Materials and Technologies).

Prof. R. Kind is the Secretary General of the Groupement AMPERE

Prof. M. Zgonik was serving as the Chairman of the 1996

- *"European Conference on Applications of Polar Dielectrics" (ECAPD-3, Bled)*

while he was still partly engaged at the Nonlinear Optics Laboratory.