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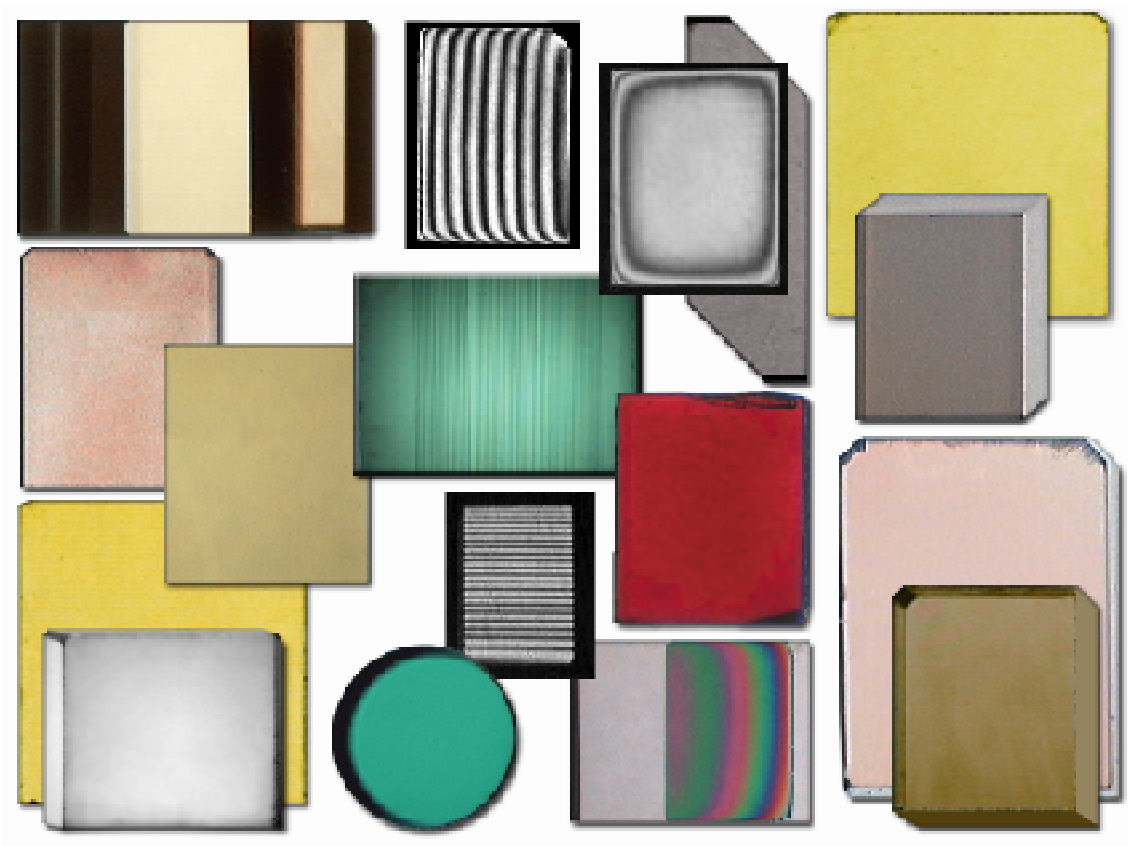
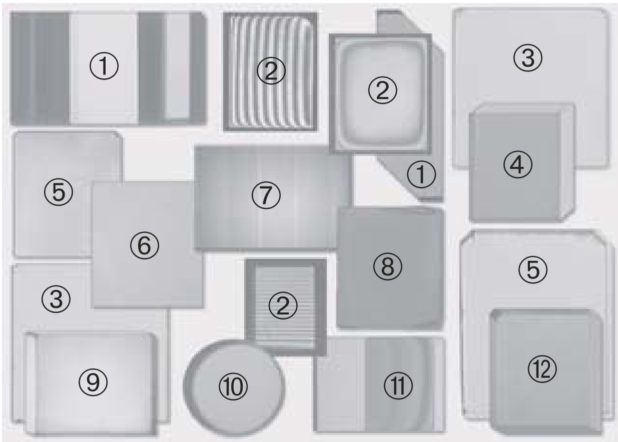
Institute of Quantum Electronics

Nonlinear Optics Laboratory

Annual Report 2003



February 2004



Front page:

Nonlinear optical crystals prepared at the Nonlinear Optics Laboratory.

① $KNbO_3$ crystal for wavelength conversion in an optical parametric oscillator
② interferograms for the determination of optical quality
③-⑥ Fe, Mn and Rh doped $KNbO_3$ crystals
⑦ $KNbO_3$ rib waveguides
⑧ DAST crystal (see page 9)
⑨ Pure $KNbO_3$
⑩ LiSAF laser crystal (see page 29)
⑪ $KNbO_3$ thin film crystal with 15µm thickness
⑫ Ni doped $KNbO_3$

Nonlinear Optics Laboratory

Annual Report 2003

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Prof. Dr. Igor Poberaj	*Institute Jozef Stefan, Ljubljana, SI*
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Dr. Carolina Medrano
PD Dr. Germano Montemezzani
Paolo Losio
Prof. Dr. Marko Zgonik *until July*

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Tobias Bach *since April*
Dr. Ashutosh Choubey
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Philipp Dittrich
Andrea Guarino
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Dr. Mojca Jazbinsek *until July*
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Dr. Bozena Koziarska-Glinka
Dr. O-Pil Kwon *since September*
Dr. Pierre Lavéant
Aleksej Majkic
Lukas Mutter
Dr. Payam Rabiei *since March*
Dr. Ali Rashid
Daniele Rezzonico
Blanca Ruiz
Arno Schneider
Axelle Tapponnier
Dr. Zhou Yang *since October*

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RESEARCH SUMMARY

This report summarizes the main research activities performed within the Nonlinear Optics Laboratory in 2003. Our group was active in the following fields:

- Integrated Optics and Microresonators
- Photorefractive Optics
- Photonics Materials Technology
- Blue and UV Solid State Lasers

The research projects in these areas are described briefly in this report. One of the main newer research areas is the EU funded project on:

"Next Generation Active Integrated Optic Subsystems (NAIS)"

and related research on inorganic and organic active microresonators.

For more details I refer to the different contributions in this report and our WEB page: http://www.nlo.ethz.ch/

In 2003 our technical assistant and long time crystal growth expert Hermann Wüest has accepted an administrative position in the Physics Department and has left the Nonlinear Optics Laboratory. During this year we could welcome Dr. Rizwan Khan, Dr. O-Pil Kwon, Dr. Payam Rabiei and Dr. Zhou Yang as new postdoctoral fellows, Tobias Bach as assistant and PhD student and Steffen Reidt as laser engineer.

It is my pleasure to thank all scientific, technical and administrative group members for their active collaboration and the ETH, the Swiss National Science Foundation, the KTI and other external funding organisations for their financial support.

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

Several members of the nonlinear optics laboratory 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. Prof. P. Günter is a member of the editorial board of the following scientific journals:

- "Ferroelectrics"
- "Ferroelectrics Letters"
- "Nonlinear Optics"
- "Optics Communication"
- "Photonics Science News"

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

- "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 Optics" (ICONO-7)
- "European Conference on Lasers and Electro-optics" (CLEO/Europe 2003) (Program Committee)
- "OSA topical meeting on "Photorefractive Materials and Applications"
- "Nonlinear Optics 2004" (OSA Topical Conference) (Program Committee)
- "European Meeting on Ferroelectricity"
- "International Workshop on Photonic Materials for the New Century"
- "International Conference on Photoactive Organics and Polymers"
- "International Workshop on Organic Self-Assembly"
- "International Conference on Organic and Molecular Electronics and Photonics"

Zürich, February 2004 Prof. Peter Günter

Teaching

P. Günter
"Physics II" for electrical engineers
WS 2002/2003

P. Günter
"Physics I" for civil, environmental and geomatical engineers
WS 2003/2004

G. Montemezzani
"Holographie und optische Phasenkonjugation"
WS 2002/2003

G. Montemezzani
"Electro-optics"
SS 2003

G. Montemezzani
"Holographie und optische Phasenkonjugation"
WS 2003/2004

Ch. Bosshard (CSEM Alpnach)
"Nonlinear Optics"
WS 02/03

Ch. Bosshard (CSEM Alpnach)
"Nonlinear optical spectroscopy: fundamentals and applications"
SS 03

Ch. Bosshard (CSEM Alpnach)
"Nonlinear Optics"
WS 03/04

INTEGRATED OPTICS AND MICRORESONATORS

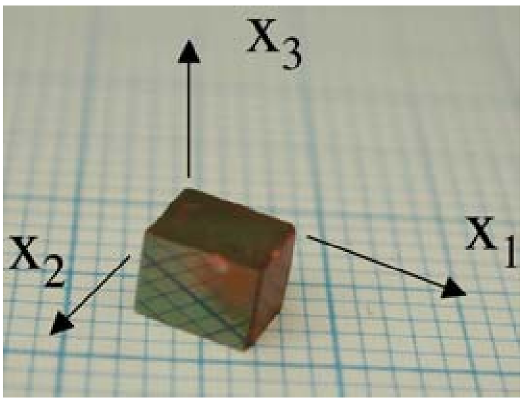
Organic Electro-optic Crystals and Thin Films

P. Lavéant, B. Ruiz, R. Gianotti and J. Hajfler

Aims: We investigate different methods to produce organic electro optic crystals. Although the major aim is to grow DAST single crystals, the design and synthesis of new materials with even larger non-linear optical properties is also pursued. The processing of the resulting crystals such as cutting, polishing and protection should also be optimized.

Approach: DAST (4-N,N-dimethylamino-4'-N'-methyl stilbazolium tosylate) crystal is very atractive for several applications and especially for integrated electro-optic modulators due to relatively high electro-optic coefficients and low dielectric constants. Bulk crystal growth is achieved within a seeded and saturated solution with precisely controlled temperature ramp. For integrated optics applications the possibility of producing a thin film of single crystalline organic material is extremely attractive. Therefore we study methods for producing thin single crystals of DAST on various substrates. Exploratory methods are applied to the new materials currently being sinthetized to produce crystals and study their properties on the bulk.

Results: 16 growth cells work in parallel to grow bulk crystals from the solution. DAST crystals with sizes of 1 to 3 cm^3 are now routinely produced. The large number of cells working in parallel allows an intensive search of the optimal growth parameters and a better understanding of the growth mechanisms of organic salts. Thin single crystals are also obtained with a typical size of 1 mm^2 for a thickness of 100 microns. The control of the nucleation and the influence of the substrate are critical issues, which are now intensively investigated. A new polishing method that allows us to obtain surface roughnesses of less than 10 nm has been developed. An adecuate protection material has been identified for our organic crystals. Additionally to DAST growth, the first JH (trans-4-dimethylamino-N-R-silbazolium hexafluorophosphate) crystals, that show similar powder SHG activity as DAST, were grown this year in collaboration with the University of Manchester.



DAST crystal polished along the dielectric axes.

Reference: P. Lavéant, C. Medrano, B. Ruiz and P. Günter,
Growth of Nonlinear Optical DAST Crystals,
Chimia 57 (6), 349-351 (2003)

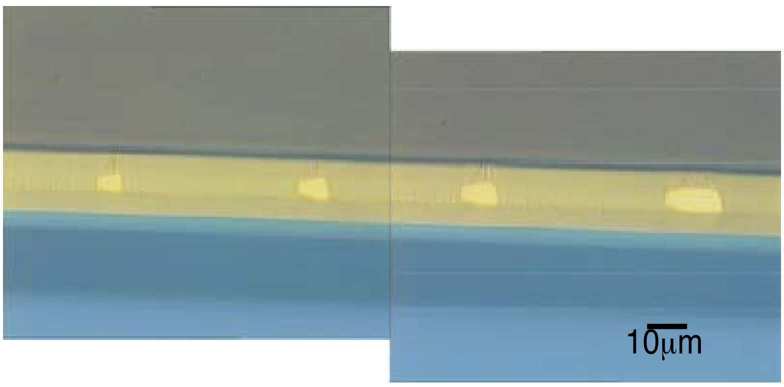
Electro Optic Polymers

D. Rezzonico, O.-P. Kwon and M. Jazbinsek

Aims: Production of waveguide structures in forms of passive microcavity resonators with materials, which would later allow upgrading to active microresonators. The device based on such microresonators should work in the telecommunication wavelength range from 1500 to 1600 nm.

Approach: Organic molecules and polymers combine the nonlinear optical properties of conjugated π-electron systems with the possibility of additional molecular engineering, i.e. creating new materials with appropriate optical, structural, and mechanical properties.
We aim to apply existing as well as new polymers to electro-optic modulators. The relatively simple methods of producing polymer waveguides are very attractive for producing advanced microcavity resonators. The most demanding skill is to obtain a high aspect ratio of the produced channel waveguides. We are developing and synthesing electro-optic materials in collaboration with synthetic chemists within and outside of our research group.

Results: After the demonstration of the filtering features of microrings of the polymeric resin Cyclotene (TM of Dow Chemicals) our target was to search for improved patterning techniques and polymeric materials in order to get higher resonator finesses. A series of different glues and resins was tested. We identified the hybrido-polymer ORMOCER (TM of Fraunhofer Institut, Wuerzburg, Germany) among the most suitable polymers for channel waveguide's structuring. This organic modified silicate has the advantage to be patterned directly after UV exposure without agressive etching processes so that the edges of the resulted channels are of high quality. We also started the synthesis of new electro-optically active polymers. Next step is to investigate the way of combining the good structurable passive materials together with the active compounds.



Section view of four waveguides in Ormocer (Ormocore) surrounded by a low index type of the same material (Ormoclad). The structures were pruduced on oxidized silicon wafers.

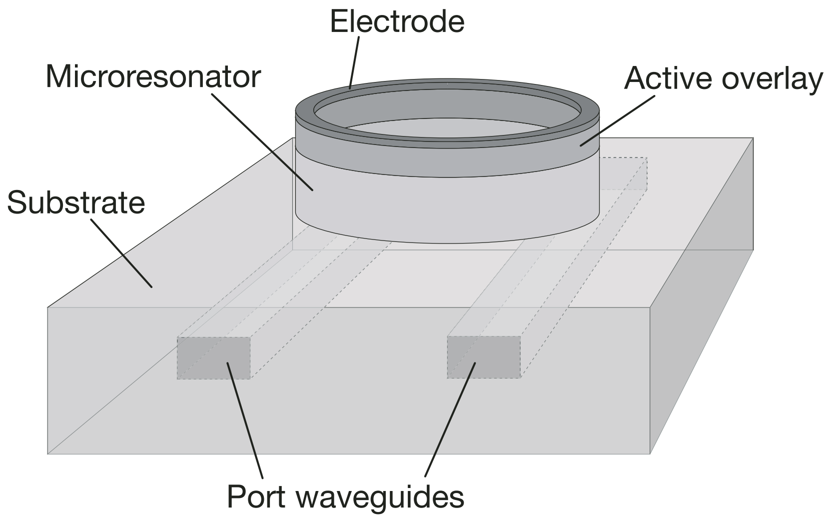
Organic Electro-optic Microcavities

B. Koziarska-Glinka, C. Herzog and M. Zgonik

Aims: Investigate the properties of new passive integrated optic structures in combination with active electro-optic materials for use in compact electro-optical elements for fiber telecommunications. Using hybrid integration of passive and active materials a working prototype of microresonator-based mux/demux and high-speed switch and modulator should be demonstrated.

Aims: Straight waveguide segments made out of Si_3N_4 form the input and output ports. By means of evanescent field coupling the waveguides interact with the TiO_2 or SOI micro resonator. The cavity causes a narrow-bandwidth, frequency dependent transfer of power between the port waveguides. Metallic electrodes are included to create an electric field in the active DAST overlay, thereby changing the resonance condition of the ring resonator.

Results: In a first attempt, DAST is applied as an electro-optic top cladding on passive straight waveguides with parallel electrodes. In order to obtain a sufficiently high effective index of composite waveguides and to exceed the index of DAST, Si_3N_4 as well as TiO_2 core layers are studied.
Using numerical calculations the critical design parameters and material properties for efficient coupling and low loss mode propagation have been identified.
In a preliminary experiment the first modulation measurements have been performed in a straight waveguide and an external interferometer.



A scheme of an electro optic active microring resonator vertically coupled to two straight optical waveguides.

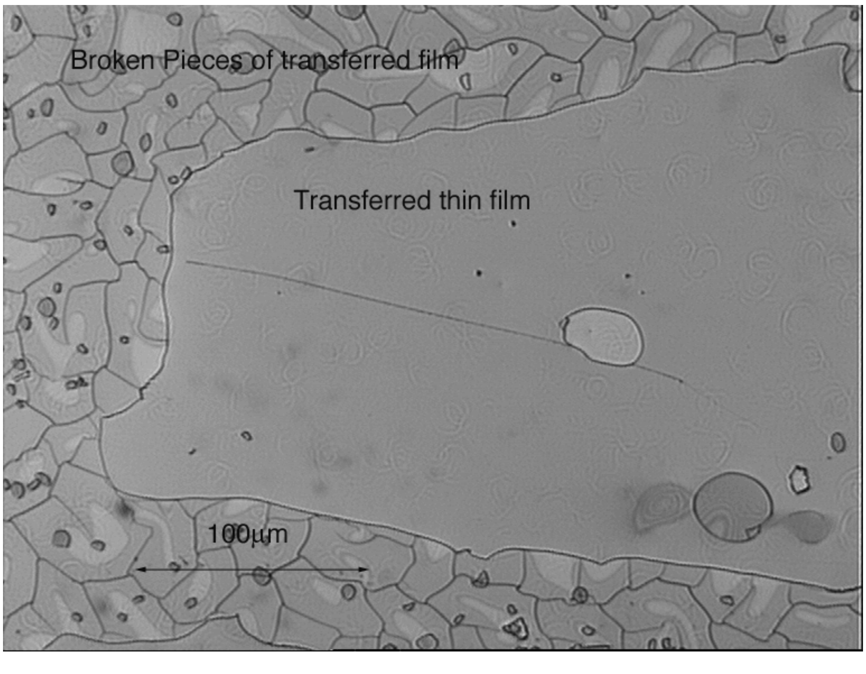
Thin Films of $LiNbO_3$ for Integrated Optics Applications Prepared by Smart Cut Method

P. Rabiei

Aims: Fabrication of thin films of $LiNbO_3$ using smart cut method. Thin films of $LiNbO_3$ with bulk quality are required for the integrated optical devices. In this project the fabrication using smart cut method is investigated. Thin films with sub micro-meter thickness are produced on low refractive index cladding layer.

Approach: A $LiNbO_3$ crystal is ion implanted using ionized He+ atoms. A layer of SiO_2 is deposited on another $LiNbO_3$ sample using plasma enhanced chemical vapor deposition system. This layer will behave as a buffer layer or a cladding for the optical waveguide, which will be fabricated. A thin film polishing technique is developed to smoothen the surface of the deposited SiO_2 layer. The ion implanted sample and the sample with cladding layer are bonded together using standard wafer bonding techniques. The samples are brought into contact inside de-ionized water and are pressed against each other to form a bond between them. The samples will attach to each other after this process. Next the bonded samples are heat treated to increase the bonding strength. By increasing the temperature further to 600ºC, a thin layer of crystal is split and transferred to another substrate. Hence one will obtain a thin layer of the nonlinear crystal using this method.

Results: The figure shows the picture of thin film of $LiNbO_3$ crystal, which has been made using the described technique. Since the thin film is directly fabricated from a bulk nonlinear crystal it has the optical properties of a bulk crystal. Hence the optical losses are very small and the electro-optic coefficient is very high.



Microscopic image of a fabricated $LiNbO_3$ thin film. The thickness of the film is 0.7 µm. Part of the film is broken to problems during bonding.

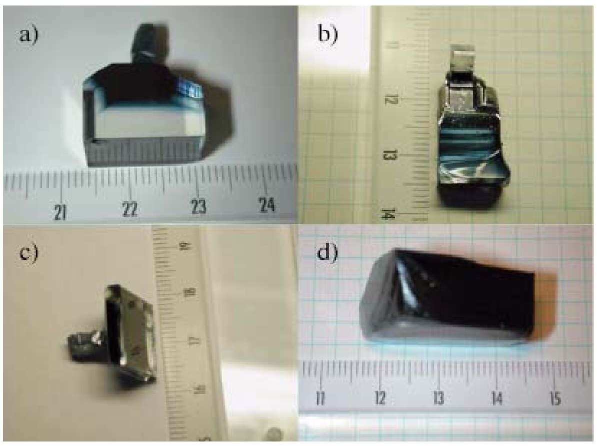
Highly Integrated Electro-optical Devices Based on $K_{1-y}Na_yTa_{1-x}Nb_xO_3$ and $KNbO_3$ crystals

S. Aravazhi and A. Guarino

Aims: Preparation of waveguiding thin films for integrated optics and exploit the outstanding pyroelectric, electro-optic and nonlinear optic properties of the solid solution system $K_{1-y}Na_yTa_{1-x}Nb_xO_3$ (KNTN).

Approach: Growth of KNTN thin films on (100) oriented $KTaO_3$ substrates by liquid phase epitaxy. In order to increase the conductivity of the substrates, $KTaO_3$ doped with Ba is grown by the top seeded solution growth method. The substrate obtained in this way can be used as a bottom electrode in pyroelectric and electro-optic applications requiring an out of plane electric field direction.
By varying the ratio of K/Na atoms in the KNTN films the lattice matching of the film - in the cubic phase - with the substrate can be adjusted to better than 0.03%. Poling of the film is possible over small areas in the in-plane or out-of-plane direction. Properties of films with the thickness of 1-10μm are studied with respect to their optical and nonlinear optic properties.

Results: Increased crystal yield (weight up to 20 g) and better barium homogeneity was achieved in the growth of $KTaO_3$. It was found that while using a (110) oriented seed the crystal yield was much higher than using a (100) oriented seed (Fig. d); also the crystal had a wide (100) plane – a favourable one for substrate fabrication. The homogeneity of Ba doping was also improved in crystals grown from (110) seeds, which is essential for successful poling of thin films. Cubic and tetragonal KNTN thin films (1-10 μm) were grown on (100) oriented $KTaO_3$ doped with 500 ppm Ba substrates. The composition of the films was measured by Rutherford Back Scattering (RBS), revealing that the film composition was as expected with the aim of the experiment. It was found that the growth rate was maximum at 930°C giving rise to monocrystalline thin films layers. Temperature dependent dielectric permittivity studies revealed a wide peak for multilayer $K_{1-y}N_yT_{1-x}N_x$ ($x_{layer1} = 0.34$, $x_{layer2} = 0.45$, y= 0.12) thin films.



Bulk $KTaO_3$ crystals doped with barium grown from a) (100) seed, b) (110) seed, c) (100) seed, d) (110) seed.

Reference: T. Pliska, D. Fluck, P. Günter, L. Beckers, C. Buchal, *Mode propagation losses in He+ ion-implanted $KNbO_3$ waveguides*,
J. Opt. Soc. Am. B. 15, 628 (1998)

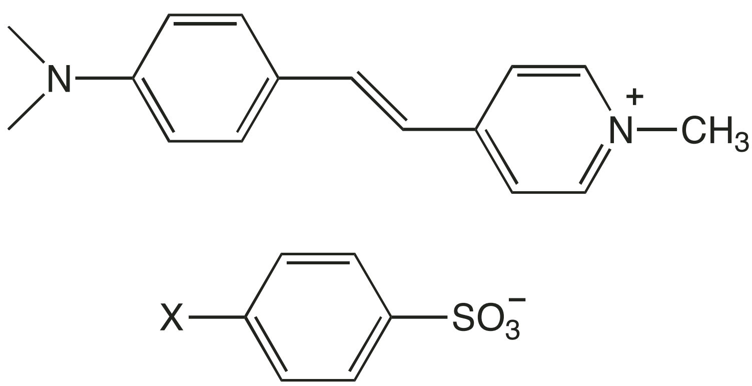
Characterization of Nonlinear Optical Materials

L. Mutter, Z. Yang, O.-P. Kwon and M. Jazbinsek

Aims: For electronic and photonic applications organic molecules with extended conjugation of the π-orbitals and donor-acceptor end groups are of particular interest. We look for new materials and characterize them with respect to their electrical, linear optical and nonlinear optical properties. We are also interested in their temperature stability and optical damage resistance.

Approach: Investigation of new molecules with electric field induced second harmonic generation (EFISH) and hyper-Rayleigh scattering. Wavelength dependent transmission/reflection measurements, Michelson interferometric measurements and Maker fringe second harmonic generation are used to determine the linear optical properties, transparency range and second-order nonlinear optic properties of new materials. Electro-optic measurements are used to characterize new materials for applications in high frequency modulators, detectors and sources of THz electromagnetic waves. Pulsed degenerate four wave mixing and third harmonic generation are used to characterize third order nonlinear optical susceptibilities of new materials.

Results: Encouraged by the excellent nonlinear optical properties of DAST, new organic nonlinear crystals based on strong Coulomb interaction to induce highly noncentrosymmetric and stable packing are being developed. Second harmonic generation (SHG) was studied in a series of new crystal powders as a preliminary test of their bulk NLO activities. The results show that some of them have pronounced SHG activities similar to that of DAST. Single crystal X-ray crystallographic studies are in progress to get details about their crystal structures.



X

1: H
2: OH
3: OCH_3
4: NH_2
5: $N(CH_3)_2$

Molecular units of the studied ionic crystals with the positively charged nonlinear optical chromophore stilbazolium.

Reference: L. Mutter, M. Jazbinsek, M. Zgonik, U. Meier, Ch. Bosshard and P. Günter, *Photobleaching and optical properties of DAST*, J. Appl. Phys. **94**, 1356 (2003)

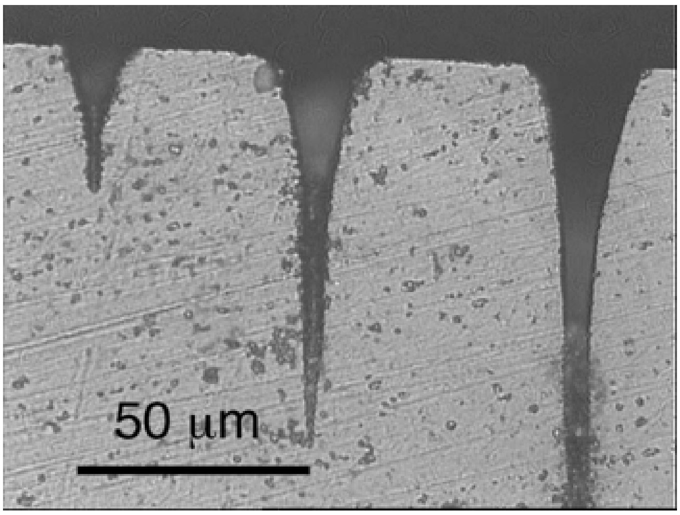
Femtosecond Laser Structuring of DAST

A. Guarino, L. Mutter and Ph. Dittrich

Aims: We investigate the method of femtosecond laser ablation regarding its applicability for the structuring of electro-optical crystals. After promising preliminary results on the fabrication of waveguides on the surface of 4-N, N-dimethylamino-4'-N'-methyl-stilbazolium tosylate (DAST), we pursue the improvement of the quality of the ablated structures and the decrease of their size to achieve a resolution suitable for integrated optics applications. Beside DAST also structuring of inorganic materials like $KNbO_3$ are of primary interest.

Approach: Femtosecond (fs) laser ablation has indeed many advantages with respect to damage free material processing. By focusing femtosecond pulses on the surface of a material, it can be ablated and structured very effectively without destroying neighboring or underlying regions due to the short interaction time in which essentially no energy can be transferred to the crystal lattice. This is especially interesting in the case of waveguide fabrication using nonlinear optical materials, where the crystalline structure inside the waveguide should be maintained.

Results: Since fs laser ablation is a novel technique, little knowledge is available on the influence of several parameters like laser beam fluence, repetition rate, wavelength and beam quality for different materials. We investigate for example the role of linear and nonlinear absorption on the threshold parameters by changing the laser wavelength and the effect of spatial filtering of the beam. The ablated surfaces can be directly observed on-site during the process, and are later examined by optical microscopy. Using shorter wavelengths it is possible to achieve more satisfactory results. Fs laser ablation is certainly very promising for patterning the surface of planar waveguides without destroying the crystal structure and reducing the nonlinear optical properties.



Side view of ablated structures in $KNbO_3$ achieved using 180 fs pulses at λ = 388 nm for fluences between 80 and 300 J/cm^2. In this case the fluence was far above threshold, and very deep structures were obtained.

Reference: Ph. Dittrich, R. Bartlome, G. Montemezzani and P. Günter, *Femtosecond laser ablation of DAST*, Appl. Surf. Sci. **220**, 88-95 (2003)

PHOTOREFRACTIVE OPTICS

Growth, Preparation and Characterization of Photorefractive Crystals

A. Choubey, H. Wüest, J. Hajfler, M. Jazbinsek and D. Haertle

Aims: This project is aimed at the investigation and characterization of several inorganic photorefractive materials ($KNbO_3$, $Sn_2P_2S_6$, $LiTaO_3$) and the assessment of their performance in view of different applications involving ultraviolet, visible or near infrared light.

Approach: Crystals of $KNbO_3$ are grown in our laboratory by the top seeded solution growth method. This year we have concentrated on the growth of pure and Rh doped crystals with seed direction $[010]_c$ (or b direction) rather than the conventional seeds of $[101]_c$ direction. Other materials under investigation are stoichiometric $LiTaO_3$ crystals grown at the National Institute for Materials Science in Tsukuba, Japan (Dr. K. Kitamura) by a double crucible method, as well as $Sn_2P_2S_6$ crystals and derivatives grown at the University of Uzhgorod, Ukraine in the group of Prof. Y. Vysochanskii and Dr. A. A. Grabar. A furnace with two separate heating zones for the growth of this crystal by the chemical vapour transport method was also constructed at ETH. The crystal quality and performance of all materials are characterized by various physical, optical and photorefractive methods, such as absorption and photoconduction spectroscopy and photorefractive wave mixing.

Results: The effect of pull rate on the crystal morphology of $KNbO_3$ crystals grown using $[010]_c$ seeds was considered in detail and an optimized pull rate of 0.3-0.4 mm/h was determined. The figure shows a typical $KNbO_3$ crystal (weight = 96 g) grown under such kind of conditions. Most photorefractive investigations this year were performed using $Sn_2P_2S_6$ crystals doped with Te that were found to exhibit large sensitivity in the near IR. Their response is even slightly faster than the one of modified brown $Sn_2P_2S_6$ investigated last year, with the additional advantage of a better sample reproducibility. Other dopings of this crystal are also under investigation.

Undoped $KNbO_3$ crystal grown from $[010]_c$-oriented seed.

Reference: M. Jazbinsek, G. Montemezzani, P. Günter, A. A. Grabar, I. M. Stoika, Yu. M. Vysochanskii, J. Opt. Soc. Am. B **20**, 1241-1246 (2003).

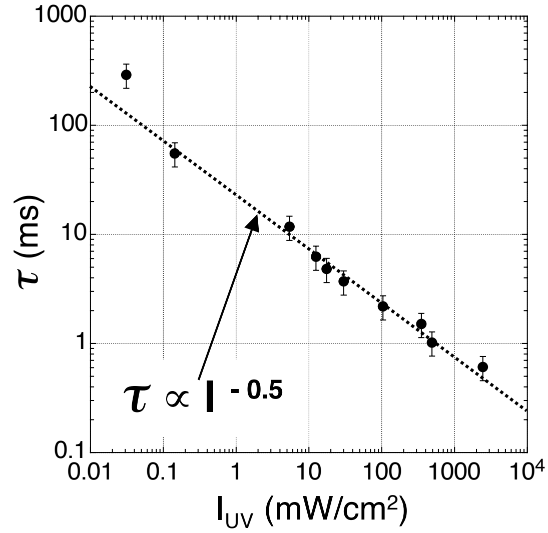
Deep Ultraviolet Interband Photorefraction and Dynamic Waveguides in Lithium Tantalate

Ph. Dittrich, B. Koziarska-Glinka and G. Montemezzani

Aims: Major advantages of interband photorefraction, compared with the conventional photorefractive effect, are faster response times and a greater robustness of the induced gratings with respect to sub-bandgap illumination. The aim of this project is to investigate deep ultraviolet (UV) interband photorefraction in pure and magnesium doped near stoichiometric lithium tantalate, promising materials for short-wavelength holographic data storage and dynamic holography. One further aim is to demonstrate light induced, dynamic waveguides in $LiTaO_3$.

Approach: Near stoichiometric $LiTaO_3$ crystals have been investigated by Bragg diffraction experiments. Special attention was given to the influence of stoichiometry and doping. Using interband photorefraction and via the linear electrooptic effect, we also expect to be able to induce dynamic waveguides underneath the surface of a $LiTaO_3$ crystal by the spatial distribution of a top surface UV illumination. By modifying the surface illumination of the crystal the waveguide structures should be controllable and be reconfigurable in real time.

Results: Interband photorefraction has been, for the first time, demonstrated in near stoichiometric $LiTaO_3$ at $\lambda_{UV} = 257$ nm. Formation of two distinct grating components was directly observed in depth-resolved measurements. We showed that doping with magnesium leads to a considerable enhancement of photorefractive characteristics. For example, response times in magnesium doped samples are by a factor of about 1000 faster than those of undoped samples. For UV intensities larger than approximately 500 mW/cm^2 the response time is faster than 1 ms (see Figure). We also observed quasi-fixing of holographic gratings with UV light and nondestructive, optically switchable readout in the visible. Regarding the light induced waveguides, first experiments in near stoichiometric $LiTaO_3$ are under way.



Response time in magnesium doped $LiTaO_3$ as a function of UV intensity.

Reference: Ph. Dittrich, B. Koziarska-Glinka, G. Montemezzani, P. Günter, S. Takkekawa, K. Kitamura, and Y. Furukawa, J. Opt. Soc. Am. B, (in press, 2004).

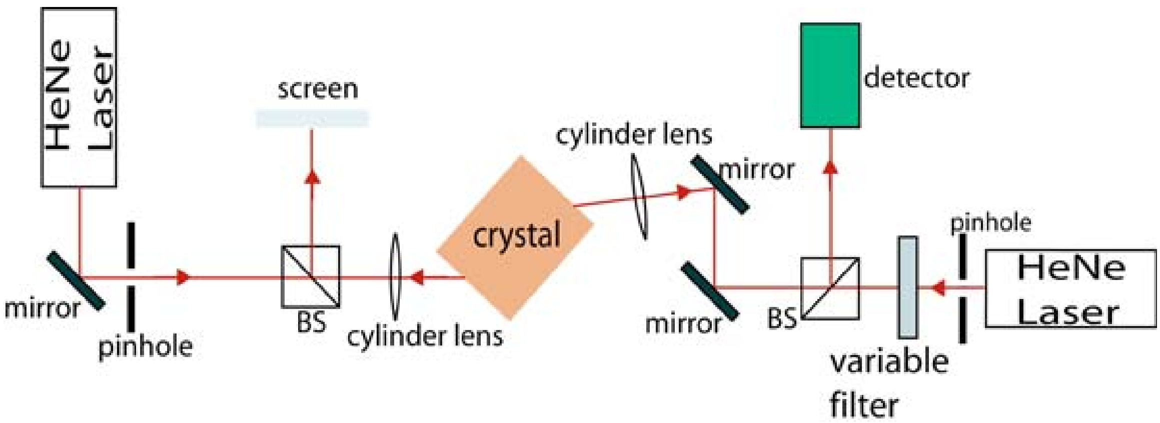
Holographic Optical Elements for Infrared Lasers

T. Bach, M. Jazbinsek and G. Montemezzani

Aims: Compared to other high power cw sources, laser diodes and laser diode arrays are compact, efficient and cheap. The main disadvantages are a reduced spatial beam quality and a rather broad spectral distribution. The aim of this work is to improve the spatial and spectral properties of near infrared laser diodes and laser diode arrays by means of holographic techniques. This would be attractive for a large number of applications, such as longitudinal pumping, frequency conversion, or laser printing or machining.

Approach: Two different approaches are being considered, which involve either static or dynamic holograms. Static holograms are mainly useful for spatial reshaping of the laser diode beam. Complex holographic optical elements in combination with an external grating or a second hologram can be used for an additional frequency locking of the emitted light. Due to the large dynamic range, our materials of choice here are different types of photopolymers. The second appoach involves dynamic holograms recorded in infrared sensitive photorefractive media. Upon careful design of the set-up, the combined nonlinear dynamics in the laser medium and the external dynamic holograms should lead the system to self-organize into a state with a nearly diffraction limited output and a much narrower spectral bandwidth.

Results: We did focus mainly on the evaluation of several crystals and optimum configurations for the approach based on dynamic holography. We also demonstrated a double phase conjugation in a setup where it is possible to lock one laser source (slave) to another laser source (master). For this setup we chose a yellow $Sn_2P_2S_6$ crystal with a double phase conjugated reflectivity of over 800% at a wavelength of 633nm and an intensity ratio of 30.



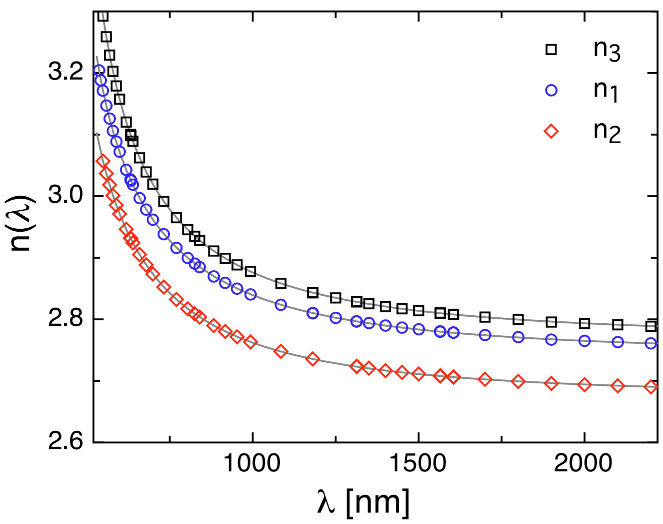
Double phase conjugation setup.

Optical and Nonlinear Optical Properties of $Sn_2P_2S_6$ Crystals

D. Haertle and G. Montemezzani

Aims: $Sn_2P_2S_6$ has recently established itself as a very promising crystal for applications involving photorefraction or nonlinear optics. However, several of the basic material properties of this low symmetry crystal are still unknown. The aim of the present project is to partially close this gap by performing direct measurements for the determination of the dielectric, electro-optical and nonlinear optical tensor components of this material.

Approach: After having measured the most important electro-optical coefficients last year, we turn our attention to the refractive indices and the nonlinear optical tensor. In $Sn_2P_2S_6$ the refractive indices are fully determined by measuring its main values n_1, n_2 and n_3 as well as the orientation of the dielectric axes with respect to the crystallographic axes. The main refractive indices were measured with a minimum-deviation setup. The rotation of the dielectric axes was determined by finding the eigenpolarizations at different wavelengths and temperatures.
The precise knowledge of the refractive indices permits to predict the best configurations for nonlinear optics. Nonlinear optical coefficients were measured by the Maker-fringe experiment.



Main refractive indices of $Sn_2P_2S_6$ versus wavelength. The continuous lines behind the data points are given by Sellmeier theory with two oscillators.

Results: The main refractive indices were measured at room temperature in the wavelength range $\lambda \approx 550 \ldots 2200$ nm (see figure). The dielectric axes of the indicatrix – i.e the dielectric axes rotate around the y-axis from 40.6° to 52.8° with respect to the x-direction over the same wavelength range.
Some of the nonlinear optical susceptibilities were measured at λ = 1907 nm. d_{111} is approximately 35 times and d_{122} approximately 9 times d_{111} of quarz. The dispersion of d was calculated to be relatively small in the wavelength range between 1.1 μm and 8 μm.

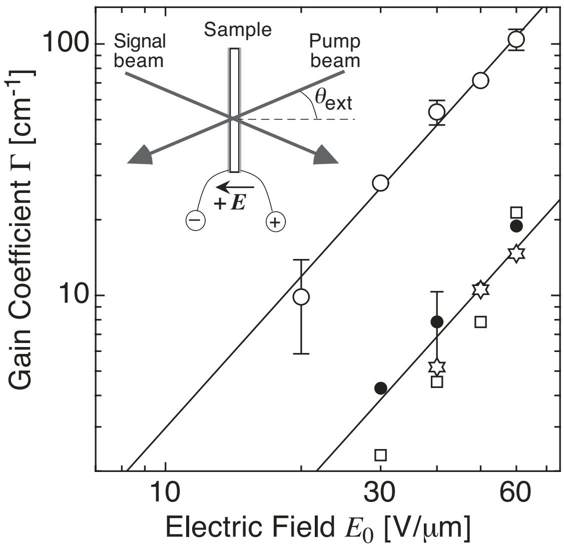
Reference: D. Haertle, G. Caimi, A. Haldi, G. Montemezzani, P. Günter, A. A. Grabar, I. M. Stoika, and Yu. M. Vysochanskii, Opt. Commun. **215**, 333-343 (2003).

Layered Photorefractive Polymers

O.-P.- Kwon and G. Montemezzani

Aims: Polymer composites showing a charge transport mediated photorefractive effect hold promise for efficient and cheap dynamic holographic devices for optical processing. In this project, in collaboration with the Ajou University (Korea), we investigate a novel very promising class of photorefractive composites that spontaneously form a layered structure and show low glass transition temperatures in absence of a plasticizer, without sacrifying the stability.

Approach: The materials studied in this work are based on a rigid backbone which is composed by poly(p- phenylene terephthalate) (PPT). A charge transporting carbazole group (CZ) is connected to the polymer backbone by oxyalkyl spacers of variable length. Several such composites containing C_{60} as a sensitizer and diethylaminodicyanostyrene (DDCST) or piperidinodicyanostyrene (PDCST) as nonlinear optical chromophores are prepared. The investigations involve x-ray and thermal characterization, dielectric, electro-optic and photoconduction studies, as well as the photorefractive characterization by two-wave mixing and Bragg diffraction.



Photorefractive two-wave mixing gain Γ in reflection geometry versus applied electric field. The open circles show the results for PDCST and C_{60} doped PPT-CZ composite. The other symbols give the results for other polymer composites.

Results: While last year we have demonstrated the excellent photorefractive gain and sensitivity of layered structured polymers in the conventional slanted transmission geometry, this year we did concentrate our attention on the study of the performance of several composites in reflection type geometry. Conventional composites perform poorly in these configurations due to an insufficient effective trap density. In contrast, we have now shown that PPT-CZ polymers doped with PDCST and C_{60} reaches two-wave mixing gain exceeding 100 cm^{-1} also in such geometries (Figure). This is attributed to a large effective trap density which can be associated to the fact that PDCST acts as an efficient hole trap.

References: O. P. Kwon, S. H. Lee, G. Montemezzani and P. Günter, Adv. Funct. Mater. **13**, 434-438 (2003).
O. P. Kwon, G. Montemezzani, P. Günter and S. H. Lee, Appl. Phys. Lett. **84**, 43-45 (2004).

PHOTONIC MATERIALS TECHNOLOGIES

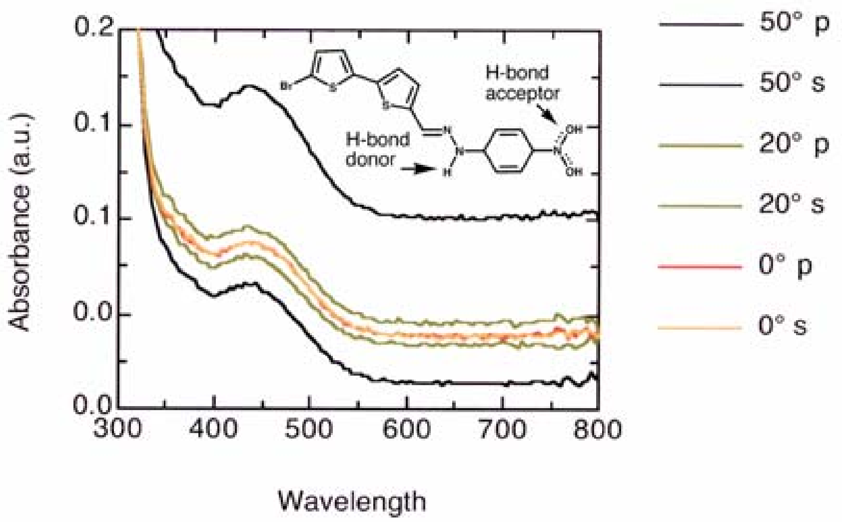
Supramolecular Organic Thin Films for Nonlinear Optics

A. Rashid

Aims: To develop a simple and effective method for the supramolecular self-assembling of thin films with directional ordering perpendicular to the surface of the substrate. The essential criteria are: (1) improved growth rates as compared to Langmuir-Blodgett techniques, and (2) a wider choice of substrate materials than are currently viable using organic molecular beam epitaxy.

Approach: Organic molecular beam deposition (OMBD) was used to grow supramolecular self-assembled thin films of a hydrazone derivative 5-bromo-5´-formyl-2,2´bithiophene 4-nitrophenyl hydrazone (BTNH) onto glass substrates. These molecules possess two H-bonding sites, which results in ordering out-of-plane of the substrate.

Results: The thin films that were grown show a variation in absorption when illuminated with plane polarized light at different incidence angles. The absorption of p-polarized light increases when moving away from normal incidence, while that of s-polarized light is almost constant.



Polarized absorption spectra of BTNH film deposited by OMBD, in the inset the structure of BTNH.

These results demonstrate that the axis of largest optical polarizability is oriented perpendicular to the substrate, corresponding to a molecular ordering nearly normal to the film plane.

Measurements of the p-polarized second harmonic generation (SHG) signals were performed on the thin films. The experimental data indicates a value of the nonlinear optical coefficient d_{111} of approximately 6 pm/V and d_{133} of approximately 0.5 pm/V. The ratio of these values is large compared to poled electro-optic polymers, which indicates that the nonlinear optical properties of these films are given by a more ordered molecular arrangement.

Reference: A. Rashid, C. Erny and P. Günter, Hydrogen-bond-directed orientation in nonlinear optical thin films, Adv. Materials **15** (23): 2024-2027

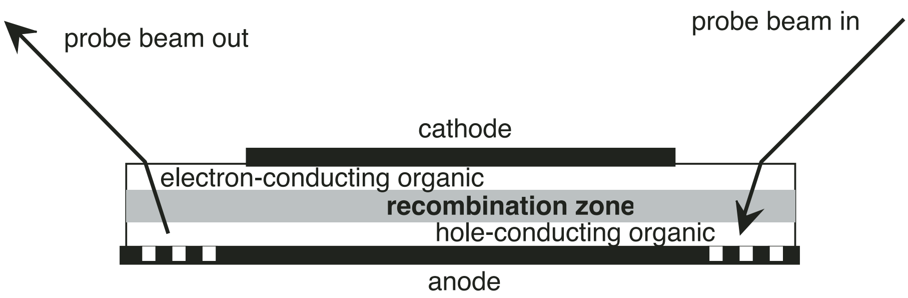
Optical and Electrical Properties of Amorphous Organic Semiconductors under Intense Electrical Excitation

P. Losio

Aims: To determine the basic physical parameters and arrangement for the realization of electrically pumped lasers based on organic semiconductors, by studying their luminescence and optical absorption properties under intense electrical and optical excitation.

Approach: We will investigate the absorption spectra, pholuminescence and electroluminescence spectra in organic semiconductors excited by short (100 ns) high voltage (up to 1 kV) pulses and ultraviolet light to observe changes in the presence of charges. All experiments will be conducted in our Ultra-High Vacuum (UHV) system and at low temperatures to avoid degradation of the samples and to maintain ohmic injection at the contacts. A waveguide geometry will allow to increase the interaction length between probing beam and injected charges.

Results: The firsts steps in this project involve the development and construction of new experimental equipment to enhance the possibilities of our UHV system. A new effusion cell with a separated pumping system has been integrated in our UHV system and it allows for fast material testing. Drawings for a UHV-compatible cryostat are complete, the new cryostat will allow to study samples from 4K to 500K without exposing them to oxygen. First experiments have been successfully done on waveguididing thin organic films and on producing coupling gratings by photolithography.



Waveguide geometry for studying absoprtion spectra of organic semiconductors under intense elctrical excitation. The probe laser beam will be coupled in and out by a grating in the substrate. This geometry improves the signal to noise ratio compared to reflection or transmission mode measurements.

We previously showed that in UHV is possible to produce ohmic contacts to amorphous organic semiconductors and we will further use this knowledge.

References: M. Kiy, I. Biaggio, M. Koehler, and P. Günter, Appl. Phys. Lett. **80** (23) 4366-4368 (2002)

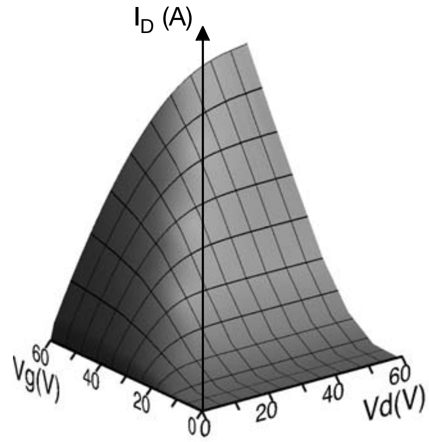
M. Kiy, P. Losio, I. Biaggio, M. Koehler, A. Tapponnier, and P. Günter, Appl. Phys. Lett. 80 (7), 1198-1200 (2002)

Charge Injection and Transport in Amorphous Organic Semiconductors

A.Tapponnier

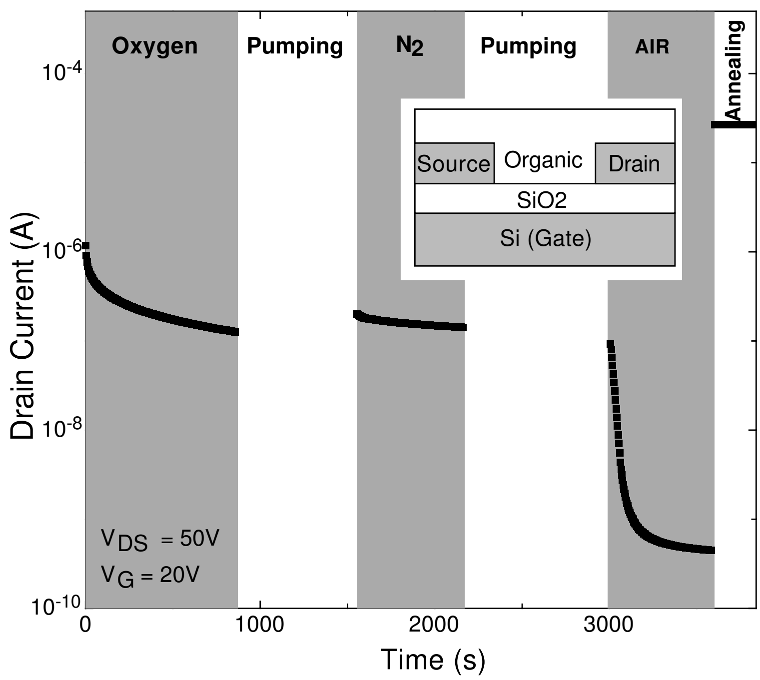
Aims: To improve the understanding of the intrinsic charge transport properties in amorphous organic semiconductors (small molecules) and of the charge-injection process at a clean metal-organic interface.

Approach: Organic field-effect transistor (FET) structures have been fabricated and characterized in ultrahigh vacuum (UHV). The active layer is formed by molecular beam deposited organic molecules. Such devices allow the study of relevant parameters such as the charge carrier mobility, the level of doping and the effect of impurity gases on those parameters.



Drain current versus drain-source voltage and gate voltage of a C_{60}-FET measured in UHV.

Results: We have first studied charge carrier transport in C_{60}-FETs (gold electrodes) in UHV, where clear n-type conduction is observed. The degradation of C_{60}-FET upon exposure to impurity gases is studied for the first time in real-time. Upon air exposure, the electron mobility decreases by 3-4 orders of magnitude. Only the UHV environement allows the characterization of the intrinsic charge transport parameters. Interestingly, ambipolar behavior is observed on oxygenated devices. This demonstrates the possibility of p/n conduction control in organic semiconductors by artificial doping. By annealing the device in UHV it is possible to bring back a ”oxygen contaminated” C_{60}-FET to its virgin state.



Drain current in C_{60}-FET under seqential exposure of oxygen, nitrogen and air at atmospheric pressure. The susequent effect of annealing at 120°C in vacuum is shown. The inset shows the schematic of the bottom-contact FET.

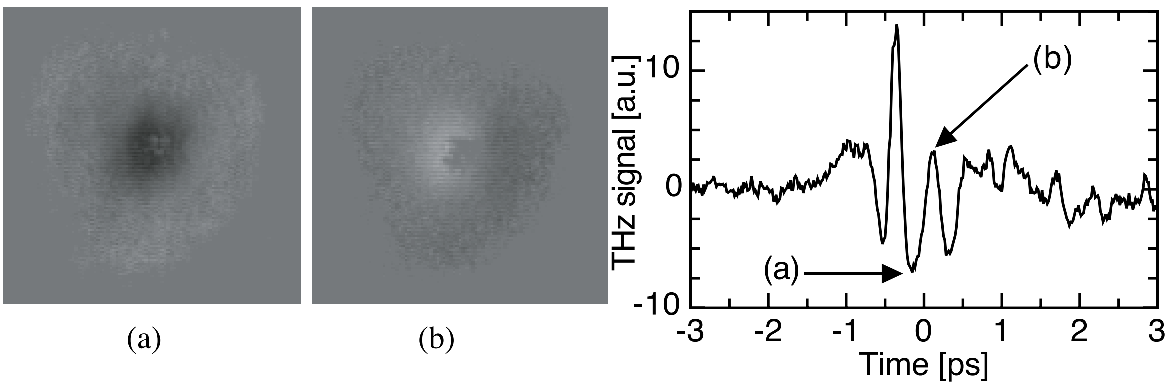
Generation and detection of THz pulses

A. Schneider

Aims: Build up of a generation and detection system for single cycle THz pulses, to investigate new all solid state THz generation schemes, and to perform nonlinear optical spectroscopy on the femtosecond and picosecond time-scale.

Approach: An ultrashort laser pulse (τ~150 fs) is used to induce a polarisation within the organic nonlinear optical crystal DAST via the second-order nonlinear optical effect of optical rectification. The amplitude of this polarisation follows the envelope of the intensity of the laser pulse. The polarisation acts as a source for a secondary electromagnetic pulse whose main frequency is inversely proportional to the duration of the primary laser pulse, i.e. a few THz. The THz pulse is focused by reflective optics onto an electro-optic crystal where it induces a refractive index change via the Pockels effect. This shift is read out by a second optical pulse (probe). By varying the time delay between the THz and the probe pulse, the temporal profile of the THz electric field can be determined (electro-optic sampling).

Results: We developed a new variation of electro-optic sampling that is also applicable to birefringent materials. This is very advantageous since crystals with high Pockels coefficients are mostly birefringent. Our new method is based on the fact that the THz induced refractive index change varies over the probe beam profile. For collinear propagation of THz and probe beam this leads to focusing or defocusing of the probe beam. The intensity change in its center can be shown to be linear with the THz field and can thus be used to measure directly the THz waveform (see figure).



Left: Difference pictures of the probe beam for two different time delays t. Light parts indicate zones of the beam where the intensity has increased due to the THz field, dark parts those with lower intensity. (a): defocused, $E_{THz}(t) < 0$;(b): focused, $E_{THz}(t) > 0$.

Right: Measured intensities in the center of the probe beam, proportional to the THz field. The values of t that correspond to the pictures on the left are indicated.

Reference: A. Schneider, I. Biaggio, and P. Günter, Opt. Comm. 224, 337-341 (2003)

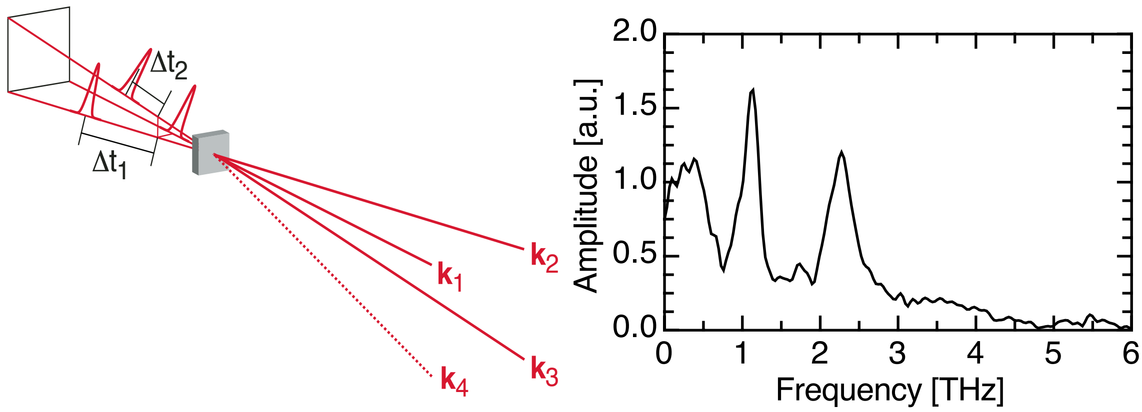
Femtosecond Nonlinear Spectroscopy

A. Schneider

Aims: Investigation of the dynamics of the nonlinear optical properties in noncentrosymmetric materials (e.g. DAST) on a sub-picosecond timescale.

Approach: A well known method for the characterization of third order nonlinear effects is degenerate four wave mixing (DFWM, see figure, left). Recently we have shown that in noncentrosymmetric materials, also cascaded second order effects (sum and difference frequency generation; optical rectification and Pockels effect) contribute to the DFWM signal. By variation of the experimental conditions one can determine the strength of the various contributions and thus also the underlying nonlinear susceptibilities. The light pulses we use are tunable continuously in a wavelength range from 550 to 1600 nm and have a length of 150 fs. This allows us to measure also the build-up and relaxation times of non-instantaneous processes. The same set-up can be used for pump-probe measurements if only two input beams are incident on the sample.

Results: We performed DFWM experiments with the highly nonlinear organic crystal DAST (4-N,N-dimethylamino-4'-N'-methyl stilbazolium tosylate). The non-instantaneous response of the material manifests itself by an exponentially decaying contribution of the k_4 signal when Δt_1 is varied. Superimposed on this exponential term we found an oscillation whose spectrum is given in the figure on the right. Two distinct peaks are clearly visible. The first at a center frequency of 1.1 THz can be identified with a strong absorption line previously observed in THz spectroscopy, the second is its frequency doubled counterpart. From the relative amplitudes one can calculate the degree of asymmetry of the underlying oscillation. Its lifetime can also directly be determined, which is not possible with direct THz spectroscopy.



Left: Arrangement used for the degenerate four wave mixing measurement. The read-out beam, directed along the phase matched direction $k_4 = k_1 - k_2 + k_3$, is measured as a function of Δt_1. Right: The signal decays exponentially with a superimposed oscillation whose spectrum is given in the figure.

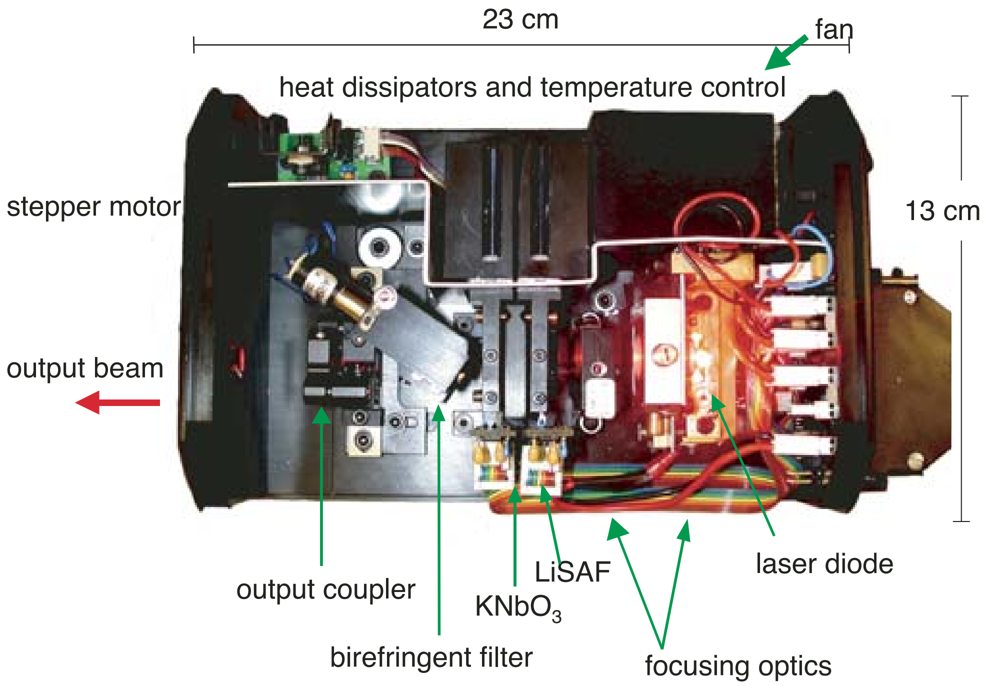
BLUE AND UV SOLID STATE LASERS

Frequency Doubled Diode Pumped Solid-State Lasers

R. Cudney, F. Sulser, S. Barman and C. Medrano

Aims: We investigate optimized configurations of all solid state diode pumped frequency doubled lasers. The laser materials that were investigated are chromium-doped colquiriites: Cr:LiSAF, Cr:LiCAF and Cr:LiSGaF. Efficiency, stability and other physical parameters were investigated with respect to their suitability as laser hosts for optical frequency conversion based on $KNbO_3$ crystals and $KNbO_3$ waveguides. Our approach is to diode-pump a solid-state laser that emits radiation at the adequate wavelength for frequency conversion. Among the laser materials we chose Cr:LiSAF, which can be pumped with 670-690 nm light, and has the strongest emission at 860 nm. Cheap and efficient laser diodes cover this region. For the doubling we use $KNbO_3$ crystals and waveguides.

Results: A compact-infrared-tunable laser with a digital power supply has been built and demonstrated. The laser uses an 800 mW 680 nm single-stripe laser diode as the pump source and a 5 mm long Cr:LiSAF crystal as the lasing medium. We have obtained more than 250 mW of output power at 860 nm. Using a birefringent plate we can tune the wavelength from 820 to 970 nm, with a TEM_{00} spatial mode and beam quality $M^2<1.1$. Frequency doubling was obtained in an intracavity doubling configuration using $KNbO_3$ crystals. A compact blue laser source with 6 mW output power (TEM_{00}) at 430 nm has been completed.



Collaboration with Rainbow Photonics AG

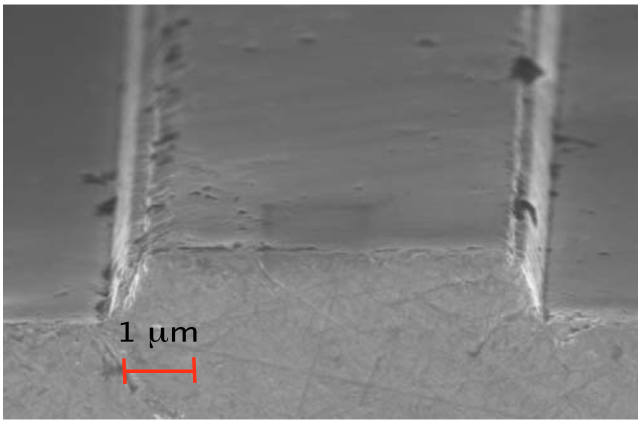
Compact Blue Light Sources Using $KNbO_3$ Waveguides

R. Degl'Innocenti and C. Medrano

Aims: Realisation of a compact blue laser source based on optical frequency conversion using waveguides in nonlinear optical crystals such as potassium niobate ($KNbO_3$) with high efficient optical frequency doubling. Waveguides of typical length of 1-2 cm can be combined with a diode and mounted together in a compact laser device. Optimization of the arrangement for efficient compact blue source will be investigated.

Approach: Refractive index changes, required for producing optical waveguides, are obtained via He^+ or H^+ single and multiple implantations. Ridge structures of photoresist are created on top of planar waveguides with standard photolithography process and subsequently we proceed with a plasma etching process which finally produces the final structures in our material (for further details see reference) .The efficiency of the optical frequency doubling depends also critically from the losses of the waveguides and from geometrical factors as well: attenuation ≤ 3 dB/cm are required. Investigation of waveguide absorption, of the refractive index barrier profile induced by ion implantation and of the smoothness of the ridges are carried out in order to characterize and optimize the nonlinear process.

Results: Using multiple implantation we were able to reduce the losses in the waveguides in the infrared range for a factor of 2. The photolithography and etching processes have been improved and the production of structures with a height ≥ 1.5 μm is normally achieved without compromising the optical quality (see figure).



Scanning Electron Microscope picture of a ridge waveguide

Reference: T. Pliska, D. Fluck and P. Günter: Applied Physics Letters, 72, (19), pp 2364-2366, 1998

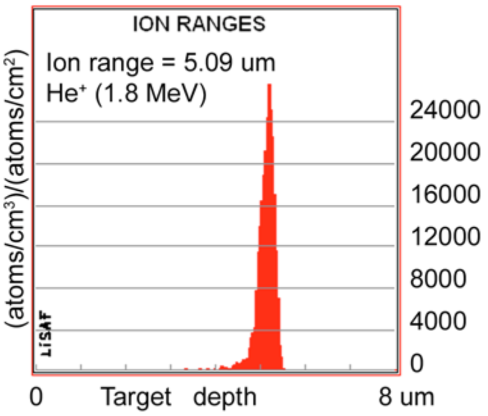
Compact Blue Light Sources Using $KNbO_3$ and Cr:LiSAF Waveguides

A.Majkic and C.Medrano

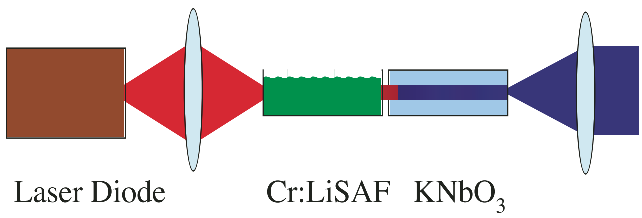
Aims: Development of a compact directly coupled blue light source using $KNbO_3$ and Cr:LiSAF waveguides. The work consists of three parts. The first part is the development of the low loss optical waveguides in $KNbO_3$ for the efficient frequency doubling into blue wavelength range. The second part is the development of Cr:LiSAF waveguide lasers emitting tuneable radiation in the 800…950 nm range. For the realisation of compact blue waveguide lasers arrangements for efficient light coupling, mode selection and intensity stabilisation are being investigated.

Approach: Planar waveguides in $KNbO_3$ and Cr:LiSAF crystals are produced by He^+ implantation into bulk materials. The ridge is produced by photolithography and reactive ion etching. In addition, laser ablation for producing the ridge waveguide is being investigated. A DFB grating on top of the Cr:LiSAF waveguide serves for narrowing and stabilising the Cr:LiSAF output. Coupling between waveguide elements is achieved using micro positioning techniques. Grating on top of the laser and the direct coupling are schematically presented in the figure below.

Results: Theoretical calculations using Monte Carlo code TRIM (Transport and Range of Ions in Matter) have been performed for $KNbO_3$ crystal. Several crystals with combinations of two or three slightly different He^+ implantation energies have been produced for optimised double- or triple-barrier waveguides. In addition TRIM simulations of the He^+ implantation into the Cr:LiSAF crystal have been performed. It has been found that for the same thickness of the wave guiding layer in Cr:LiSAF He^+ ions with an energy of 1.8 MeV can be used. The figure below shows the He^+ ion penetration range in TRIM simulation of He^+ implantation into the Cr:LiSAF crystal.



He+ ion range in Cr:LiSAF crystal (TRIM simulation).



Arrangement of the compact blue laser source (schematic).

Reference: D. Fluck and P. Günter, IEEE Journal of Selected Topics in Quantum Electronics, Vol. 6, No.1, 122-131, 2000

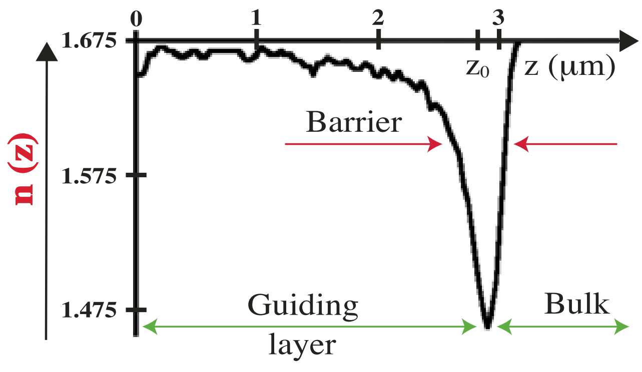
UV Solid State Waveguide Lasers

R. Degl'Innocenti and C. Medrano.

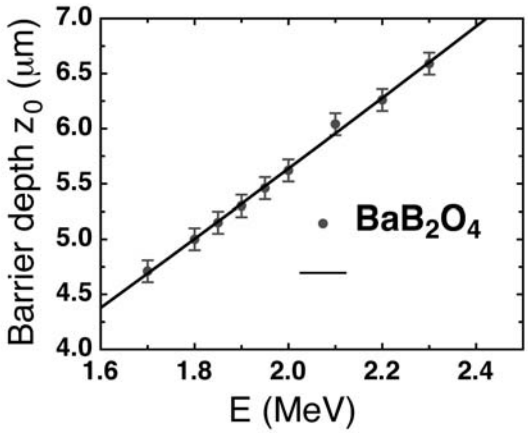
Aims: Production and investigation of a compact UV laser source by the optical frequency doubling of a green-emitting solid-state laser, using in a nonlinear crystal such as *b*-BaB_2O_4 or other borates.

Approach: Waveguides are produced via He^+ implantation, which creates a decreased refractive index barrier, and laser ablation. The borates are nonlinear optical crystals which exhibit a transparent frequency range down to 190 nm (BaB_2O_4) or even lower therefore permitting optical frequency doubling in the UV: because they are in general sensitive to moisture an approach different from photolithography is required. Femtosecond laser pulses could be used to structure ridges on top of the crystals.

Results: Using multiple implantation we were able to produce efficient barriers in a crystal showing the confinement of light. Experiments on the relation between the implantation parameters and the barrier profile are currently carried out together with measurements of the effective refractive index losses. Using the simulation program SRIM 2003 (the Stopping and Range of Ions in Matter) it is possible to predict the depth of the barrier and obtain the nuclear damage, which is in first approximation responsible for the presence of the barrier. From the measurements of the effective indices of the planar waveguides we can give a first estimation of the decrease of the refractive index and confirm the reliability of the theorical simulations.



Refractive index profile *n(z)* for the ordinary refractive index of an ion implanted BaB_2O_4 crystal with energy E = 1.1 MeV and a dose of $2 \cdot 10^{16}$ ions/cm^2.



Energy dependence $E(z_0)$ of the refractive index barrier.

PUBLICATIONS 2003

Journal Publications

S. Concilio, I. Biaggio, P. Günter, S.P. Piotto, M.J. Edelmann, J.-M. Raimundo and F. Diederich
"Third-order Nonlinear Optical Properties of In-backbone Substituted Oligo(triacetylene) Chromophores"
J. Opt. Soc. Am. B ***20*** *(8), 1656-1660 (2003)*

Ph. Dittrich, R. Bartlome, G. Montemezzani and P. Günter
"Femtosecond Laser Ablation of DAST"
Applied Surface Science ***220****, 88-95 (2003)*

D. Haertle, G. Caimi, A. Haldi, G. Montemezzani, P. Günter, A.A. Grabar, I.M. Stoika, Yu.M. Vysochanskii
"Electro-optical Properties of $Sn_2P_2S_6$"
Optics Communications ***215*** *(4-6), 333-343 (2003)*

B. Jagadish, M.D. Carducci, Ch. Bosshard, P. Günter, J.I. Margolis, L.J. Williams and E.A. Mash
"Organic Crystal Engineering with Piperazine-2,5-diones. 4. Crystal Packing of Piperazinediones Derived from 2-Amino-7-cyano-4-methoxyindan-2-carboxylic Acid"
Crystal Growth & Design ***3*** *(5), 811-821 (2003)*

M. Jazbinsek, G. Montmezzani, P. Günter, A.A. Grabar, I.M. Stoika and Yu.M. Vysochanskii
"Fast Near-infrared Self-pumped Phase Conjugation with Photorefractive $Sn_2P_2S_6$"
J. Opt. Soc. Am. B ***20*** *(6), 1241-1246 (2003)*

M. Jazbinsek, M. Zgonik, M. Lee, S. Takekawa, K. Kitamura and H. Hatano
"Optimization of Non-Volatile Two-Color Holographic Recording in Near-Stoichiometric $LiNbO_3$"
Ferroelectrics ***296****, 37-46 (2003)*

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"Influence of Diffusion, Trapping, and State Filling on Charge Injection and Transport in Organic Insulators"
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O-P. Kwon, S-H. Lee, G. Montemezzani and P. Günter
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Polymeric Materials: Science & Engineering ***88****, 296-297 (2003)*

O-P. Kwon, S.-H. Lee, G. Montemezzani and P. Günter
"Highly Efficient Photorefractive Composites Based on Layered Photoconductive Polymers"
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"High-gain Photorefractive Reflection Gratings in Layered Photoconductive Polymers"
Appl. Phys. Lett. ***84*** *(1), 43-45 (2004)*

P. Lavéant, C. Medrano, B. Ruiz and P. Günter
"Growth of Nonlinear Optical DAST Crystals"
Chimia ***57*** *(6), 349-351 (2003)*

L. Mutter, M. Jazbinsek, M. Zgonik, U. Meier, Ch. Bosshard and P. Günter
"Photobleaching and Optical Properties of Organic Crystal 4-N, N-Dimethylamino-4'-N'-Methyl Stilbazolium Tosylate"
J. Appl. Phys. ***94*** *(3), 1356-1361 (2003)*

M. Raimundo, S. Lecomte, M.J. Edelmann, S. Concilio, I. Biaggio, Ch. Bosshard, P. Günter and F. Diederich
"Synthesis and Properties of a ROMP Backbone Polymer with Efficient, Laterally Appended Nonlinear Optical Chromophores"
J. Mater. Chem. ***14****, 292-295 (2004)*

A. Rashid, Ch. Erny and P. Günter
"Hydrogen-Bond-Directed Orientation in Nonlinear Optical Thin Films"
Advanced Materials ***15*** *(23), 2024-2027 (2003)*

J. Santos, E.A. Mintz, O. Zehnder, Ch. Bosshard, X.R. Bu and P. Günter
"New Class of Imidazoles Incorporated with Thiophenevinyl Conjugation Pathway for Robust Nonlinear Optical Chromophores"
Tetrahedron Letters ***42****, 805-808 (2001)*

A. Schneider, I. Biaggio and P. Günter
"Optimized Generation of THz Pulses via Optical Rectification in the Organic Salt DAST"
Optics Communications ***224****, 337-341 (2003)*

A. Tapponnier, I. Biaggio, M. Koehler and P. Günter
"Integrated Pulsed Photoconductivity of Organic Light Emitting Diodes"
Appl. Phys. Lett. ***83*** *(26), 5473-5475 (2003)*

M. Wintermantel and I. Biaggio
"Temperature-dependent Electron Mobility and Large Polaron Interpretation in $Bi_{12}SiO_{20}$"
Phys. Rev. B ***67****, 165108-1 - 165108-6 (2003)*

Conference Publications

Ph. Dittrich, G. Montemezzani and P. Günter
"Interband Photorefraction for Tunable Optical Filters at Telecom Wavelength"
OSA Trends in Optics and Photonics, Vol. **87**
"Photorefractive Effects, Materials, and Devices"
Ph. Delaye, C. Denz, L. Mager and G. Montemezzani, eds. (Optical Society of America, Washington D.C.), 620-624 (2003)

A.A. Grabar, I.V. Kedyk, I.M. Stoika, Yu.M. Vysochanskii, M. Jazbinsek,
G. Montemezzani and P. Günter
"Enhanced photorefractive Properties of Te-Doped $Sn_2P_2S_6$"
OSA Trends in Optics and Photonics, Vol. **87**
"Photorefractive Effects, Materials, and Devices"
Ph. Delaye, C. Denz, L. Mager and G. Montemezzani, eds. (Optical Society of America, Washington D.C.), 10-14 (2003)

D. Haertle, G. Caimi, A. Haldi, G. Montemezzani, P. Günter, A.A. Grabar, I.M. Stoika, Yu.M. Vysochanskii
"Electro-optical Properties of Photorefractive $Sn_2P_2S_6$"
OSA Trends in Optics and Photonics, Vol. **87**
"Photorefractive Effects, Materials, and Devices"
Ph. Delaye, C. Denz, L. Mager and G. Montemezzani, eds. (Optical Society of America, Washington D.C.), 73-78 (2003)

M. Jazbinsek, D. Haertle, G. Montemezzani, P. Günter, A.A. Grabar, I.M. Stoika and Yu. M. Vysochanskii
"$Sn_2P_2S_6$ Crystals for Fast Near Infrared Photorefraction and Phase Conjugation"
OSA Trends in Optics and Photonics, Vol. **87**
"Photorefractive Effects, Materials, and Devices"
Ph. Delaye, C. Denz, L. Mager and G. Montemezzani, eds. (Optical Society of America, Washington D.C.), 190-194 (2003)

O-P. Kwon, G. Montemezzani, P. Günter and S.-H. Lee
"High Performance Layered Photorefractive Polymers in Reflection Grating Geometry"
OSA Trends in Optics and Photonics, Vol. **87**
"Photorefractive Effects, Materials, and Devices"
Ph. Delaye, C. Denz, L. Mager and G. Montemezzani, eds. (Optical Society of America, Washington D.C.), 262-266 (2003)

PRESENTATIONS 2003

* = invited talk

Ph. Dittrich
"Tunable Optical Filters at Telecom Wavelengths by Interband Photorefractive Gratings"
CLEO USA, Baltimore, USA
1.-6.6.03

Ph. Dittrich
"Interband Photorefraction for Tunable Optical Filters"
Topical Meeting on Photorefractive Effects, Materials, and Devices (PR'03), La Colle sur Loup, F
17.-21.6.03

Ph. Dittrich
"Femtosecond Laser Ablation of the Nonlinear Optical Organic Crystal DAST"
CLEO Europe 2003, Munich, D
23.-27.6.03

A. Grabar, I Kedyk, I. Stoika, Yu.M. Vysochanskii, M. Jazbinsek, G. Montemezzani, P. Günter
"Enhanced Photorefractive Properties of Te-doped $Sn_2P_2S_6$"
Topical Meeting on Photorefractive Effects, Materials, and Devices (PR'03), La Colle sur Loup, F
17.-21.6.03

* **P. Günter**
"Organic Crystals, Electro-optics and the Generation of THz Waves"
Frühjahrstagung des Arbeitskreises Festkörperphysik der Deutschen Physikalischen Gesellschaft, Dresden, D
24.-28.3.03

* **P. Günter**
"Organic Crystals, Electro-optics and the Generation of THz Waves"
"Banfi Memorial Workshop on Nonlinear Optics and Lasers, Pavia, I
16.6.03

* **P. Günter**
"Polar Organic Nonlinear Optical Crystals for Electro-optics"
Romanian Conference on Advanced Materials – ROCAM 2003, Constanta, Romania
15.-18.9.03

* **P. Günter**
"Nonlinear Optics with Organic Materials"
39th Course of the International School of Quantum Electronics, Erice, I
18.-25.10.03

* **P. Günter**
"Organic Materials in Electro-optical Devices"
39th Course of the International School of Quantum Electronics, Erice, I
18.-25.10.03

* **P. Günter**
"Electro-optics in VLSI Photonics Using DAST Crystals"
7th International Conference on Organic Nonlinear Optics and Organic Electronics (ICONO'7), Sorak, Korea
4.-8.11.03

* **P. Günter**
"Nonlinera Optical Effects and Applications"
Seminar Ajou University, Suwon, Korea
10.11.03

* **P. Günter**
"Progress in Organic Materials for Microresonators"
EU Progress Meeting (NAIS, IST), Brussels, B
25.12-03

D. Haertle
"Electro-optical Properties of Photorefractive $Sn_2P_2S_6$"
Topical Meeting on Photorefractive Effects, Materials, and Devices (PR'03), La Colle sur Loup, F
17.-21.6.03

M. Jazbinsek
"$Sn_2P_2S_6$ Crystals for Fast Infrared Photorefraction and Phase Conjugation"
Topical Meeting on Photorefractive Effects, Materials, and Devices (PR'03), La Colle sur Loup, F
17.-21.6.03

O-P. Kwon, S.H. Lee, G. Montemezzani, P. Günter
"High Performance Photorefractive Materials Based on Layered Photoconductive Polymers"
American Chemical Society National Meeting, New Orleans, USA
23.-27.3.03

O-P. Kwon, S.H. Lee, G. Montemezzani, P. Günter
"Photorefractive Properties of Layer Structured Polymer Composites"
Korean Polymer Society Meeting, Seoul, Korea
11.-12.4.03

O-P. Kwon, G. Montemezzani, P. Günter, S.H. Lee
"Highly Efficient Photorefractive Materials Based on Layer Structured Polymers"
7th International Conference on Organic Nonlinear Optics (ICONO-7), Sorak, Korea
4.-8.11.03

P. Lavéant
"Growth of High Quality Crystals for Nonlinear Optics"
E-MRS 2003, Strasbourg, F
10.-13.6.03

* **G. Montemezzan**i
"Low Intensity Photorefractive Nonlinear Optics for Dynamic Holography and Applications"
Mid Sweden University, Sundsvall, S
28.1.03

* **G. Montemezzani**
"Photorefractive Effects and Light Diffractor in Strongly Anisotropic Materials"
6th Mediterranean Workshop and Topical Meeting "Novel Optical Materials and Applications (NOMA'03), Cetraro, I
8.-13.6.03

G. Montemezzani
"High Performance Layered Photorefractive Polymers in Reflection Grating Geometry"
Topical Meeting on Photorefractive Effects, Materials and Devices (PR'03), La Colle sur Loup, F
17.-21.6.03

* **G. Montemezzani**
"Fast Near Infrared Photorefraction and Phase Conjugation in $Sn_2P_2S_6$"
CLEO Europe 2003, Munich, D
23.-27.6.03

G. Montemezzani
"Layered Structure Photoconductive Polymers: A new Class of Photorefractive Composites"
CLEO Europe 2003, Munich, D
23.-27.6.03

* **G. Montemezzani**
"Conventional and Interband Photorefraction in Inorganic Crystals"
Ajou University, Suwon, South-Korea
4.7.03

G. Montemezzani
"$Sn_2P_2S_6$ Crystals for Near Infrared Processing and Wave Manipulation"
COST P8 Working Group Meeting, Angers, F
4.-5.9.03

* **G. Montemezzani**
"Effets Photoréfractifs dans Matériaux Inorganiques et Organiques"
MOPS, Université de Metz et Supélec, Metz, F
23.9.03

* **A. Rashid**
"Origin and Supramolecular Ordering in Nonlinear Optical Thin Films"
E-MRS 2003, Strasbourg, F
10.-13.6.03

B. Ruiz
"Growth of DAST Thin Films Crystals"
E-MRS 2003, Strasbourg, F
10.-13.6.03

A. Schneider
"Velocity-matched Generation of Terahertz Pulses in the Organic Crystal DAST"
CLEO Europe2003, Munich, D
23.-27.6.03

PHD THESES IN PHYSICS 2003

PHD Thesis

Dittrich, Philipp
“Ultraviolet Interband Photorefraction for Dynamic Waveguides and Filters, and Femtosecond Photo-structuring”
ETH Nr. 15414 (Prof. Dr. P. Günter, Prof. Dr. T. Esslinger & PD Dr. G. Montemezzani)

Korreferate

Fischer, Cornelia
"Trace-Gas Sensing with a Pulsed Difference Frequency Laser Spectrometer and Three Different Detection Schemes"
ETH Nr. 15350 (Prof.Dr. M. Sigrist & Prof. Dr. P. Günter)

Guerrero, Gilles
"Active Photonic Crystals Implemented with Phase-Locked Arrays of VCSELs"
EPFL (Prof. Dr. E. Kapon, Prof. Dr. R. Dändliker, Prof. Dr. A. Forchel,
Prof. Dr. P. Günter)

DIPLOMA THESES IN PHYSICS 2003

Bartlome, Richard
"Harmonic Emission from the Rear Side of Overdense Thin Foils Irradiated at Near Relativistic Intensities"
ETH Zürich & Max-Planck Institut, Garching, June 2003
(Prof. Dr. P. Günter & Prof. Dr. K. Witte)

Clausen, Pascal
"Quantum Wire Light Emitting Diode"
ETH Zürich & EPFL Lausanne, March 2003
(Prof. Dr. P. Günter & Prof. Dr. E. Kapon)

Haldi, Andreas
"Hole Mobility of 2.7-Bis(diarylamino)-9.9-Dimethylfluorenes (TPF) Doped into Poly(styrene)"
ETH Zürich & University of Arizona, Tucson, March 2003
(Prof. Dr. P. Günter & Prof. Dr. B. Kippelen)

Walser, Andreas
"Grating Stabilized Blue Solid State Laser"
ETH Zürich, March 2003
(Prof. Dr. P. Günter)