4th Mediterranean Workshop and Topical Meeting

"Novel Optical Materials and Applications"

NOMA '99

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ABSTRACTS

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ABSTRACTS

In alphabetical order of speakers

Grand Hotel San Michele

Cetraro - Italy, June 4 - 10, 1999

Optical Patterns

F.T.Arecchi
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Abstract
Optics provides the most reliable laboratory tool to test the crucial transition from boundary- to bulk- dominated patterns. One should realize that boundary-dominated patterns are trivial, insofar as the boundary constrains a particular symmetry, reducing the system to a low-dimensional manifold describable by ODE's. A nonlinear optical device within an optical cavity offers a simple way for smoothly changing the "aspect ratio", that is, the Fresnel number, or number of eigenmodes of the free propagation problem which can coexist and compete. As one plots a suitable pattern indicator as the density of topological defects or the imbalance of their topological charges versus the Fresnel number, one observes a change in the scaling law as the defect separation becomes smaller than a dissipative length of the nonlinear optical medium. Furthermore, addition of a non local feedback (either rotation or translation of the return image) couples different space regions. The non local interaction introduces higher order space derivatives and hence broadens the spatial spectrum yielding localized structures. Finally, transient effects, equivalent to the quenching of a thermodynamic phase, play a fundamental role in shaping the pattern: both defect density and domain sizes scale with the quench time. These experimental findings suggest useful insights toward a qualitative understanding of PDE's.

POLYMER CELL-WALL TYPE LIQUID CRYSTAL OPTICAL SHUTTERS AND THEIR APPLICATIONS

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Abstract

Polymer Cell-Wall Type Liquid Crystal (PCW-LC) light shutter has been developed. This is a kind of liquid crystal light shutter without the usage of polarizes, that is, energy saving type. As the cell is occupied with the liquid crystal grains covered with thin polymer films, the polymer content is very small, around 10 wt%. Consequently, the driving voltage is very low (Ca.5-6V). Usually cholesteric liquid crystals are used as the liquid crystal components for light shutters, utilizing the tremendous light scattering of cholesteric focal conic texture. This type of LC light shutter has the great advantage not only for non-polarizer usage but also for non-preorientation treatments. Therefore, this type of light shutter can be useful for other applications, for example, spatial light modulator (SLM), beside being useful for liquid crystal display devices. Moreover, when cholesteric or other types of liquid crystals are used as the liquid crystal components, this type of liquid crystal cell may be used as optically addressing memory. In this work, PCW-LC is introduced at first, and then the applications of PCW-LC to a light shutter for large area displays and also to optically addressing memories.

COALESCENE OF MULTI-COLOR IN QUADRATICALLY NONLINEAR PHOTONIC BANDGAP STRUCTURES

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Abstract

Bragg gratings in quadratically nonlinear waveguides allow the formation of multi-color gap-solitons or *simultons*. Under specific conditions, such gap-solitons can be excited by a single-frequency input, collide, slow down and stop within the structure, enabling the realization of all-optical bistable gates, delay-lines and buffers. We review the theoretical/numerical progress in the field, with specific reference to the simplest case of second-harmonic generation in singly and doubly resonant distributed feedback gratings.

Application of POLARCOR-type dichroic surface layers for novel and improved polarizing optical elements

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Abstract

By the permanent orientation of elongated nanometric silver crystals in the outer surface region (20-50 (m) of borosilicate glass in a common direction, Corning succeeded in making high-quality polarizers, that operate in the 633-1550 nm wavelength range, under the trade name of Polarcor. This is probably the most significant advance in dichroic polarizer technology since the invention of the Polariod sheet by Edwin Land. The polarizing mechanism is essentially the same as that of the classic wire-grid polarizer. In this paper, it is shown that by applying Polarcor-type layers in orthogonal directions to the two exit faces of a McNeille polarizing-beam splitter (PBS) cube, the long-standing field-of-view restriction of this widely used prism is eliminated, with a concomitant substantial improvement in the extinction or contrast ratio of the device. Other potentially useful PBSís that use a combination of Brewster-angle polarization by reflection and a Polarcor layer on the exit face of a right-angle prism are also described. Finally, it is proposed that absorbing elongated needle-shaped particles ((10-50 nm length, > 10 aspect ratio) with permanent electric or magnetic dipole moments be identified, that can be oriented by radial electric fields or azimuthal magnetic fields, for the possible realization of novel dichroic polarizers that could produce azimuthally and radially polarized laser beams, respectively. Such beams have been the subject of recent interest. Azimuthal orientation of elongated particles is also possible in a rotational fluid-flow field prior to freezing.

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A statistical approach on the orienting photopolymer - nematic liquid crystal anchoring energy

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A central problem to construct liquid crystal displays is to have a substrate with anisotropic surface anchoring properties. This has been done either with obliquely evaporated SiO layers, Langmuir-Blodgett films or rubbed polymer films. The most common of them, mechanical rubbing of polyimide layers, has also some disadvantages like physical damage and nonuniformities, generation of dust particles and/or electrostatic particles. A nonrubbing alignment process would not have the disadvantages listed above and this can explain the actual interest on photo-alignment process. We are studying the alignment of a nematics on a photopolymer layer from a theoretical point of view. We use a statistical approach for the nematic order including surface anisotropy in the frame of mean field theory. It gives a Boltzmann type orientational distribution function depending on both nematic-nematic and nematic-polymer interaction energies. The azimuthal anchoring energy coefficient has also been evaluated. In the case of UV photo-polymerization acquired surface anisotropy the anchoring energy coefficient depends on the exposure time.

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A.Th.Ionescu, R.Barberi, M.Giocondo, M.Iovane, A.L.Alexe-Ionescu, Phys.Rev.E 52, 1967 (1998)

Photoinduced optical anisotropy of, holographic grating recording on, and nematic orientation by a chiral smectic photochromic polymer

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Photoinduced optical anisotropy has been studied for a chiral comb-like liquid crystalline copolymer containing azobenzene chromophores in its side chains. The polymer manifests a twist-grain-boundary smectic phase and, on cooling, solidifies into an optically isotropic lamellar glass. Upon irradiation by UV light, long living (for days) *cis*-isomers of the azo-chromophores are observed [1]. Spin coated films, irradiated by linearly polarised light manifest a photo-induced birefringence, whose sign and magnitude is measured *in situ* by an ellipsometer with a rotating analyser. The optical anisotropy is caused by enrichment and depletion of a chosen angular direction, correspondingly, with *cis* and *trans*-isomers of the chromophores and related reorientation of the mesogenic groups and the polymer backbone.

These films are shown to be novel medium for holographic image recording sensitive to UV light. The principle of recording includes a primary process when a hidden image (e.g., of a mask) is recorded by unpolarised UV light, which creates a considerable amount of the *cis*-isomers. After the first step, the film is still dark under a polarisation microscope equipped with a red filter. Then, an image is "developed" by linearly polarised, interfering beams of an Ar-ion laser which convert *cis*-isomers back into their *trans*-counterparts and induces changes in the refraction index. Since sensitivity for grating formation dramatically depends on the UV treatment, a holographic patterns is recorded only on the UV irradiated areas. Therefore a holographic image is formed which is stable, at least, for weeks

but may easily be erased by uniform UV irradiation of the film and then rewritten again on the same spot.

Irradiated films of the copolymer may be used for orientation of nematic liquid crystals. Being irradiated by unpolarised UV light the films orient liquid crystals homeotropically, however, after treating the same spot with polarised visible light the liquid crystal acquires new orientation, with its director oriented *along* the light electric vector. This opens up a possibility to create a "quasi-bistable" liquid crystal orientation [2] by holographic gratings recorded on the copolymer.

[1] L. Blinov, M. Kozlovsky, M. Ozaki, K. Skarp, K. Yoshino: *J.Appl.Phys.*, **84** (1998) 3860.
[2] L. M. Blinov, R. Barberi, G. Cipparrone, M. Iovane, V. Lazarev, S. Palto: *Liq. Cryst.*, **26** (1999) 427.

Poling of Fused Silica - A Never-Ending Process

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Abstract
Since the first discovery of a large second-order nonlinearity [$\chi(2) \sim 1$ pm/V] in poled fused silica, this effect has been associated with the creation of a large, frozen-in, static electric field associated with ionic charge transport below the anodic electrode that breaks the macroscopic inversion symmetry of the amorphous material. Generally, Na+ has been assumed to be the dominant charge carrier with a response time on the order of 10's of seconds at typical poling temperatures. We present evidence from: in-situ poling experiments; from after poling etching experiments; and from secondary-ion mass spectroscopy (SIMS) measurements that the poling process is considerably more complex with contributions from both comparable mobility species such as Li+ and much less mobile species K+ and H+ (or H3O+). The large surface fields associated with the initial depletion region result in a charge exchange process with these slower species introduced from the surface. A consequence of these additional charge motions is that, even though a stable second harmonic signal is established within short poling times (minutes), the nonlinearity continues to evolve over much longer times (hours). A charge exchange model, going beyond the usual charge neutrality assumption, is introduced that qualitatively accounts for all of the observed phenomena. Recent results exploiting this second-order nonlinearity in an integrated all-fiber 2x2 electrooptic switch are also presented. In first experiments, 30-db isolation with a sub-microsecond switching speed has been achieved.

This work was partially supported by the Air Force Office of Scientific Research and by the Defense Advanced Research Projects Agency.

Switchable Reflective Films formed from Polymer-Dispersed Liquid Crystals

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Abstract

The research reported here centers on the development of switchable reflection holograms for application in display and communication areas. The use of ambient light to provide color has tremendous implications in the reduction of cost and weight by eliminating the artificial light source used in most LC displays, the backlight. We have demonstrated the ability to form highly reflective films by controlling the phase separation of liquid crystal domains from a free-radically polymerized matrix. Colors across the visible into the near-infrared region can be obtained with large contrasts (>200:1). High resolution microscopy studies are used in conjunction with real-time in-situ notch monitoring experiments to shed light on the dynamics of the phase separation process. These studies are also used to investigate differences in the endpoint structure with regard to changes in the starting monomer type and concentration.

Photopolymer Media for High Density Holographic Data Storage

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Abstract
The demand for increases in the capacity and transfer speeds in data storage tests the limits of conventional technologies and drives the search for new approaches. Optical holography has long held high promise, however, the realization has been frustrated by the lack of suitable storage materials which satisfy the stringent criteria of dynamic range, dimensional stability, optical clarity and flatness. I describe a new design of photopolymer materials for holography that has enabled us to essentially meet these goals. We have demonstrated a recording material that exhibits the highest dynamic range yet reported in a ~1 mm thick optically flat format with low light scatter. This material supports the storage and recovery of high capacity digital data pages at a density as high as 48 channel bits/μm^2 (~50 Gbytes/5_ " disk) with calculated transfer rates in the range of 30Mbytes/sec.

LIQUID CRYSTALLINE MOLECULAR GLASSES

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Glass-forming liquid crystals (GLCs) represent an emerging class of organic materials uniquely suited for optical applications. This material class is characterized by the ability to vitrify while retaining liquid crystalline order, to resist spontaneous crystallization, and to form films and fibers. Because of low melt viscosity, favorable dynamic mechanical properties, and superior chemical purity (*e.g.* well-defined molecular structure and absence of chain ends), GLCs can be readily processed into monodomain solid films. A generally applicable molecular design approach has been implemented for the realization of nematic, smectic, cholesteric, and columnar GLCs with morphological stability emulating high polymers. Various optical device concepts have also been demonstrated. In particular, cholesteric GLC films are capable of high-efficiency circular polarization and selective reflection of incident light. Furthermore, the spectral region of circular polarization can be significantly broadened by spatially modulated photoracemization of a chiral dopant. Photoexcitation of a light-emitter embedded in a cholesteric GLC film results in nearly pure circularly polarized light. The challenges and opportunities that GLCs present will be highlighted as well.

Wavelength Shifting of Optical Pulses through Cascaded Second - Order Processes in a Lithium Niobate Channel Waveguide

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Considerable efforts have been devoted in the last decade to the development of nonlinear optical materials, especially in view of the application to all-optical photonic devices. A new very promising line of research consists of generating effective third-order nonlinearities in noncentrosymmetric media by using a cascade of two second-order processes. Our previous experiments, in bulk organic and inorganic crystals, have shown that cascaded effects can indeed give rise to large nonlinearities with ultrafast response times and perfect transparency of the nonlinear medium, and, in particular, have clearly demonstrated the usefulness of cascaded processes for frequency shifting. The next step toward the device is to make an efficient conversion in a channel waveguide. Going from bulk to a waveguide we also expect the efficiency to markely improve and, at the same time, the required pump power to decrease as a consequence of the optical confinement and of the larger interaction length.

In this work we describe a wavelength shifting experiment based on cascading in a lithium niobate 58-mm-long channel waveguide of high optical quality. By using 20 ps pulses with both signal and pump wavelength around 1100 nm, we find that an energy of the pump pulse of 250 pJ is sufficient to generate a wavelength-shifted pulse with unit efficiency. We compare the results with the prediction of a numerical model which includes in the propagation equations the effect of the modal structure of the interacting beams. Taking into account that, because of the large spectral broadening of the pulses, we use in practice only one fifth of the pump energy, the agreement between theory and experiment is good. Our results are quite encouraging for the feasibility of a wavelength-shifting waveguide device to be applied in an optical communication system and motivate further efforts on the approach of cascading.

Nonlinear optical effects in unbiased near-transition paraelectric photorefractive KLTN

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Abstract:
The analysis of localized optical nonlinear propagation in a KLTN (potassium-lithium-tantalate-niobate) crystal at a room temperature close to the paraelectric-ferroelectric phase transition proves to be particularly fruitful. From a theoretical point of view, propagation is described by a new nonlinear evolution equation which possesses many exact analytical solutions (which are missing in most nonlinear models, including the ones based on the standard nonlinear Schroedinger equation), corresponding to self-trapped beams and spatial solitons (in one and two transverse dimensions). From an experimental point of view, interesting new features are revealed (like the possibility of recovering the aspect-ratio of a diffractive asymmetric beam), especially when working very close to the transition temperature.

Frequency conversion through parametric interaction and cascaded processes in a N-(4-nitrophenyl)-L-prolinol crystal

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and

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Crystals of N-(4-nitrophenyl)-L-prolinol (NPP) of large size and of high optical quality are grown in methanol solution starting from toluene nucleated seeds. Measurements are conducted on a 2.8 mm-thick specimen obtained by cleaving a thick slice parallel to the (101) plane. This type of cut allows access to the dominant phase matching orientation, including the noncritical one. We exploit the high second-order susceptibility of NPP to produce various frequency conversion processes (second harmonic, parametric generation and nearly-degenerate wavelength conversion through cascading) at a very low input intensity. In particular, frequency conversion of a signal pulse (from 1.16 to 1.14 μm) under the action of a pump pulse (at 1.15 μm) with unit gain is obtained with a pump intensity as low as 9 MW/cm^2, while parametric generation from quantum noise, with 10% conversion efficiency, is obtained in a single pass of the pump pulse focussed to an intensity around 10^8 W/cm^2.

Generation of coherent blue and green light based on novel configurations and structures

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During this presentation, we will summarize our recent results on generating coherent blue/green light based on different configurations and structures.

We have investigated second-harmonic generation (SHG) in short-period periodically-poled bulk and waveguide potassium titanyl phosphate crystals to generate blue light using subpicosecond laser pulses in the forward configuration. The highest conversion efficiency is about 32%. We have also generated blue light due to *completely* quasi-phase-matched cascaded SHG and sum-frequency generation (SFG) in periodically-poled RTP/KTP waveguides. This is the first time to achieve backward effective third-harmonic generation where both of SHG and SFG are quasi-phase-matched. The highest conversion efficiency is measured as ~ 0.4%.

We have generated blue light by SHG in undoped KTP and subsequent SFG in Ce-doped KTP. For the first time to the best of our knowledge, we have reduced absorption coefficients of flux-grown KTP crystals in the blue to green domain by doping them with Cerium atoms (replacing ~ 9% of Titanum atoms). Therefore, we can achieve a relatively higher conversion efficiency in this domain by using a Ce:KTP crystal while minimizing the effect of laser heating. We have successfully generated coherent blue light at 0.44 μm by using a *single* pump beam at 1.32 μm. The overall conversion efficiency from the pump beam to the blue beam achieved so far is ~ 2.5%. Most recently, we have also generated blue light in a single Ce:KTP crystal using subpicosecond laser pulses.

We have generated blue light based on quasi-phase-matched backward SHG in periodically-segmented ion-exchanged KTP waveguide with the period as short as 0.7 μm. We have observed the quasi-phase-maching peaks at the 7^{th} (385.8 nm) and 6^{th} (442.7 nm) orders. The measured linewidth for the backward SHG is ~ 0.7 nm, which is much larger than our estimated value of ~ 0.023 nm. Following the previous result, we have determined the variance in the period to be 4.5×10^{-3} μm. Since backward SHG has a much narrower linewidth for an ideal domain structure, it can be eventually developed to a novel and sensitive technique for measuring the fabrication errors of the domains.

The applications of KTP crystals to frequency conversion depend on their damage thresholds. We have studied mechanisms for optical damage of KTP crystals using a CW Argon laser. We have found that the damage threshold strongly depends on the polarization of the pump beam. There are two types of optical damage: invisible damage and gray tracks. We have proposed the damage mechanisms based on drift of ions and electron trapping at perturbed Ti sites. We have also observed photorefractive effect in KTP crystals. Based on our results, we have concluded that KTP crystals can replace LBO crystals for CW generation of coherent green light with the output power up to 2 Watts, via intracavity-frequency-doubling 1.064-μm pump beam.

Excitonic nonlinearity in self-organized quantum-well materials

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The nonlinear optical response of excitons in quantum-well systems has received considerable attention because of enhanced exciton binding energy and oscillator strength. If excitons have anharmonicity, the combination of large oscillator strength and the anharmonicity leads to large optical nonlinearity. Numerous studies have shown that the origin of the anharmonicity in quantum-well systems is arising from the interaction between excitons. In the low excitation density region ($\chi^{(3)}$ region), biexcitons play an important role in the nonlinear optical responses. Therefore, a study on two-exciton state is quite important for both understanding the physics of excitonic nonlinearity and searching for large-$\chi^{(3)}$ materials. In this study, we have studied excitonic nonlinearity in self-organized quantum-well systems. We measured the $|\chi^{(3)}|$ values using four-wave-mixing (FWM) method, and observed biexciton contributions in FWM process. We also performed spectrally-resolved (SR) FWM and non-degenerate (ND) FWM experiments in order to study two-exciton state in detail. We found that the two exciton states in our materials consist of biexciton state and weakly interacting two-exciton state.

Inorganic-organic-layered perovskite-type materials, $(C_nH_{2n+1}NH_3)_2(CH_3NH_3)_{m-1}Pb_mI_{3m+1}$, are self-organized quantum-well systems with a large band-gap-energy difference between well and barrier layers. The excitons are tightly confined within the thin inorganic well layers composed of two-dimensional network of $[PbI_6]^{-4}$ octahedra sandwiched by organic barrier layers, as shown in Fig.1. One can varies the thickness of inorganic layers by varying m, while the thickness of the organic layers by changing n. Moreover the dielectric constant of barrier layer is much lower than that of well layer, therefore the exciton biding energy can be enhanced by the dielectric confinement effect as well as the quantum confinement effect. Table 1 shows the binding energies of exciton and $|\chi^{(3)}|$ value at excitonic resonance in monolayer (m=1) and bilayer (m=2). We can see that these materials have extremely larger binding energies and $|\chi^{(3)}|$ than those of inorganic semiconductor quantum-well materials. From SR-FWM and ND-FWM, we estimated the binding energies of the biexciton state and the band width of the weakly interacting two exciton state (also listed in Table 1). The origin of the large nonlinearity and the influence of confinement size will be discussed.

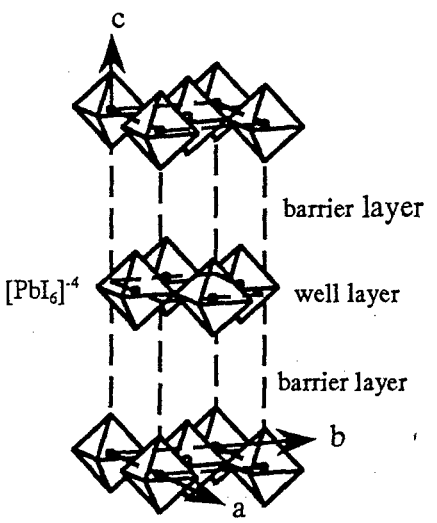

Fig.1 Crystal structure of monolayer (m=1)

	monolayer (m=1)	bilayer (m=2)
exciton binding energy	~240 meV	~210 meV
$\chi^{(3)}$ at exciton resonance	4 x10^{-6} esu	2 x10^{-6} esu
biexciton binding energy	~40 meV	~35 meV
band width of weakly interacting two-exciton state	~40 meV	~20 meV

Table 1 Excitonic parameters of our samples

Quasi-Phasematching: Materials, Devices, and Applications

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Due to advances in solid-state pump lasers and in available nonlinear crystals, a variety of nonlinear sources, operating from the mid-infrared to the ultraviolet are now available. These techniques and materials have developed to the point where nonlinear interactions not previously practical, such as devices for all-optical signal processing for telecommunications applications, shaping pulses in space and time, and generation of intense ultrashort pulses have become possible.

In quasi-phasematched (QPM) nonlinear interactions, the sign of the nonlinear susceptibility is changed periodically in the material, which compensates for the phase velocity mismatch between the interacting waves. The currently best developed patternable media for QPM are periodically-poled ferroelectrics; techniques for patterning the ferroelectric domains in these materials will be described.

QPM materials have been applied to large variety of coherent sources in both bulk and waveguide configurations. These applications will be briefly reviewed, including multi-watt visible and broadly tunable mid-IR coherent sources, and fiber-laser-based ultrafast sources in the near and mid-IR.

An important current research direction is unconventional applications enabled by these same laser and materials technologies. Notable among these are devices that use aperiodic QPM gratings to alter the spectral tuning behavior of nonlinear mixing devices. These aperiodic gratings behave much like RF delay-line filters, but operate at optical frequencies, allowing fairly general ultrafast pulse shaping in simple monolithic structures. Examples of pulse compression for fiber chirped-pulse amplifiers, and generation of THz pulse trains will be presented.

Another class of unconventional applications involves the use of highly efficient waveguide difference frequency mixers for optical signal processing in the 1.3 $s\mu$m and 1.5 μm telecommunications bands. These devices have been used for wavelength conversion within the 1.5 μm band for WDM systems, bidirectional conversion of 1.5 μm to 1.3 μm signals, and spectral inversion for dispersion compensation.

Important materials challenges remain, especially for high average power devices and extension to shorter UV and longer IR wavelengths. Residual absorption in nonlinear materials, both conventional and QPM, leads to thermal loading that distorts the optical beams. Patternable materials operating in the UV, such as stoichiometric lithium tantalate and perhaps twinned crystal quartz, are important research directions. Growth of GaAs with controlled twins, a potentially excellent mid-IR material, is another material system with promising initial results. These new materials directions, as well as other novel device directions, will conclude the talk.

Nonlinear Optical Gyrotropy and Nonreciprocity

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The polarization state of the light reflects the vector nature of the electromagnetic field, in particular the interplay between its electric and magnetic parts, and introduces topological features that have important implications regarding discrimination and robustness of certain electromagnetic interactions. This can be particularly striking when gyrotropy, or the ability of a material to rotate the polarization state, and nonreciprocity come into play as in the case of magnetooptical interactions and have some interesting conceptual repercussions in applications as well. This is for instance, the case when unidirectional control or shielding of optical signal transfer is an issue, or in connection with storage and transfer of coherence, quantum optical or spin coherence in particular.

Here we present recent studies in photoinduced gyrotropy with particular emphasis on the interplay between gyrotropy and nonlinearity in a nonreciprocal configuration. We briefly summarize the recent results on the giant photoinduced Faraday rotation and magnetization in semimagnetic semiconductor quantum wells close to their excitonic resonances where photoinduced polarization state rotations as large as the linear Faraday rotations have been observed and even cancel the later ; the measured values can be as large as 20 degrees in 1μm thick sample with moderate magnetic field and light beam intensities. Photoinduced magnetization has also been observed with circularly polarized light and without an applied magnetic field. We present also

preliminary results on the transmission characteristics of a magnetooptic microcavity in the strong coupling regime.

We present a theoretical modelization of the transmission and reflection characteristics of a nonlinear magnetooptic cavity where the nonreciprocity can lead to specific multistable transmission patterns and in particular to a polarization controlled multistability at constant input intensity ; it is also shown there that the reciprocity/nonreciprocity can be switched on/off for certain parameter regimes.

We also discuss a possible scheme of soliton mode locking by photoinduced nonlinear rotation.

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INSTABILITIES AND STABILITIES OF SEMICONDUCTOR LASERS SUBJECT TO OPTICAL FEEDBACK

A. Gavrielides

The complex and rich dynamics of the semiconductor laser in an external cavity will be examined and analyzed. The multiple fixed points and the coexisting periodic attractors will be discussed and experimental results will be presented. Further, it will be shown both experimentally and numerically that as the feedback strength is progressively increased the system undergoes a cascade of bifurcations where each of the external cavity modes becomes unstable and is replaced by the next one of higher intensity. In the stable regions the laser operates in the maximum intensity external cavity mode and in the unstable regions the laser exhibits chaos which evolves into the low frequency fluctuations regime (chaotic itinerancy). We will demonstrate that this complex dynamics can be controlled experimentally. Further, we present results in which the global chaotic itinerancy is disrupted by the spontaneous appearance of complex but very periodic pulsating modes.

PHOTOREFRACTIVITY IN POLYMER DISPERSED NEMATICS

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Organic photorefractive materials have recently become the focus of attention of many researchers for their possible applications in the field of photonics, which include olografic memories, optical correlators and dynamic holography[1]. Photorefractive polymers are particularly promising because of their high efficiency, low cost and because they can easily be shaped into fibers and thin films. The very high refractive index modulations recently obtained in polymers ($\Delta n \cong 10^{-2}$) have been attributed to orientational effects. Nevertheless, the high electric fields necessary to reorient cromophores constitute a severe limitation. Nematic liquid crystals have then been proposed as a photorefractive medium[2] but, although the fields are in such case much smaller, other limitations exist, due to the low resolution achievable.

We present here results on the photorefractive properties of a relatively new class of materials[3], polymer dispersed liquid crystals (PDLC). They combine the high resolution of photorefractive polymers with the high refractive index modulations due to the reorientation of the nematic director under the influence of an electric field. Our materials are prepared by dispersing roughly spherical nematic droplets within a photoconducting solid organic polymeric matrix. The polymeric matrix contributes the photoconducting properties necessary to establish a space-charge field, while the refractive index variations are a consequence of the nematic reorientation.

In our experiments we used thermoplastic polymers such as polymethylmethacrylate, doped with charge transport agents like N-ethylcarbazole and charge generators such as 2,4,7-trinitro-9-fluorenone. Thermoplastic fotoconductors such as polyvinylcarbazole have also been used. For the nematic phase we used eutectic mixtures such as E49 or TL202. We were able to control the dimensions of our nematic domains and obtained the best results with droplets diameters around 0.2-0.3 μm. The photorefractive properties of the resulting materials have been studied with four-wave-mixing and two-beam-coupling experiments. Results show a diffraction efficiency well above 50% at less than 20 V/μm in 53 μm thick samples. In samples with thickness of 106 μm we also observe a diffraction maximum for applied fileds of less than 9 V/μm. In addition, we were able to show that grating build up times in PDLC's can be of the order of 100 ms.

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Quadratic Nonlinear Optics of Semiconductors

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Abstract

Characterization and manipulation of the quadratic nonlinear optical properties of compound semiconductors are reported. In particular, new characterization methods for semiconductor epitaxial films based on reflected second harmonics are presented, and sublattice reversal epitaxy, which enables one to reverse the sign of the quadratic nonlinear optical coefficient of the zincblende structure and hence will be suitable for quasi-phase matched devices, for GaAs/Si/GaAs and GaAs/Ge/GaAs systems is discussed.

Mid-IR Fiber Lasers Material Research and Optimization Issues

Ravi Jain, University of New Mexico

Abstract

High power mid-IR lasers at wavelengths near 3 microns are needed for several applications, including endoscopic and ophthalmic surgery, and spectroscopic monitoring of several organic species at parts-per-billion levels. Although the 2.7 micron transition in Erbium is ideally suited for these applications, the self-terminating nature of this transition has limited its usefulness for reliable and efficient cw lasers, including diode pumped fiber lasers.

In this talk, I will describe materials research and optimization issues -- leading to novel methods -- for enhancing the efficiency and stability of such lasers. These include the choice of appropriate low-phonon-energy, high-transparency (mid-IR) glasses, the use of high erbium doping densities and ion clustering methods to invoke inter-ion cross-relaxation (to alleviate the population bottleneck in the lower laser level), and the use of co-dopants such as praesodymium (for efficient energy transfer from the lower level) to enable stable steady-state population inversion in the lasing transition. In addition, I will discuss optimized double-clad fiber designs and our recent achievement of record "watt-level" cw output powers (nearly two orders of magnitude higher than those previously reported) from compact and efficient diode-pumped mid-IR fiber lasers.

Device Applications of Organic Nonlinear Optical Materials

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To control large amounts of information that are necessary for our daily life in those days, development of highly sensitive signal processing and transmission systems are required. To attain these ends, photonic devices that use optical nonlinearity of materials will play an important role in actual systems especially in telecommunication systems. Although organic nonlinear optical (NLO) materials developed so far have high potential to attain the requirements for system applications, to date, no materials are applied for actual photonic devices. Among many organic NLO materials, some kinds of electro-optic (EO) polymers and crystals with large second-order optical nonlinearity are expected to be applied as a realistic material for optical signal sensing and processing device.
Here, I will focus on a bis-azo-dye-attached EO polymer and a molecular crystal, AANP and discuss about their potential for device applications.

Waveguide (WG) structure will be the most promising structure for optical system applications. To develop NLO-polymer devices, combination of passive WG (transparent WG) and active WG (NLO WG) will be an ideal structure because almost all NLO-polymers have a large optical loss compared with passive WG polymers. In these hybrid structures, only an active part for signal processing and sensing will be composed with NLO-polymers and the rest of the WGs will be made with transparent polymers. We have developed a hybrid WG where an UV-cured epoxy and an EO-polymer are serially-grafted each other in a channel WG structure. By electrical poling of the EO-polymer, this part in the WG became SHG active. As a result, quasi-phase matching (QPM) SHG WG was fabricated. This QPM-WG showed highly efficient SHG, i.e., the highest among organic QPM materials

Using an indirect laser-heated-pedestal-growth method (LHPG method), growing direction controlled organic NLO crystals were successfully fabricated. Using the technique, 2-adamanthyl-amino 5-nitro pyridine (AANP) crystals whose growth direction was that of phase-matching at 1.3 and 1.55 μm wavelengths were attained. These crystals were applied as a material for optical sampling systems that allow us to diagnose ultra-high-speed optical signals. At 1.3 μm wavelength, the SHG efficiency from AANP was about two orders higher than that of typical inorganic crystal, KTP, though, the efficiency at 1.55 μm was not so good because of its absoprptional loss at that wavelength. To solve the problem, several types of deuterated AANP were synthesized and crystallized. As a result, deuteration of hydrogen in an amino group of AANP was revealed to effective to lower the absorption. As a result high SHG efficiency at whole 1.55 μm wavelengths were attained.

A horizontal Bridgman-Stockbarger (HBS) method for organic crystal was also developed to grow a direction-controlled AANP crystal. By using a specially designed glass cell, growing direction of the crystal was effectively controlled depending on the structure of the cell.

These organic NLO materials will become key materials for the coming third-generation photonic transmission societies

Single-atom "grandfather clock" with a laser "ticker"

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A weak cw laser radiation can induce large self-sustained motional oscillations of a trapped single particle (an atom, ion, molecule, or cluster). The effect is due to Doppler-induced instability of the particle subjected to radiation pressure of light which is blue-shifted off absorption resonance. This oscillator can be nearly thresholdless. With *mw* pumping, the oscillations exhibit huge hysteresis and may easily reach a trap-size orbit (i. e. up to a *cm*). We consider specific examples of $^{24}Mg^{+}$ ion in a static (e. g. Paul) trap with a frequency of oscillations of about *1 MHz*, and an atom ^{23}Na in an optical (or magneto-optical) trap. Feasible applications include "Foucault pendulum" in a trap, rotation sensor and inertial navigation, single atom spectroscopy, isotope separation, atomic clock, etc.

Some interesting methods of nonlinear frequency conversion in multi-layered waveguides

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Y. J. Ding - Bowling Green

Abstract
We describe some novel methods for frequency conversion in nonlinear waveguides that allow efficient phase-matching in zinc-blende materials and as well as high-down-conversion efficiency in the materials with high absorption. Both methods can be described as "cascading in a wide sense of this word". We also make interesting analogies between light propagation in nonlinear waveguides and multi-photon processes in time domain.

In-line Fiber Evanescent Field Electro-optic Modulators

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Erji Mao and James S. Harris Jr.
Stanford University

With the increased interest in optical links to transmit large amounts of information comes a need for electro-optical components to operate at bandwidths in the tens of GigaHertz. To meet this demand, the performance of optical fibers, optical sources, optical receivers, and associate electronics has been enhanced, and these components are becoming available at lower cost. Similar progressive trends are absent in high performance electro-optic modulators. A review will be given of the system, material, and technological challenges that are faced by electro-optic modulators. An overview will be given of advances in our group towards the development of modulators that are based on in-line fiber evanescent structures. Analog modulators with large bandwidth,and large dynamic range are implemented with electro-active polymers. Digital modulators with low modulation voltage and large modulation efficiency are implemented with multiple quantum well materials.

Photo-Induced Changes of Bulk and of Surface Liquid Crystal Properties

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A number of organic materials, such as azobenzenes for instance, which may exhibit also liquid crystalline properties, undergo a trans- to cis-isomerisation under light illumination. Photoisomerisation process, however, may result in changes of the net molecular dipole moment but it may or may not result in changes of the molecular shape. As a consequence, changes of the bulk liquid crystalline properties, as scalar order parameter S, dielectric $\Delta\varepsilon$ and optical Δn anisotropy, cholesteric pitch, spontaneous P_s, induced polarization P_i in chiral smectic liquid crystals as well as flexoelectric polarization P_f, may take a place.

Here, are presented the results of our recent studies on the light-induced changes in P_f, P_s and P_i due to photoisomerisation of azobenzene dopants dissolved in different liquid crystalline hosts. Of particular interest, from application point of view, is the light-induced shift of the sign reversal temperature of P_s. The photo-induced changes of the flexoelectro-optic response of a liquid crystalline azobenzene, with cholesterol moiety in its molecular structure, is presented and discussed. Some other related examples are given as well.

The photoisomerisation process also results in changes at the solid surface/ liquid crystal interface thus causing changes of the anchoring strength of the liquid crystal molecules. In some cases, the photoisomerisation process may induce an alignment transition. It has been found that a reversible alignment transition from planar to homeotropic takes place only if the molecular shape drastically changes during the photoisomerisation process. A simple model is proposed to explain such an anchoring transition.

Some possible implementations of the light-induced changes of bulk and of surface liquid crystal properties are widely discussed.

DEVICE REQUIREMENTS AND MOLECULAR ENGINEERING FOR OPTICAL COMMUNICATIONS : FROM HIGHLY EFFICIENT DIPOLAR MOLECULES TO STRONG FIELD POLING OF MULTIPOLAR STRUCTURES

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Polarization independence is a crucial requirement to qualify polymer-based electro-optic devices for use in optical telecommunication systems. Polymers containing highly dipolar chromophores oriented under an external electric field cannot simply fulfill this important requirement, the ratio r_{33}/r_{13} of their electro-optic tensor components parallel and perpendicular to the poling field, respectively, being as large as 3. The need for adapted architectures using transverse electrode configurations requires the availability of highly efficient electro-optic polymers, involving new molecules with $\mu.\beta$ values 3 to 5 times higher than that of the currently used disperse Red One chromophore. Another issue would be to use multipolar molecules oriented in a strong poling field regime, then involving octupolar contributions of the β tensor that allows for a significant decrease of the nonlinear anisotropy α. Firstly, we will report here on the design and nonlinear optical characterisation of new efficient dipolar molecules with « rigid » conjugated backbones and/or new acceptor moieties. Static $\mu.\beta$ values as large as 10 to 20 times higher than that of DR1 are evidenced. The interest of these molecules will be discussed in terms of thermal stability and compatibility with photo-orientation processes. Second, the possibility to decrease significantly the nonlinear anisotropy ratio is experimentally demonstrated using, a multipolar molecule oriented under strong field poling conditions. The observed behavior perfectly fits with the theoretical model. The interest of a more elaborated engineering of multipolar molecules is discussed in that respect.

Recent Progress toward Molecular Engineering of Optically -active Polymer Multilayers

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Abstract
We discuss recent progress toward molecular engineering of optically-active polymer multilayers for applications in nonlinear optics, photovoltaics, artificial photosynthesis and biological sensors. Conjugated polymers represent a promising class of materials for holographic information processing, with extremely high temporal diffraction efficiencies (demonstrated diffraction efficiencies of order one percent with subpicosecond grating formation times) and tunable grating lifetimes. We have demonstrated that polymeric self-assembled multilayers can be constructed in which both energy transfer and charge transfer can be engineered in a preferred direction, with high efficiency. We discuss the current state of our materials development efforts, challenges and potential applications.

Fast Holographic Optical Computing using Photorefractive Polymers

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We report on new organic photorefractive (PR) material with outstanding properties both, in steady-state and response time. It is based on a π-conjugated polymer, specifically a copolymer made from the common organic photoconductor TPD and poly[1,4-phenylenevinylene] (PPV), the so-called TPD-PPV. After adding the appropriate sensitizer, plasticizer, and electrooptic chromophore, the composite displayed response times approaching 100 μs (@ 1 W/cm^2 and 100 V/μm). This is by far the fastest response time reported to date in organic PR materials. At the same time, the material maintains large index modulation which allows for complete internal diffraction even in thin film devices ($\Delta n > 5\times10^{-3}$), unlike the other "fast" organic PR materials reported so far. The physical origin of the speed enhancement is discussed by comparison with more traditional organic PR materials containing isolated charge-transport moieties for hopping such as the commonly used photoconductor poly(N-vinylcarbazole) (PVK).

Blue Polarized Electroluminescence from a Liquid Crystalline Polyfluorene

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Even though liquid crystal displays have reached a high level of perfection, they still suffer from high power consumption. One problem is the need to polarize the isotropic backlight – usually generated by fluorescent bulbs – with sheet polarizers. One way to alleviate this problem would be the use of a highly polarized backlight. Light-emitting diodes (LED) based on aligned conjugated polymers have been shown to emit light with a reasonable degree of polarization. One approach is to form the emission layer from liquid crystalline molecules, which are oriented on rubbed polyimide.

We have synthesized several liquid-crystalline polyfluorenes with different side chain patterns. The thin polymer films were aligned at elevated temperatures on a rubbed polyimide alignment layer. For the most suitable substitution (Poly(di-ethylhexyl)fluorene), a dichroic ratio of fifteen was observed in absorption.

This polymer was used to construct light-emitting devices with ITO and Ca electrodes. Suitable dopant molecules were added to the polyimide layer to obtain the required hole transporting ability in addition to its good alignment properties. Analysis of the current–voltage characteristics of the doped layers showed a current density of about 1 A/cm² and space charge limited conduction.

Both the thickness of the polyfluorene and the hole transporting alignment layers were varied to optimized device performance. The optimized devices emitted blue light with a polarization ratio of fifteen and brightness of approximately 100 Cd/m² at 18 V (Fig. 1).

Even though these values are still below the requirements in application, our results prove that highly polarized emission can be obtained with polymer LEDs and can be optimized by chemical and electrical engineering.

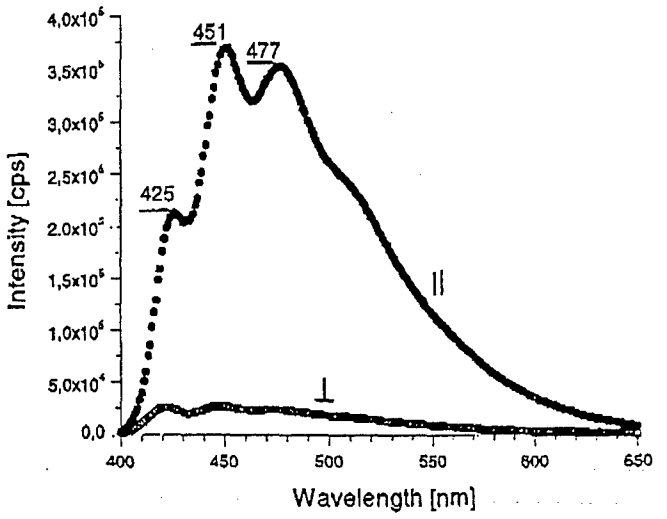

Fig 1.: Emission spectra of annealed Poly(di-ethylhexyl)fluorene on rubbed polyimide in a polarized light emitting diode with a polarization ratio of fifteen

PHOTOINDUCED ORDER AND REORIENTATION IN ABSORBING LIQUINDS AND LIQUID CRYSTALS

Domenico PAPARO

Recent experimental and theoretical results on the optical non-linearity associated with molecular reorientation in dye-doped liquids and liquid crystals are reviewed. All the results seem to indicate that the effect is a consequence of the photo-induced change in intermolecular forces which leads to a variation of the statistical molecular parameters such as rotational friction and orientational energy. These changes on a microscopic base can cause dramatic variations in the optical non-linear response of the original host materials. In particular, many materials can experience enhancements of their optical non-linearities up to three orders of magnitude.

Up to now, it is not clear the upper limit for this enhancement. In this respect, it is essential to understand the role played in the intermolecular interactions by different substituents of the molecules. Our very recent results give a good insight in this aspect and they will be presented here too.

SECOND-ORDER NONLINEAR OPTICS OF CHIRAL SUPRAMOLECULAR SYSTEMS

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We have studied the nonlinear optical properties of helicenebisquinone derivatives. Former studies have shown that bulk samples of the enantiomerically pure form of this material consist of long fibers that can be seen under an optical microscope. The racemic mixture of the two enantiomers on the other hand, does not organize into such fibers.

We have found that Langmuir-Blodgett films of the racemic and nonracemic helicenebisquinone also have different nonlinear optical properties. For example, the second-harmonic intensity from Langmuir-Blodgett films of the nonracemic material can be several orders of magnitude higher than that of a comparable film of the racemic mixture. The higher nonlinear efficiency of the nonracemic films can be attributed to the presence of high chiral susceptibility components that dominate their nonlinear response. The magnitude of these components is of the order of 50 pm/V. In the racemic films, such tensor components must cancel because the chiral components of the two enantiomers have the same magnitude but opposite sign.

A possible application of the helicenebisquinone films lies in the design of quasi-phase-matched devices for frequency conversion. In chiral materials, the tensor components associated with chirality change sign between the two enantiomers. Therefore, films consisting of alternating segments of the two enantiomers can provide a completely new approach to quasi-phase matched structures. By building Langmuir-Blodgett films composed of segments of the R and S enantiomers of the helicenebisquinone, we were able to demonstrate such quasi-phase matching based on chirality.

AZOBENZENE POLYMERS FOR OPTICAL INFORMATION STORAGE

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Digital and analog optical storage in side-chain azobenzene polyesters and peptide oligomers is described. Information can be recorded either through polarization holography or direct computer generated patterns (grey levels). A large diffraction efficiency (>50%) with a long shelf life (>7 years) has been obtained so far. High storage density (>7000 lines/mm) has been achieved in the polymers through evanescent wave polarization holography. The stored information can be erased by heating the liquid crystal polymer films to approximately 80 ⊕C or through irradiation with UV light. In addition, in the case of amorphous polymers, erasure can take place through irradiation of the amorphous films with one circularly polarized beam. Atomic force and scanning near-field optical microscopic investigations reveal the presence of a strong surface relief, dependent on the polarization of the incident beam(s), and on the architecture of the polymers. Just one 5 ns pulse from a frequency doubled YAG laser at 532 nm has been found to produce a surface relief hologram.

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Electro-Optics of Electroclinic Liquid Crystals

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Electroclinic effect (ECE) was first demonstrated by Garoff and Meyer in 1977 in a Smectic-A liquid crystal composed of chiral molecules. The combination of fast electro-optic response time and inherent analog capability makes the electroclinic liquid crystal materials very attractive for a wide variety of applications such as optical data processors, projection displays and real time holography where speed, high contrast and gray scale are of the utmost importance. The evolution of this technology greatly depends on the development of chiral smectic A materials exhibiting large induced tilt angles for low applied fields, field-independent fast switching times and a broad operating temperature range. This requires a fundamental understanding of the relationship between the molecular structure and the electro-optic behavior. At the Naval Research Laboratory we have developed a number of series of liquid crystals exhibiting large electroclinic coefficient over a wide temperature. A number of new effects associated with the large induced tilt angle have been observed in these materials. I will present these results in relation to the molecular structure. I will also discuss details of our demonstration of the analog gray scale capability in these materials.

Thick holograms in PDA (photopolymer with diffusive amplification) for optical filtering

Nadya Reinhand, Alexander Popov, Andrei Veniaminov, Irina Semenova

KEYWORDS: holographic photosensitive materials, spectral and angular selectivity, diffraction gratings.

It is wellknown that very thick volume holograms both transmissive and reflective type being illuminated by light indicate very high angular (less than milliradian) and spectral (less than nanometer) selectivity. The variety of diffraction elements: filters, angular and spectral selectors, etc. can be designed basing on very thick holograms.

The main problem in manufacturing of thick holograms (of about millimeter thickness) is in developing of very thick photosensitive media, in which this grating can be recorded by means of its illuminating by interference pattern. Usual photosensitive materials can not be used in this case. Differential shrinkage on the stage of the postexposure development causes the difference in Bragg conditions on different parts of the grating that leads to the total reduction of the hologram efficiency. Some holographic materials without shrinkage were recently developed. One of them is PDA (photopolymer with diffusive amplification). This is a medium consisted of polymethylmethacrylate (PMMA) including photochromic quinone molecules. The reaction of the phenantrenquinone photoreconstruction in PMMA leads to the formation of phenantrenic structures associated with polymers. As a result on the stage of recording the two opposite phase gratings are produced, one of which is formed by variations of concentration of these phenantrenic structures and the other by variations of concentration of free quinone molecules. During the postexposure processing (thermal treatment) the free quinone molecules are re-distributed uniformly in the polymer matrix volume. This re-distribution leads to a disappearance of the one of opposite phase gratings and, thus, to a considerable increase of the hologram diffraction efficiency.

We demonstrate the experimental results of the recording of high efficient (90%) transmissive angular selector (with the selectivity bandwidth of about milliradian) and reflection spectral selector (bandwidth of about nanometer) using PDA material. Such very high selective optical elements can find application in spectroscopy, space communication, lidar sensing, wavelength demultiplexing, optical storage, and others.

The financial support for this work by European Office of Aerospace Research and Development (EOARD) is gratefully acknowledged.

BRIEF BIOGRAPHY

Dr. Nadya Reinhand

Graduated from Optical Department of State University, St.Petersburg, Russia in 1984. Got PhD in the field of physics and mathematics in 1990 at State University, St.Petersburg. Since that time till present time she works at the Institute of Mechanical Engineering Problems of the Russian Academy of Sciences. Last four years she has a position of Vice-Director of this institute. She is known for her works in the field of holography, diffraction elements, laser optics, nondestructive testing; the author of 46 papers, among them 5 certified inventions. She was the member of organising committees of several international conferences.

Dynamic interferometers implemented with photorefractive crystals for non destructive testing

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Ultrasonic techniques are now widely used in non destructive testing and evaluation, for thickness measurements, flaw detection or material characterization. Ultrasonic vibrations are usually generated and detected with piezoelectric transducers, coupled to the tested part by a direct contact or through a water bath or a water jet. This contact, as well as the presence of a coupling liquid, have a negative impact for their use in many industrial applications, particularly for on-line control, for characterization of parts at high temperature or for inspection of advanced materials. This makes the interest of optical techniques which, despite the fact that they are less sensitive than piezoelectric sensors for the detection of ultrasounds, have the great advantage of being non contact and of having a large frequency bandwidth.

Optical systems are based on the coherent detection of phase modulation, imprinted on the beam by the vibrating surface. This obviously requires an exact superposition of the wave issued from the target with a plane reference wave. As a consequence, these devices only operate with a plane wave signal beam that requires either to polish the tested surface what is generally not possible in industrial environment, or to filter the signal beam what leads to a strong loss in light power, and subsequently a strong reduction of the detection performances. Thus, although largely used in the laboratory, laser ultrasonic systems see their spread in industry greatly slowed down by these constraints.

As we will show, the use of dynamic holographic materials relaxes these constraints and allows to implement interferometers that work whatever the roughness of the object to be tested. Such systems thus possess a high field of view and a large light gathering power leading to a detection sensitivity very close to the theoretical limit.

Their working principle will be described. Requirements for the dynamic material to be used as well as the way to reach the right characteristics will be discussed. Performances for ultrasound detection (sensitivity, bandwidth, adaptativity, ...) will be also given and discussed. Further perspectives will be finally addressed in conclusion.

Hype-Structured Carbazole Derivatives for Photorefractive Applications

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We have developed novel multifunctional chromophores for photorefractive applications. These chromophore, so-called hyper-structured carbazole oligomers and polymers, possesse all the properties required for photorefractivity. Furthermore, because of their good film forming properties, they can be used for optical image processing. The photocarrier generation properties of these chromophores and their second order nonlinear optical response in acceptor-substituted carbazoles were examined by xerographic discharge, second harmonic generation, and electro-optic measurements. Photorefractivity was measured directly by two-beam coupling and four-wave mixing experiments. Furthermore, these chromophores are applicable for the electroluminescent layers due to their electron and/or hole transporting properties, and strong fluorescent properties.

FRACTALS IN MICROCAVITIES: GIANT COUPLED, MULTIPLICATIVE ENHANCEMENT OF OPTICAL RESPONSES

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Abstract

A novel class of optical materials, microcavities doped with nanostructured fractal aggregates, was studied. Fractal aggregate optical excitations may be concentrated in regions smaller than the diffraction limit of conventional optics, resulting in large local fields. Seeding the aggregates into microcavities further increases the local fields because of light trapping by microcavity resonance modes. These microcomposites possess unique optical properties, including very large probabilities of radiative processes. In our experiments, lasing at extremely low pump intensities, below 1 mW, and strongly enhanced Raman scattering was observed in microcavity/fractal/dye composites.

Pathway to the School of Optics

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Abstract:

The School of Optics was formally established at the University of Central Florida in the Fall of 1998. The School grew out of the Center for Research and Education in Optics and Lasers (CREOL) and offers comprehensive graduate education in Optical Science and Engineering. The talk tracks the origins of CREOL and the evolution of the Center through the formation of the School. Specifics of the academic and research programs of the School of Optics/CREOL will also be reviewed.

Multiphoton Effects in Polydiacetylene

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Abstract:

The polymer Polydiacetylene, specifically bis-paratoluene sulfonate (PTS), has large nonlinear optical properties because the $2p_z$ electrons associated with the double and triple carbon bonds form delocalized π-electrons which are free to move along the backbone polymer chain. Previous work has shown that very intense one and two photon absorption occurs for photons of wavelength 620 and 920 nm respectively. The absorptive response has long high energy tails extending > 100 nm due to vibronic side-bands. The oscillator strengths linking the odd symmetry one photon excited state to both the even symmetry ground and first excited states are amongst the largest known resulting in very large peak one ($> 10^5 cm^{-1}$) and two photon (>800 cm/W) absorption coefficients. In this paper we report on large three and four photon absorption coefficients in the wavelength range 1600 to 2000 nm.

Single crystals of PTS were grown and polymerized under controlled conditions to yield high optical quality single crystal platelets 50 - 500 μm thick. The crystals, which had damage thresholds > 400 GW/cm^2 for 100 fsec pulses at 1600 nm were investigated with open and closed aperture Z-scan over the wavelength range 1600 to 2000 nm with 100 fsec pulses.

Strong four photon absorption was found at 1600 nm, augmented for intensities less than 10 GW/cm^2 by three photon absorption. The four photon coefficient α_4 where $\Delta\alpha = \alpha_4 I^3$ rises with increasing wavelength to a value of 0.5 cm^5/GW^3 at around 1900 nm. At this wavelength both three and four photon absorption are resonant leading to resonantly enhanced four photon absorption. Near the peak, an intensity of 20 GW/cm^2 results in an absorption coefficient of 4000 cm^{-1}in a transparent region of the linear absorption spectrum!

The corresponding closed aperture Z-scan has been measured at 1600 nm and an anomalous response with increasing intensity was found. A possible interpretation of the results will be discussed.

EXPERIMENTAL STUDIES OF INITIAL STAGE OF PDLC CURING BY UV INTERFERENCE PATTERN.

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Results are reported of diffraction efficiency (DE) temporal evolution of diffraction gratings arising in a PDCL sample under curing it by UV laser interference pattern. It is shown that the main specific feature of the grating curing process with respect to conventional spatially uniform one lies in efficient concentration redistribution of the presyrop components in the early stage of curing (i.e. before phase separation process is started). Such redistribution leads to formation of diffraction "pre-grating" in the sample, although of rather weak (about a per cent) DE, - but of quite sharp morphology.

The nature of this redistribution, as well as temporal evolution of the diffraction efficiency of the pre-grating is studied in detail. For particular case of highly mutually soluable nematic and pre-polimer components of the presyrop (5CB nematic and SAM-114 prepolimer acrylate composition by Merck in our experiment) the experimental results coincide well with those of simple semi-phenomenological model worked out.

It is shown that for such mixtures the main part of mass-redistribution in the medium takes place before the appearance of nematic phase domains in the sample, thus enabling one to treat the process as **polimerization-induced mass redistribution followed by I-N phase transition,** rather than direct **phase separation.**

Moreover, the final "phase-separated" (i.e. revealing nematic domains) grating sometimes is "re-diluted" to pre-grating stage by surrounding raw presyrop. But it can be readily returnet to nematic-containing stage by simple cooling down the sample.

It should be noted that, in striking contrast to conventional UV cured PDLC grating, the morphology of the pre-grating reveals no inhomogeneities (droplets) of spacial scale comparable to optical wavelength, **thus producing no unwanted stochastic scattering.**

Further investigations of this "pre-grating" nature and evolution reveal the ways of its utilization for improvement of final phaze-separated grating DE and morphology.

Electro-Optical Phenomena in Dye-Doped Liquid Crystals

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Abstract

Modulation of material parameters of liquid crystals (LC) due to absorption of light beams allows inducing and controlling reorientation of LC with ac electric fields. Particularly, photorefractive-like orientation gratings that are phase shifted with respect to the pattern of interfering light beams can be recorded. The material and external parameters determine the magnitude of the shift. These orientation gratings are stationary, and no diffusion processes are involved in their build-up. The results of experimental demonstration of optically controlled, electrically induced reorientation in dye-doped LC will be presented, and potential electro-optical applications discussed.

Abstract for Invited Talk, NOMA '99

Femtosecond Optical Pulse Induced Dynamics of Holes in GaAs in the Mid-Infrared*

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Abstract

The ultrafast dynamics of heavy-, light-, and split-off holes in GaAs are studied using time-resolved two-wavelength pump-probe and hot luminescence techniques.

The multi-color experiments have been performed by using the recently developed broadly tunable femtosecond optical parametric oscillator in the mid-infrared that allowed photoexcitation of the electron-hole plasma and probing of the associated changes in both parts of the dielectric function in a wide spectral range (~ 1 - 4 μm) with femtosecond time resolution. These experiments give detailed information on the inter-valence band relaxation dynamics of heavy- and light-holes and on the bulk diffusion and surface recombination of free carriers in the semiconductor.

The ultrafast relaxation dynamics of split-off holes are studied using a two-wavelength excitation luminescence experiment. Following valence-to-conduction band transitions that are excited by near-infrared femtosecond pulses, delayed mid-infrared pulses are used to promote holes from the heavy- and light-hole band to the split-off hole band. The subsequent conduction-to-split-off-hole luminescence indicates that the room-temperature lifetime of split-off holes in GaAs is approximately 50 fs. The accompanying changes in conduction-to-valence-band luminescence could also be observed.

The broadly tunable femtosecond radiation in the mid-infrared can be used to obtain a great variety of new information on the properties semiconductor materials and devices in general. Recent results on the relaxation dynamics of microcavity semiconductor lasers following femtosecond pulse injection will also be reported briefly.

Nonlinear Optical Polymers: Ultrafast and nanoscale applications

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Nonlinear Optical Polymers developed for electro-optical and all-optical signal processing applications offer a unique opportunity for the inspection of future generations of silicon based electronic and optoelectronic devices with feature sizes in the 100 nm range and radiated fields with bandwidths in excess of 100 GHz. The need for such resolutions is anticipated by the year 2010. We demonstrate that such high resolutions are compatible with modern nonlinear polymers, ultrafast lasers and high-resolution optical metrology. We demonstrate that under two-photon resonance enhancement, centro-symmetric thin films less than 100 nm thick are capable of mapping low frequency fields at the surface of a semiconductor device with sensitivities in excess of 1 mV/μm and sub-micron resolution.

A "Real" Nonlinear Spectrophotometer

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Abstract:

We have developed a nonlinear spectrophotometer capable of measuring the nondegenerate nonlinear absorption spectrum of optical materials from 1.7 μm in the IR to 300 nm in the UV. This nondegenerate spectrum is exactly what is needed to apply causality and obtain the dispersion of the nondegenerate refractive index change. What is meant by nondegenerate here, is the change in absorption (index) at a wavelength ω due to the presence of a strong beam at another frequency Ω. Thus, the experiment is the standard pump-probe experiment; however, in order to rapidly measure nonlinear spectra, a white light continuum is used as the probe. Thus, femtosecond sources are the easiest to use to get the broadest possible continuum. This also automatically allows for temporal resolution of the nonlinear response, helping in identifying the nonlinear mechanism or mechanisms. We show examples of data taken on several materials showing different types of nonlinear responses.

PROPAGATION OF GAUSSIAN BEAMS IN DYE DOPED LIQUID CRYSTALS: EXPERIMENTAL OBSERVATION OF SPECIFIC MODES

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We have undertaken an experimental study of the propagation of beams emerging out of an optical fiber and entering in dye doped liquid crystals (L.C.) confined in capillaries with radial size larger than that one of the fibers. The beam propagates along with the axis of the capillary in a medium, which is strongly non-linear. In absence of illumination, the medium is uniaxial, with the optical axis aligned along with the capillary axis: at low power, the medium is seen as isotropic by the beam. As the input power is increased, the optical axis of the material is reoriented due to an interaction between the optical field with the averaged local L.C. dipole moment (Optical Freedricksz Effect). In our geometry, this effect occurs above a threshold. As some dye is mixed into the liquid crystal, the nature of interaction between the optical field and the mixture is a little bit different, however, the obtained macroscopic effect looks the same: a reorientation of the optical axis with a threshold which is several orders of magnitude lower (Janossy Effect). This local effect is balanced by boundary conditions yielding to an averaged molecular reorientation profile within the capillary, which in turn yields to an index profile: the light propagates through it, creating its own wave-guide structure.

We have experimentally observed the behavior of the beam propagating in such non-linear material for different input powers and we report here the major results, namely two specific situations of propagation one of them being presumably a spatial soliton. We present successively the set up, the general behavior of the propagation as the input power is increased and we focus the report on the two specific powers for which the beam looks propagating straightforward, reminding spatial soliton propagation. Studying the far field, the profile of the beam during the propagation and collision of two such beams, it is shown that the low power case can be assimilated to a spatial soliton, whereas the high power one cannot. The latter is similar to what another group has reported in a larger geometry.

Finally, some theoretical approach is given to show the role of the thermal gradient in the observed behavior.

Photoinduced Charge Transfer Reactions in Liquid Crystals for Photorefractive Applications

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Abstract

Liquid crystals are an interesting solvent for the study of electron transfer reactions. For example, optical studies of biomimetic molecules dissolved in liquid crystal solvents provide insight into the photosynthetic primary processes that occur in anisotropic membrane environments. Furthermore, from an applications viewpoint, an understanding of electron transfer reactions in liquid crystals is important because charge separation within these materials is known to dramatically increase their nonlinear optical character. With these ideas in mind, a variety of experiments are described that probe the nature of photoinduced electron transfer reactions in molecules doped into nematic liquid crystal solvents. Since the molecular and collective solvent motions of nematic liquid crystals are well characterized by non-resonant light scattering measurements, we can correlate which types of motions are important for solvating an ion pair. Further experiments are described that harness electron transfer reactions in liquid crystals to induce large photorefractive effects, i.e. changes in the index of refraction of a material due to the creation of an internal electric field by ion diffusion. Comparisons to other organic photorefractive materials are made and possible applications are discussed.

Photonic Bandgap "Crystals" Theory, Experiments, and Application to Nonlinear Optics

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California Institute of Technology

I will review recent progress in the world of artificial periodic optical "crystals" (Photonic bandgap crystals). Specific topics to be covered are:

(1) Periodic Structures
Block-Floquet Modes
Forbidden Gaps

(2) Applications:
Add/Drop Filters in Wavelength Division Multiplexing
Adiabatic Mode Converters

(3) Control of Spontaneous Emission in Semiconductor Quantum Wells

(4) Coupled Resonators Optical Waveguiding (CROW)

(5) Application to Nonlinear Optics

(6) Lasing Experiments in Photonic Bandgap "Defect" Resonator and in Whispering Gallery Mode Resonator

(7) "Thresholdless" Lasers

MANIPULATING MOLECULES FOR NONLINEAR OPTICS BY NONLINEAR OPTICS:

From fundamentals to applications in waveguides and microcavities

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Molecular nonlinear optics is currently experiencing a revival, with possible impacts in other fields, based on the conjunction of two mutually reinforcing trends. Firstly, molecular engineering has widened its scope to encompass 2-D and 3-D multipolar molecules involving multiple charge transfer pathways much beyond the earlier 1-D polar donor-acceptor template (1). Experiments based on polarized harmonic light scattering and associated molecular quantum modelling have confirmed this avenue which is currently implemented by chemistry laboratories following a variety of synthetic routes. Secondly, the traditionnal electric field thermal poling technique is being increasingly challenged by more advanced configurations whereby the electric field is partially or fully replaced by coherent single- or multi-photon excitations. The dual concepts of multipolar molecules and multipolar field tensor proposed by our group is the corner-stone of these schemes which uniquely reveal and exploit the full tensorial dimension of multipolar molecules (2). Refined orientational susceptibility patterns displaying higher order symmetry features have thus been dynamically or permanently imprinted in films, waveguides and microcavities.

Whereas *nonlinear photonic engineering* appears as a new promissing field, challenging applied and fundamental issues remain to be solved such as long term stability, participation of adequately defined mechanically excited states, optical poling yield versus absorption trade-off.

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POSTERS

OPTICAL FRÉEDERICKSZ TRANSITION INDUCED BY TWO COMPETING PULSED LASER BEAMS

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We present the characterization of a threshold effect observed in the field of two competing extraordinary light waves of a pulsed laser, travelling at an angle to the director (we refers to this effect using the designation PLANAR LIFT II).

In the far field zone we have observed patterns related to the initial transient and to the steady state above threshold.

We have characterized the behaviour of the phase shift induced in the beam with higher divergence versus the impinging power of the same beam. We have also characterized the behaviour of the threshold intensity versus the incident angle.

A circularly polarized Er^{3+}-doped fiber laser using a cavity formed by an intracore Bragg grating reflector and a cholesteric liquid crystal (CLC) mirror

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As it is well known a fiber laser usually operates with two polarization modes which are generated by the slight birefringence of the fiber core. Both these states are linearly polarized and orthogonal. We present here a new cavity design which incorporates at one end an intracore Bragg grating reflector of reflectivity 90% at 1537.3nm with 0.2nm linewidth and at the other end a CLC mirror with a selective reflection band of about 150nm. This type of cavity allows us to obtain directly a circularly polarized action out of an Er^{3+}-deped fiber around 1537nm. Two different cavity set-ups have been studied and are presented here.

EFFECT OF GOLD CLUSTER SIZE ON THE OPTICAL LIMITING RESPONSE AND DYNAMICS

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Recently, metal cluster suspensions were studied as optical limiters[1], owing to their stability properties comparable with those of carbon black particles, which were extensively investigated[2].

The optical limiting response of gold particle suspensions has been studied toward nanosecond pulses at 532 nm. The non linear optical response of particles induced by γ-radiolysis in water solution (with different diameter of 5, 18 or 30 nm) and stabilized by polyvinyl alcohol is size-dependent. The smallest clusters do not limit light transmission even at very high fluence of nanosecond laser pulses, whereas the larger clusters do strongly. The threshold of limitation depends also on the particle size. Note that such an effect of the size on limitation has never been showed before for particle suspensions. The time evolution of the optical limiting effect is measured at 600 nm by picosecond laser spectroscopy. For the particles of 18 and 30 nm diameter, it lasts 2 nanoseconds. The effects are discussed and compared with other literature data on silver [1, 3] or nickel [1]. The limitation effect is attributed to the light scattering by a microplasma formed at the surface of the particles.

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[3] P. V. Kamat and al. J. Phys. Chem. B, 102, 3123 (1998)

EXPERIMENTAL ANALYSIS OF LC REORIENTATION FOR SPATIAL SOLITON PROPAGATION OF LIGHT IN DYE DOPED NLC

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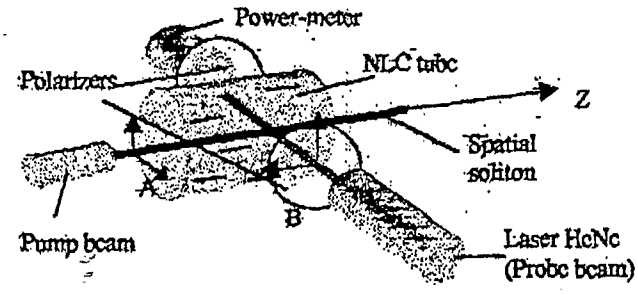
Since 15 years, optical spatial solitons have been exciting many researchers in the world. In 1993, MacLaughlin and co-workers performed experiments on self-trapping of a beam in a nematic liquid crystal. They observed self-focusing and filamentation of the beam for a moderate power of the laser (1 KWatt). We have performed a similar experiment, but with a different way of injecting the pump beam, and a slightly differently sized system. An optical single-mode fiber, penetrating the a due doped LC, is used to enter the beam within the LC. For a given power of the laser, we obtain a steady-state spatial soliton propagating along with the capillary axis (z, see picture below).

In this work, we have analyzed the evolution of the reorientation of LC during the formation of the spatial soliton. For this purpose, we have sent a probe laser beam perpendicular to the soliton axis (see the picture below). As the soliton is observed, the modification of the transmission of the probe beam between crossed polarizers is recorded and exhibits periodic damped oscillations revealing the director reorientation change via the birefringence. We compare this phenomenon for different polarizations of the light inducing the soliton (A) and also for different polarizations of the probe beam (B).



We discuss then the relation between the oscillations and the reorientation of the LC.

The estimation of the effective conjugation length of Polythiophene derivative P(S)MBET

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Although the optical property of a polymer is dependent on the effective conjugation length distribution, there is few report of estimating the effective conjugation length and the estimated length of polythiophene vary widely. In this study we estimated the average effective conjugation length from absorption and $|\chi^{(3)}|$ spectra.

Figure 1 shows polythiophene derivative, poly(3-[2-((S)-2-methylbutoxy)ethyl]thiophene) [1] , which is hereafter denoted as P(S)MBET. Since the sidechain in P(S)MBET contains the ether coupling (R-O-R') which is less rigid than the C-C coupling, the interaction between sidechains can be reduced, and it is expected that the torsion occur at random position. We prepared a Langmuir-Blodgett (LB) film of P(S)MBET and measured the absorption spectrum and $|\chi^{(3)}|$ one which was obtained by four-wave-mixing method (Fig. 2). The estimation was carried out by comparing measured spectra with corresponding spectra obtained by the calculation. The calculation was done by following strategies; [2]

(1) The molecular weight, i.e. chain length, follows the Flory-Schulz distribution [3].

(2) The torsion occurs at random position because of the flexibility of sidechains.

(3) The transition energy is proportional to the reciprocal of the effective conjugation length.

(4) The dipole moment is proportional to the square root of the effective conjugation length.

(5) The third order nonlinearity $\chi^{(3)}$ is arising from the ideal two levels system.

The average effective conjugation lengths at 10K and room temperature were estimated to be approximately 21- and 15-thiophene rings, respectively.

Reference

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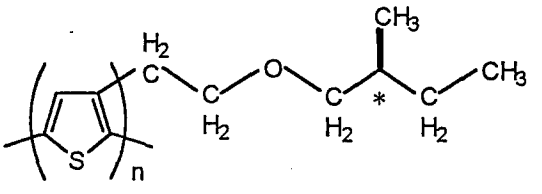

Fig. 1 The chemical structure of P(S)MBET

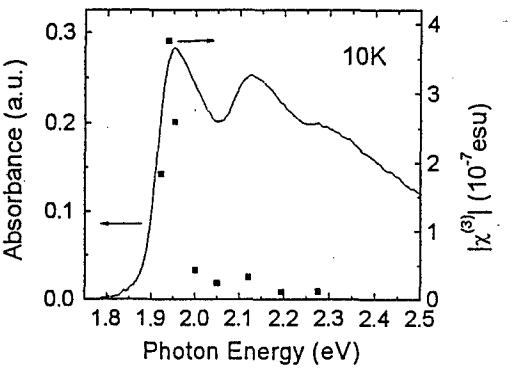

Fig. 2 Absorption and $|\chi^{(3)}|$ spectra of P(S)MBET

Transient Distributed Thermelectric Effect For Energy Conversion and Vibrometry

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Abstract
We suggest new methods of energy conversion and detection of small vibrations, using transient distributed thermooelectric effect. This method is based on conversion of nonionizing infrared radiation into electric current by optimal modulation of rradiation in time and space. Our model
show promising characteristics of this novel effect.

Electro-optical switching with a high contrast ratio in a Polymer Dispersed Liquid Crystal

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Presentation style: Poster Presentation

Key words: optical switching, liquid crystals, electro-optical characterisation

Abstract

Liquid crystal polymer composites have been widely studied in the last years because of potential applications in switchable windows, displays, colour projectors and other electro-optical devices.
These composite materials are known as Polymer Dispersed Liquid Crystals (PDLC's) and are constituted of Liquid Crystal (LC) droplets embedded in a polymeric matrix.
A PDLC film sandwiched between substrates having a transparent conducting electrode, such as Indium Tin Oxide (ITO), forms a shutter. Upon application of a voltage across the electrodes of the shutter, it switches from a light scattering state to a transparent one. The applied electric field aligns the molecular director of LC inside the droplets so that their refractive index matches that of the polymer and this results in a drastic decreasing of the light scattered.
Employing PDLC films in electro-optical devices depends on their properties: they must operate over a broad range of temperature and must switch fast. Therefore, it is necessary to measure their electro-optical performance and the response time.
In this communication we present experimental results on electro-optical properties of PDLC samples prepared in our laboratories, consisting of nematic liquid crystal (commercially known as E7) droplets in a epoxy resin binder. The sample thickness was 50 μm. We measured the rise time and the decay time as a function of the applied electric field (square wave) and also the transmitted light *vs* the applied voltage.
The experimental results showed promising switching times with a rise time of 200 μsec and a decay time of 2.2 msec and an exceptionally high contrast ratio up to 410.
These results demonstrate the validity of employing this new PDLC in electro-optical devices.

Photorefractivity and local heating to fix holographic gratings in dyed PDLC.

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We have carried out a detailed investigation of the photorefractive origin of the permanent orientational gratings[1] induced using a holographic technique in a dyed PDLC film. This investigation has been performed by use of optical two wave mixing characterization with two beam coupling (TBC) experiments. We determine the TBC gain by means of asymmetric energy transfer measurements and the photorefractive phase shift with a translation technique.

The photorefractive origin of the effect has been proved by the experimental results. Nevertheless some peculiarities show the presence of other mechanisms that combine with the photorefractivity to obtain the observed storage effect. The long time stability and some characteristic of the recorded structure are explained as a thermal fixing of the gratings. During the writing process due to the light absorption, the sample is locally heated; in this condition the space charge field effect can modify the interfaces and consequently the orientation of the liquid crystal inside the droplets. After removing the two writing beams this new configuration is frozen. Some experiments are in progress to investigate the modification at the interface in the irradiated region.

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Photocurrent mesurements in dye doped polymers and PDLC

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We report a preliminary study of the photocurrent in dye doped polymeric materials and polymer dispersed liquid crystals. The measurements have been performed during irradiation the sample by Ar^+ laser beam, the analysis have been done in function of both intensity and temperature. The intensity gradient along the propagation direction of the beam arising due to the absorption of the dye, allow to investigate the presence of charge photogeneration and diffusion via detection of the current in the same direction. Typical order of magnitude of photocurrent was $\sim 10^{-10}$A and of correspondent photovoltages $\sim 10^{-4}$V.The comparison of the measurements obtained for the two materials mentioned above indicate that the presence of the liquid crystal do not change substantially the behavior and the time dependence of the current. The results lead to conclusion that charge separation, due to the charge flow induced by the concentration gradient, originate an internal electric field. The growth of this field compete with the charge diffusion process producing the current reduction across the sample.

Exploration of third order nonlinearity in chalcogenide glasses.

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Abstract.

Third order nonlinearity, especially intensity dependent refractive index, has been studied in glasses for all-optical switching device applications. Glasses present good potentialities for these applications: transparency in a large bandwidth, low linear losses, easy shaping in various geometries such as bulks or fibers. Among the different glass families listed in the literature, chalcogenides seem to present the higher non-linear refractive index.

Non-linear refractive index (n_2) and non-linear absorption coefficient (β) have been measured for glasses of Ge-Se, Ge-As-Se and As-Se-S systems by the z-scan technique at 1064 nm. This glasses exhibit n_2 750 times higher than that of silica.

Non-linear properties of Ge_xSe_{1-x} glasses, in the range x= 0.05 to 0.30 have been studied and an atypic result has been obtained for $Ge_{15}Se_{85}$. A Raman investigation showed an atypic result for the same composition. For all the Ge_xSe_{1-x} glasses, the Raman spectra present a band near 260 cm^{-1} attributed to Se-Se vibration, a band at 200 cm^{-1} with a shoulder at 215 cm^{-1} originated from Ge-Se vibration in $GeSe_4$ corner-sharing tetrahedra (Td) and Ge-Se vibration in $GeSe_4$ edge-sharing tetrahedra respectively. The edge-sharing tetrahedra represent four members rings. The Raman spectra are deconvoluted into a set of Gaussian peaks. The Td $GeSe_4$/rings ratio increases from x= 0.05 to 0.15 then decreases until x=0.30. The non-linear refractive indices present the same evolution excepted for the $Ge_{30}Se_{70}$ glass. The Td $GeSe_4$/Se-Se bounds ratio is in relation with n_2 too.

Non-linear refractive index has been measured at different irradiance levels for an AsSe glass. We observed a variation then a saturation of the non-linear refractive index.

Analysis of the dynamical regimes laser induced in nematic liquid crystal films.

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We analyse the temporal evolution of the polarization state of a laser beam transmitted by a NLC film in which molecular reorientation effects are induced.
We obtain the Fourier spectra of the parameters that describe the light polarisation state and we reconstruct the phase space of the system. This analysis shows that, as the control parameter increases, the polarisation state goes from a regular regime to a stochastic one trough a series of interesting transitions.

Polarimetric study of the optically induced dynamical behavior in nematic liquid crystal films

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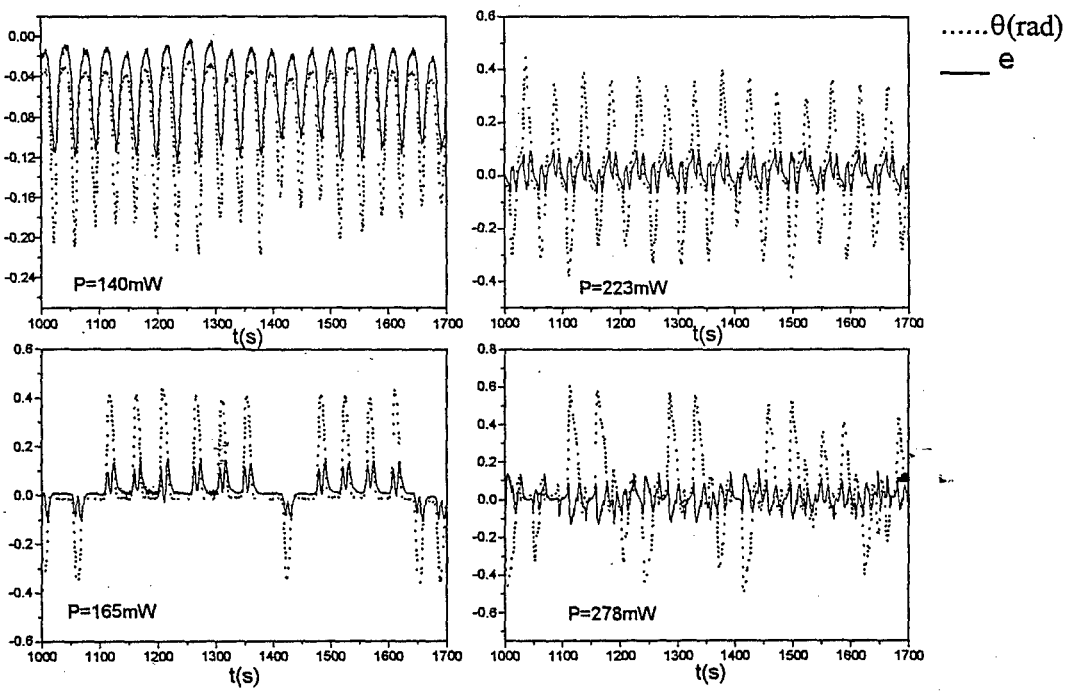
We present the polarimetric study of the dynamical behavior of the molecular director observed in a nematic liquid crystal sample when an s- polarized laser beam impinges with a small angle in a omeotropically aligned nematic liquid crystal film. We propose a new experimental apparatus which, using a pump probe technique and a new polarimeter (four detector polarimeter), allows us to measure with a good resolution the variation on the polarization state of the laser probe during the molecular reorientation induced by a laser pump beam in the sample. We study the time evolution of both the ellipticity and the polar angle, we show some interesting bifurcations towards a chaotic state as the incident intensity increases.



Soliton-like Propagation in Biexciton Two-Photon Resonant Region

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Recently, we proposed a new scheme of soliton-like propagation in excitonic resonant region supported by biexciton two-photon dispersion [1]. The principle of our soliton-like propagation is shown in Fig. 1. The dotted curve shows the linear exciton polariton dispersion curve in CuCl and the solid curve shows the total dispersion curve $[k(\omega)+k^{NL}(\omega)]$. The nonlinear dispersion compensates polariton dispersion in the frequency region of the input pulse at certain intensity. We performed sub-ps pulse propagation experiments under several conditions using biexciton two-photon resonance in CuCl (Fig. 2) and compared the results with the calculated results using the frequency domain wave equation. We obtained good agreement between them, and confirmed that the soliton-like propagation was supported by biexciton two-photon dispersion [2]. However, because of using biexciton two-photon resonance, the pulse suffers strong two-photon absorption (TPA). In the present study, to decrease the effect of biexciton TPA, we propose the following pulse propagation.

In the following pulse propagation, a weak signal pulse follows a strong pump pulse. Signal pulse propagates in the nonlinear dispersion that is made by the pump pulse. We can expect that if signal pulse propagates before the nonlinear dispersion relaxes, signal pulse propagates without broadening. The experimental results will be presented.

References

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[2] M. Sakai, *et al*, IEEE Nonlinear Optics '98 (Cat. No.98CH36244), 236-8 (1998)

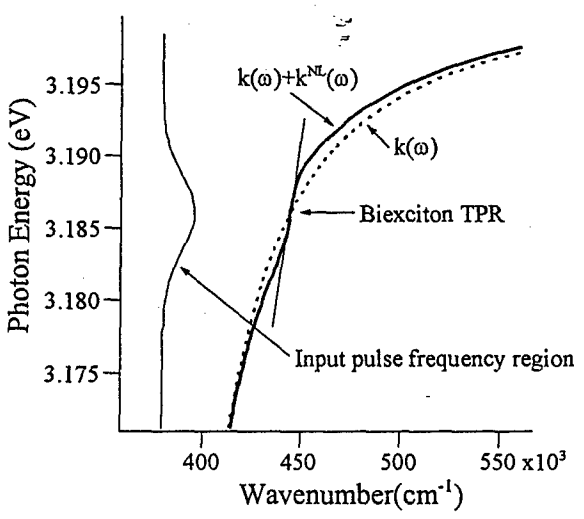

Fig. 1 Dispersion curve in biexciton TPR region

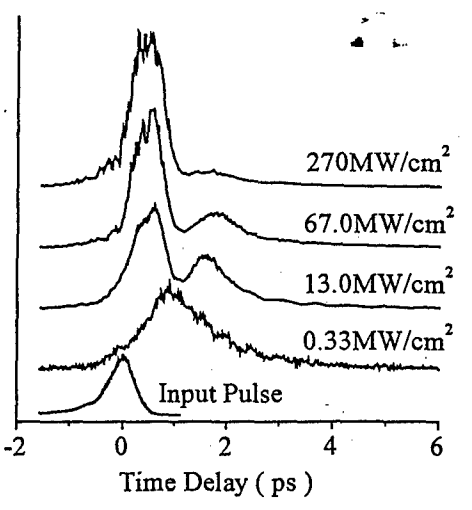

Fig. 2 Pulse shape of propagated pulse

Solitons of Singly Resonant Optical Parametric Oscillators

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We present a model for Singly-Resonant-Optical-Parametric-Oscillators (SROPOs) applicable to the design of repetitively pumped ultrafast SROPOs.

In the mean field limit, we show that a modified cubic-quintic nonlinear Ginzburg-Landau evolution equation describes accurately the evolution of the resonated signal wave. Similar evolution equations accurately predict the pulse evolution of mode-locked lasers and amplified optical fiber links. More importantly, the soliton solutions of this single equation can be used as design tools for ultrafast OPOs. For example, in the cubic nonlinear Ginzburg-Landau limit, analytical solutions can easily be obtained.

Extremely nonlinear photosensitive liquid crystals

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Abstract:
In methyl-red doped nematic liquid crystal films, we have observed an extraordinarily large nonlinear refractive index change mechanism accociated with optically induced director axis reorientations. We discuss the origins of these nonlinearities, and present the results of recent experimental studies of image conversion, optical limiting and sensor protection using aligned dye-doped nematic liquid crystal films in all-optical configurations. These processes are characterized by unprecedented low threshold laser powers, thus presenting nonlinear photosensitive nematic liquid crystals as promising next generation image processing and optical switching/limiting material.