INTERNATIONAL SYMPOSIUM

"PHOTONS AND PHONONS IN SOLIDS"

TO HONOR PETER HALEVI

on the occasion of his 70th birthday

Instituto de Física de la BUAP, Puebla, Pue., Mexico
January 27 and 28, 2005

ABSTRACTS

Sponsored by the Consejo Nacional de Ciencia y Tecnología de México.

INVITED TALKS

MEAN FIELD THEORY OF METALLO-DIELECTRIC PHOTONIC CRYSTALS - I

Peter Halevi*
Instituto Nacional de Astrofísica, Optica y Electrónica
Apartado Postal 51 y 216, Puebla, Pue, 72000.

Metallo-dielectric photonic crystals (MDPCs) are artificial composite materials that exhibit, in general, three-dimensional periodicity. Every unit cell of the MDPC includes a (dominant) metallic inclusion, the rest of the unit cell being occupied by a dielectric or air. An incident electromagnetic wave induces both electric and magnetic dipoles in every unit cell, thus leading to both polarization and magnetization of the medium. In the first part of my talk I will review some of the extraordinary electric, magnetic, and optical properties of MDPCs, usually occuring in the GHz regime of the spectrum (vacuum wavelength on the order of 1 cm). Depending on the geometry of the unit cell and on the precise frequency value, MDPCs may be characterized by either a positive or a negative refractive index. In the latter case, negative refraction occurs with important consequences for geometric optics – for example, overcoming the diffraction limit.

In the second part of the talk I will outline a mean-field theory of MDPCs; namely, I will present formulas for the effective permittivity and the effective permeability of the MDPC; these, of course, determine the frequency-dependent refractive index. Results will be given for arbitrary geometry of the unit cell and of the Bravais lattice, as well as for the important special case of cubic symmetry. The only material parameter in this calculation is the conductivity of the metallic constituent.

* In collaboration with Felipe Pérez-Rodríguez, IFUAP

MEAN FIELD THEORY OF METALLO-DIELECTRIC PHOTONIC CRYSTALS – II*

Felipe Pérez-Rodríguez**
Instituto de Física de la Benemérita Universidad Autónoma de Puebla,
Apdo. Post. J-48, Puebla, Pue. 72570, Mexico

Applying the theory of metallo-dielectric photonic crystals (MDPCs), the effective permittivity for specific MDPCs, such as cubic arrays of small spheres and thin-wire lattices, is calculated. The obtained formulas for the effective permittivity are rather simple and allow to determine its dependence on the conductivity of the metallic constituent. I shall compare the new formulas with those obtained within previous theories. The advantages of our theory of MDPCs are discussed.

* This work is partially supported by CONACYT (Grant J200.627/2001)
** In collaboration with Peter Halevi, INAOE

EFFECTIVE PARAMETERS OF PERIODIC MEDIA AND THEORY OF HOMOGENIZATION OF PHOTONIC AND PHONONIC CRYSTALS

Arkadii Krokhin
University of North Texas, Denton, TX 76203

The theory of homogenization deals with behavior of inhomogeneous media in the long-wavelength limit. Usually inhomogeneous media contains inclusions imbedded in a homogeneous matrix (background). In the long-wavelength limit an inhomogeneous medium may behave as a homogeneous one due to the averaging over space scales of the order of the wavelength. If this happens the effective parameters may be introduced for the inhomogeneous medium. In this presentation I show how to calculate the effective parameters, speed of light and speed of sound, for periodic dielectric and elastic media. These artificial periodic structures are widely used in modern optoelectronics and acoustics and they are called photonic and phononic crystals.

PHOTONIC CRYSTALS AND PHOTONIC CRYSTAL FIBERS

Jesús Arriaga
Instituto de Física "Luis Rivera Terrazas"
BUAP, Apdo. Postal. J-48, 72570, Puebla, Pue., México

One of the potential applications of Photonic Crystals are the so-called photonic crystla fibers. These systems can be constructed, for example, using a long thread of silica glass with a periodic array of air-holes running down its length. If the central hole is absent, we generate a high-index "defect" in the repeatng structure which acts like the core of an optical fiber. Light which is expelled from the periodic structure surrounding the core can only propagate along it. It has been demonstrated that the photonic crystal fibers have very unusual properties compared by the conventional fibers. For example, anomalous dispersion can be obtained at wavelengths were both the group velocity dispersion of pure silica and that of convencional single-mode fiber is normal. This has recently enabled the demonstration of soliton propagation and superbroad white-light generation.

ACOUSTIC WAVES IN ONE – AND TWO – DIMENSIONAL PHONONIC CRYSTALS*

F. Ramos-Mendieta
Centro de Investigación en Física, Universidad de Sonora, Hermosillo, México

The so-called acoustic or *phononic crystals* (PnC's) are artificial heterogeneous arrays with mass density $\rho(\boldsymbol{x})$ and sound velocities $c_t(\boldsymbol{x})$ and $c_l(\boldsymbol{x})$ spatially periodic. The elastic vibrations in PnC's are described by a band theory. Depending on the material and structural parameters it can appear bands of forbidden wave propagation – *the band gaps* - due to diffraction effects only. We have studied some properties of PnC's of 1D and 2D periodicity; some of the main results are presented in this talk. In 1D systems we found that the band gaps close when the frequency and wave vector satisfy the Brewster condition. As in the optical case in acoustic there exists the Brewster acoustic angle. We studied its effects in Zn/Fe, Pb/Fe and Si/Au multilayers. On the other hand we found that the transmittance of acoustic waves through finite superlattices can be enhanced. The effect requires the assistance of a surface resonance. Peaks of wave transmission were found in the systems Al/W, Mo/W, Pt/Mo with any of the two solids as medium of incidence and water as the transmission medium. For 2D PnC's we calculated the dispersion relation of the surface elastic waves. In addition to the Rayleigh-type modes we have reported the existence of new modes whose confinement at the surface results from wave diffraction. It was found that the elastic displacement of the surface modes in the square array of W cylinders in Si penetrates with exponential decay as far as three unit cells inside the crystal. On the other hand, very recently we have demonstrated the tuning of PnC's with the temperature. Variations as higher as 30% were found for both the mid-frequency gaps and the surface mode frequencies in the 1D system Epoxy/Polyvinylacetate when the temperature changes from 2 to 95 $^{\circ}$C. Finally, on the experimental side, we have proved the existence of omnidirectional acoustic band gaps in Pb/Epoxy 1D systems. The thicknesses of the layers were chosen in order to have the omnidirectional gap at a few hundred of kHz.

*Work realized with the close collaboration of Betsabé Manzanares-Martínez (UNISON-Navojoa)

SIMULACIÓN NUMÉRICA DE ÓPALOS COMO CRISTALES FOTÓNICOS

Dr. Jesús Manzanares Martínez
Departamento de Investigación en Fisica,Universidad de Sonora

Los cristales fotónicos a base de ópalos están constituidos por esferas submicrometricas que se agrupan formando una red cristalina. Estas estructuras difractan la luz gracias a que su periodicidad es del orden de la longitud de onda en el visible. Se presenta la simulación numérica de las propiedades ópticas de películas delgadas de ópalo utilizando un Método de Diferencias Finitas. Se hace un análisis de algunas características finas del espectro de reflexión. *Primero*, se presenta la dependencia del espectro de reflexión en función del número de capas. *Segundo*, se estudia el fenómeno de difracción de Bragg múltiple que se manifiesta cuando se hace un estudio en función del ángulo de incidencia. *Tercero,* se analiza el rol de la polarización y la variación azimutal en las propiedades ópticas. En estos *tres* puntos, nuestros resultados teóricos son comparados con resultados experimentales. *A continuación*, mostramos la influencia del desorden sobre la transmisión de la luz para un cristal fotónico bidimensional. El desorden modifica la transmisión en la Banda Fotónica Prohibida (BFP). Se muestra que la transmisión difusa es sustancialmente diferente de la transmisión derecha. El mínimo de la transmisión difusa no corresponde al centro de la BFP. El desorden ensancha la transmisión en la BFP en forma asimétrica. Se demuestra que es necesario pasar por un cierto umbral de desorden afín de obtener un cambio en el espectro de transmisión. *Por ultimo,* se hace una pequeña presentación del Proyecto Europeo PHOBOS. Este proyecto fue dedicado al estudio de los ópalos como materiales de BFP. Los resultados de esta presentación están inscritos en el marco de este proyecto.

SYNTHETIC SPECTRA FROM ROUGH SURFACE SCATTERING

A. A. Maradudin
Department of Physics and Astronomy, University of California, Irvine, CA 92697

In recent years interest has arisen in the design of diffractive optical elements for spectral functions, in particular in the design of one-dimensional rough surfaces that synthesize the infrared spectra of real compounds [1,2,3]. Such surfaces can be used in correlation spectroscopy, in which the degree of correlation between the transmission of light through, or its reflection from, an unknown sample and that of a reference cell containing a known compound is determined over a fixed spectral range, as a means of identifying the unknown sample [4]. In the case that the known compound in the reference cell is toxic and/or corrosive, it is useful to have a diffractive optical element that synthesizes the infrared spectrum of that compound for use in a correlation spectrometer. In contrast to the deterministic approach to the design of one-dimensional rough surfaces that synthesize experimental infrared spectra adopted in [1,2,3], we propose an alternative, probabilistic approach to the solution of this problem. It is based on the assumption that the surface profile function of the surface defined by $x_3 = \zeta(x_1)$ has the form

$$\zeta(x_1) = bd_n, \qquad nb < x_1 < (n+1)b, \qquad n = -N, -N+1, ..., N-1, \tag{1}$$

where $\{ d_n \}$ are independent, identically distributed, random deviates, and b is a characteristic length. Therefore, the probability density function of d_n, $f(\gamma) = <\delta(\gamma - d_n)>$, where the angle brackets denote an average over an ensemble of realizations of the $\{ d_n \}$, is independent of n. The problem of determining $f(\gamma)$ reduces to the problem of reconstructing a function from a knowledge of the modulus of its Fourier transform, where the latter function is expressed in terms of the spectrum we wish to reproduce. The solution of this problem is obtained by the use of a modified Gerchberg-Saxton algorithm [5]. A sequence of $\{ d_n \}$ is obtained from $f(\gamma)$ by means of the rejection method, and a realization of the surface profile determined by the use of Eq. (1). Our approach is validated by means of scattering calculations based on the Kirchhoff approximation.

References

[1] M. B. Sinclair, M. A. Butler, A. J. Ricco, and S. D. Senturia, Appl. Opt. **36**, 3342 (1997).
[2] M. B. Sinclair, M. A. Butler, S. H. Kravitz, W. J. Zubrzycki, and A. Ricco, Opt. Lett. **22**, 1036 (1997).
[3] G. Zhou, F. E. H. Tay, and F. S. Chau, Opt. Express **11**, 1291 (2003).
[4] R. Goody, J. Opt. Soc. Am. **58**, 900 (1968)
[5] R. W. Gerchberg and W. O. Saxton, Optik **35**, 237 (1972)

IMPURITIES AND RANDOM DISORDER EFFECTS IN THE PHOTONIC KRONIG-PENNEY MODEL. THEORY vs. EXPERIMENT

G.A. Luna-Acosta[+,*] **H. Schanze**[*]**, U. Kuhl**[*]**, and H.-J. Stöckman.**[*]
(+) Instituto de Física, Universidad Autónoma de Puebla,
Apdo, Postal J-48, Puebla, Pue, 72570, México;
(*) Fachbereich Physik der Philipps Universität Marburg, Renthof 5,
D-35032, Marburg, Germany.

We experimentally and theoretically investigate the effects of single defects and random positional disorder in 1D photonic lattices of finite length. The set-up consists of an array of teflon pieces of length d_T alternating periodically with air spacings of length d_A in a single-mode microwave guide. Since the system is governed by the Helmholtz equation, our results are also pertinent to the corresponding quantum system. On the one hand, we predict, and observe in the transmission measurements, the appearance of distinguishing effects of various types of impurity defects. On the other, positional random disorder is achieved by an uncorrelated random variation ξ of the air spacings and/or the teflon inserts. We show that "Teflon resonances" play a fundamental role in determining the transport effects of weak, intermediate, and strong random positional disorder. Specifically, teflon resonances inhibit strongly the Anderson localization of states. We discuss our results in connection with theories of correlated and uncorrelated random disorder in 1D potentials.

FIRST PRINCIPLES TOTAL ENERGY CALCULATIONS OF THE ADSORPTION OF GERMANE AND DIGERMANE ON Ge(001)

Gregorio H. Cocoletzi
Instituto de Física, Universidad Autónoma de Puebla

Experimental studies of the adsorption of disilane (Si_2H_6) and digermane (Ge_2H_6), and the epitaxial growth of Si on Si(001)[1] and Ge(001) [2] have been reported in the literature. Evidences show that the adsorption of SiH_4 (silane) and Si_2H_6 molecules on Si(001) surfaces is a dissociative process with the formation of SiH_3 and SiH_2 fragments. Similarly, the adsorption of GeH_4 (germane) and Ge_2H_6 on Si(001) [3] is a dissociative process, with the formation of GeH_3 and GeH_2 fragments. Taking into account these evidences we perform first principles total energy calculations to study the energetics and the atomic structure of the adsorption of GeH_4 and Ge_2H_6 on Ge(001). We consider the models used in previous studies to optimize the electronic and atomic structure of the adsorption of: (A) a GeH_2 molecule in two configurations. (B) GeH_2 plus two H atoms in two configurations and SiH_3 plus H atom in one configuration. And (C) two GeH_3 in two different dimer sites, and two SiH_2 plus two H atoms in two different configurations. In agreement with the adsorption of silane, disilane, germane and digermane on Si(001), and of silane and disilane on Ge(001), we find that in the adsorption of GeH_2 the most favorable atomic structure corresponds to the on dimer site. In contrast, when GeH_2 is considered together with two H atoms, the intra-row site is the most stable geometry. Finally, in the adsorption of two GeH_3 the on a-dimer site is the most favorable structure, and in the adsorption of two GeH_2 plus two H atoms, the intra-row adsorption of both GeH_2 molecules with the H atoms adsorbed on an adjacent dimer is the most favorable configuration.

References.

[1] M. J. Bronikowski, Y. Wang, M. T. McEllistrem, D. Chen, and R. J. Hamers, Surf. Sci. **298**, 50 (1993).

[2] D.-S. Lin, T. Miller, and T.-C. Chiang, Phys. Rev. B **47**, 6543 (1993).

[3] K.-H. Huang, T.-S. Ku, and D.-S. Lin, Phys. Rev. B **56**, 4878 (1997).

SIMPLE PLASMON MULTIPLEXERS

L. Dobrzynski *[1] , M. Beaugeois [2], A. Akjouj [1], B. Djafari-Rouhani [1], J.O. Vasseur [1], M. Bouazaoui [2] ,J.P. Vilcot [3], J.P. Vigneron [4]

[1] Laboratoire de Dynamique et Structures des Matériaux Moléculaires, CNRS-UMR 8024, Université de Lille 1, 59655 Villeneuve d'Ascq Cedex, France

[2] Laboratoire de Physique des Lasers, Atomes et Molécules, CNRS-UMR 8523, Université de Lille 1, 59655 Villeneuve d'Ascq Cedex, France

[3] Institut d'Electronique, de Microélectronique et de Nanotechnologies, CNRS-UMR 8520, Université de Lille 1, 59655 Villeneuve d'Ascq Cedex, France

[4] Facultés Universitaires Notre Dame de la Paix, rue de Bruxelles 61, B-5000 Namur, Belgium

We present a new type of multiplexing device for the telecommunications. This device uses two discrete (1) or continuous (2) plasmon wires, coupled by two nanometric metallic clusters. We show that a wavelength can be transferred from a wave-guide to another one without disturbing the others wavelengths. We give in closed form the transmission coefficients by using interactions based on a quasi static approach and including damping effects. We proposed also similar devices for photon, phonon, electron and magnon multiplexers (3).

[1] L. Dobrzynski, A. Akjouj, B. Djafari-Rouhani, J.O. Vasseur, M. Bouazaoui, J.P. Vilcot, H. Al-Wahsh, P. Zielinski, J.P. Vigneron, Phys. Rev. E **69** (2004) 035601.

[2] M. Beaugeois , L. Dobrzynski, A. Akjouj, B. Djafari-Rouhani, J.O. Vasseur, M. Bouazaoui, J.P. Vilcot, J.P. Vigneron, to be published.

[3] See for example: J.O. Vasseur, A. Akjouj, L. Dobrzynski, B. Djafari-Rouhani, E.H. El Boudouti, Sur. Sci. Rep. **54** (2004) 1.

SINGLE-BEAM AND CROSSED-BEAMS SHG GENERATION FROM Si NANOCRYSTALS

Dr. Luis Mochán
Centro de Ciencias Físicas, UNAM
Apartado Postal 48-3, 62251 Cuernavaca, Morelos, México

Optical second harmonic generation (SHG) may be used as a noninvasive probe of buried interfaces, such as those of Si nanocrystals (nC) embedded within a SiO2 matrix in novel memory devices. We calculate the SHG angular pattern from a single nC and find that it produces no forward radiation when illuminated by a plane wave. However, when a nC composite is illuminated by a non-uniform finite beam, quadrupolarly-originated SH radiation appears along two lobes close to the forward radiation. Experiment has confirmed the angular pattern predicted and the sensibility of the signal to the state of the nC-host interface. Paradoxically, as the signal depends on the lateral variation of the beam, more powerful lasers yield a reduced SH signal, defeating their purpose. However, the signal may be enhanced several orders of magnitude in a two beam geometry, in which the interference between the two beams provide the strong field variation required for an efficient quadrupolar radiation. The dependence of the SH signal on the polarization of the beams, their crossing position within the sample and the sample conmposition will be discussed.

GENERACIÓN DE SEGUNDO ARMÓNICO POR NANOCRISTALES DE SI ILUMINADOS CON UN HAZ Y CON HACES CRUZADOS

La generación de segundo armónico (GSA) puede emplearse como una sonda no invasiva de interfaces enterradas, tal y como la de los nanocristales de Si (nC) inmersas en una matriz de SiO2 que conforman un tipo novedoso de dispositivos de memoria. Calculamos el patrón angular de GSA producido por un nC individual, hallando que no produce radiación en la dirección frontal cuando es iluminado por una onda plana. Sin embargo, cuando un compuesto es iluminado con un haz finito no-uniforme, radiación de SA aparece en dos lóbulos cercanos a la dirección frontal. Experimentos han confirmado el patrón angular predicho y la sensibilidad de la señal al estado de la interface nC-matriz. Paradójicamente, como la señal depende la variación lateral del haz, láseres más potentes producen señales más débiles. Sin embargo, la señal se puede incrementar varios órdenes de magnitud empleando una geometría de dos haces, en la cual la interferencia entre los haces provee las fuertes variaciones espaciales requeridas para una radiación cuadrupolar eficiente. La dependencia de la señal de GSA en la polarización de los haces, en su punto de cruce y en la composición de la muestra será discutida.

EXCITONIC PROPERTIES OF ONE-MONOLAYER THICK QUANTUM WELLS AND QUANTUM DOTS OF II-VI SEMICONDUCTORS*

Isaac Hernández-Calderón[#]
Physics Department - CINVESTAV, Av. IPN 2508, 07360 México, DF., México
Isaac.Hernandez@fis.cinvestav.mx

We have demonstrated that no more than 4 monolayers thick quantum wells (1 ML = $a/2$, where a is the lattice constant) of CdTe or CdSe were required to cover the red to blue spectral range [1]. In the case of CdTe the barriers were made of ZnTe and in the case of CdSe the barrier was ZnSe. These ultra-thin quantum wells (UTQWs) were grown by atomic layer epitaxy (ALE). Low temperature photoluminescence spectroscopy revealed that most of them presented very intense and relatively narrow excitonic emission and, depending on growth conditions, no thickness fluctuations are observed over the whole sample area. In-situ Reflection high energy electron diffraction (RHEED) experiments indicated a 2D growth of the nanostructures and the real-time temporal analysis of the intensity of RHEED pattern features demonstrated the absence of degradation of the structural quality of the QW film during the ALE growth. In this work we will focus on the properties of 1 ML thick UTQWs and fractional monolayer quantum dots (FMQDs) produced by the deposition of ~ 0.5 and ~ 0.25 ML of CdSe which present very intense and narrow excitonic emission. The sharp luminescence is indicative of their highly uniform and homogeneous size and shape; deep blue emission is obtained from these ultra-thin quantum dots. Even though the 1ML QWs are very thin, the calculated transitions obtained by means of the envelope function in the effective mass approximation are in quite good agreement with the observed excitonic transitions. A brief discussion about the description and interpretation of these subnanometric structures and their physical properties will be made.

[1] I. Hernández-Calderón, et al, Phys. Status Solidi (b)**24**, 558 (2004).

*Partially supported by Conacyt.
In collaboration with M. García-Rocha, P. Díaz-Arencibia.

NANO-STRUCTURES IN SI-GE FILMS

A.Kosarev, A.Torres
Institute National for Astrophysics, optics and Electronics, Puebla, Mexico

It is not sufficient to fabricate something of nano-size for nano-electronics, which has used nano-sized films for years. It is necessary to get some quantum effects, which could open new functional facilities for devices. For potential industrial applications only methods, which enable formation and positioning of elements in nano-scale in parallel are of interest rather than scanning techniques with electron (or other) beam, scanning tunnel microscope etc., which operate in point-by-point regime. At present two principal ideas of self-assembling and self-organization are being developed for nano scale structures and their organization. They are studied and developed for preparation of semiconductor nano-materials and nano-device structures and requires usually high temperature processes at T≈ 1000 C°. Molecular beam epitaxy is conventionally used method for fabrication of nano-materials and nano-structures for electronics. Though this technique can be employed for rather specific tasks, rather than for large-scale production of electronic devices. Therefore low temperature processes with scaling up opportunity as e.g. plasma deposition are very attractive. Firstly we shall give a brief overview of the recent results for crystalline Si-Ge nano-structures prepared by various techniques. The second part will concern the investigations performed by INAOE for plasma deposited Si-Ge films. We shall demonstrate some examples of nano-structures in Si-Ge films and also examples of self-organized structures, some of which has periodicity comparable with optical wavelength.

Acknowledgement. This work is performed in the framework of CIAM-2002 program supported by the CONACyT project # 42367.

SURFACE MODES IN ONE-DIMENSIONAL PHOTONIC CRYSTAL WITH LEFT-HANDED MATERIALS.

Jorge A. Gaspar and Francisco Villa*
Centro de Investigación en Física de la Universidad de Sonora
Apdo. Postal 5-088, 83000 Hermosillo, Sonora, México.
**Centro de Investigaciones en Óptica, A. C., León, Guanajuato. México.*

We study the surface modes in one-dimensional photonic crystals whose unit cell is composed by right-handed (rhm) and left-handed material (lhm), for both dispersive and non-dispersive lhm. For the special case of dispersionless lhm, the band structure is computed and surface modes are found inside the bandgaps and also below the light line of the medium with the highest refractive index (its absolute value). In the last case, the surface mode is related to the band of modes formed by interface modes. The topology of the band structure depends on the average refractive index, being very different when this is negative in comparison to positive values.

We consider also a photonic crystal with dispersive lhm. The dielectric function is represented by a Drude model that is negative for frequencies below the plasma frequency, ω_p, while the magnetic permeability is represented by a Lorentz oscillator model, which becomes negative between a transverse magnetic frequency ω_{mT} and a longitudinal frequency ω_{mL}. The frequency ω_p is chosen larger than ω_{mL}, so that both functions become negative in the interval between ω_{mT} and ω_{mL}, and then the refractive index is negative.

For a one dimensional photonic crystal that contains a dispersive lhm in its unit cell, it is know the existence of a bandgap about the frequency where the average refractive index equals zero. Clearly this occurs when the refractive index of the lhm is negative. We find a surface mode located inside this gap and show its electric field. We observe several bandgaps that pile up as we approach ω_{mT}. This region is very sensitive to absorption as we show in calculations of reflectivity.

ELECTROMECHANICAL EFFECTS IN LIQUID CRYSTALS

Antal Jákli
Liquid Crystal Institute and Chemical Physics Interdisciplinary Program,
Kent State University, Kent, OH 44242, USA

Liquid crystals are orientationally ordered fluids with various range of positional ordering. Nematic liquid crystals that are used in LCDs, are 3-D anisotropic fluids; smectic liquid crystals (such as soap, cell membranes) are 2-D fluids; and columnar liquid crystals have 1-D fluidity. Liquid crystals exhibit a large number of symmetries ranging from the uniaxial D_∞ symmetry of nematic liquid crystals of rod-shape molecules to the triclinic C_1 symmetry of double-tilted smectic phases of bent-shape molecules. A number of phases are not centro-symmetric and allow linear coupling between electric field and mechanical stress (piezoelectricity). Since liquid crystals are fluid in some directions and solid in others, the field - induced stress has complicated strain and flow responses, and vice versa.

After summarizing the symmetries and director structures of the most popular liquid crystal phases, we are going to review the most typical experimental observations and ideas in connection with piezoelectricity and other electro-mechanical related phenomena in liquid crystals. Study of these phenomena not only imposes intellectual challenges in understanding complex rheological phenomena and coupling mechanisms, but is also promising in applications. Examples of these applications include novel displays with dynamic speakers (sound comes where the picture dictates), smart lenses that correct aberrations, or change focus according to external stimuli. However the most important applications are probably those that related to biological effects. We will show that in a number of respects the cell membranes can be considered as piezoelectric liquid crystals, where the mechanical stimuli generate electrical signals that can be sensed by the brain. For example, mineral magnetite particles dispersed in beaks play an important role navigating night-migration of songbirds; however, still unresolved is the puzzle about how the brain receives the signals from the magnetite. We will discuss the possibility that the signaling involves piezoelectricity and flexoelectricity.

SPATIAL SOLITON IN CHIRAL CRYSTALS

Adrián Reyes Cervantes
Instituto de Física, UNAM, CU

We study theoretically the nonlinear propagation of a narrow optical wavepacket through a cholesteric liquid crystal. We derive the equations governing the weakly nonlinear dynamics of an optical field by taking into account the coupling with the liquid crystal. We construct the solution as the superposition of four wavepackets centered around the linear eigenmodes of the helical structure whose corresponding envelopes A are slowly varying functions of their arguments. We found a system of four coupled equations to describe the resulting vector wavepacket which has some integration constants and that under special conditions reduces to the Nonlinear Schrödinger equation with space-dependent coefficients. We solve this equation both, using a variational approach and performing numerical calculations.

TRANSPORT OF NONEQUILIBRIUM PHONONS IN SEMICONDUCTORS

Yuri G. Gurevich
Depto. de Fisica, CINVESTAV-I.P.N.

The paper presents a review of the present-day knowledge of the nonequilibrium phonons and their role in transport phenomena. It describes approaches, based on the Boltzman kinetic equation, to the study of interacting subsystems of acoustic and optical phonons with electrons in semiconductors characterized by an arbitrary degree of degeneracy of charge-carrier gas and non-equilibrium of phonons and electrons in the energy-momentum space. Novel drag mechanisms associated with nonuniform quasiparticle heating (thermal drag) and intense interaction between acoustic and optical phonons (two-stage acoustooptical drag) are discussed.

A fundamentally new phenomenon of spatial classification of carriers according to their energies, owing to the electron-phonon drag is considered. The approach employed allows the study of strong electron-phonon drag and some entirely new effects in drag-related trasport phenomena. These include primarily an essential effect of drag on current transport, involving in particular sign reversal in the magnetoresistance of isotropic semiconductors. Under certain conditions, drag effect may result in anomalous temperature field of charge carriers.

Validity of the Onsager relations is analyzed for the case of electron-phonon drag.

SUPERCONDUCTIVIDAD: NOVEDADES IMPORTANTES.

R. Baquero
Departamento de Física, CINVESTAV.

En la primera parte esta charla resume los argumentos, contradictorios y encontrados, que se discuten en la literatura internacional con respecto al mecanismo de los nuevos materiales de alta temperatura critica. Me referiré, en particular, a los argumentos en favor de las fluctuaciones de espín y de los fonones. El centro de mi charla será mi trabajo personal y el punto de vista que emana de mis cálculos. En particular quiero intentar una respuesta muy objetiva a la pregunta: pueden ser los fonones el mecanismo de los nuevos superconductores?

INVITED POSTERS

EMISIÓN ESPONTÁNEA EN UN CRISTAL FOTÓNICO UNIDIMENSIONAL

Adán S. Sánchez y P. Halevi
Instituto Nacional de Astrofísica, Óptica y Electrónica
Apdo, Postal 51, Puebla 72000, México.

Estudiamos la emisión espontánea de un átomo inmerso en un cristal fotónico unidimensional, o superred, usando una teoría electrodinámica clásica de radiación. La razón de emisión es función de la frecuencia del fotón emitido, la posición y orientación del dipolo, así como de los parámetros geométricos y materiales de la superred. El espectro de emisión muestra un comportamiento oscilatorio que sigue a la estructura de bandas fotónica. Para los modos TE, hay regiones de frecuencia donde la emisión radiativa está completamente prohibida debido a la ausencia de este tipo de modos, la radiación es entonces con polarización TM. Además de los modos radiativos, siempre existen los modos evanescentes los cuales son guiados por las capas con constante dieléctrica alta. La contribución evanescente a la emisión espontánea es dominante si una capa con constante dieléctrica alta está en la región de campo cercano del dipolo. Para los modos TM, las razones de emisión varían enormemente para momentos dipolares perpendiculares o paralelos a las interfaces. En un cristal fotónico con una alta fracción de llenado y con dipolos perpendiculares localizados en la delgada capa de constante dieléctrica baja, la razón de decaimiento puede llegar a ser de 76 veces el valor en el espacio libre para un solo átomo y de 50 veces para un gas de átomos. También hallamos que la razón de emisión presenta una dependencia fuerte con la posición del átomo.

SINTONIZACIÓN ELÉCTRICA DE CRISTALES FOTÓNICOS BIDIMENSIONALES INFILTRADOS CON CRISTAL LÍQUIDO

P. Halevi[a], J. A. Reyes-Avendaño[a] y Juan Adrián Reyes-Cervantes[b].
[a] *Instituto Nacional de Astrofísica, Óptica y Electrónica,*
Apdo. Postal 51, Puebla, Pue., México 72000.
[b] *Instituto de Física, Universidad Nacional Autónoma de México,*
Apdo. Postal 20 364, DF, México 01000

En este trabajo se estudia la sintonización eléctrica de un cristal fotónico (CF) bidimensional. El sistema está formado por una red de cilindros circulares huecos los cuales han sido llenados con un cristal líquido nemático (CLN). Un campo eléctrico estático es aplicado de manera paralela a los cilindros.

La configuración que adopta el CLN dentro del cilindro es una función de las fuerzas de Van der Waals entre las moléculas del CLN, de la fuerza de anclamiento a las paredes del cilindro y del campo eléctrico aplicado. Los cálculos realizados muestran que una variación en el campo eléctrico aplicado tiene un efecto significado en la respuesta óptica del CF. Esta variación es consecuencia directa del realineamiento que sufren las moléculas del CLN con el campo aplicado.

En el caso de una red cuadrada, se encontró una banda prohibida completa para modos cuya componente del campo eléctrico perpendicular a los cilindros es pequeña a comparación con la componente paralela. Esta banda prohibida puede ser paulatinamente sintonizada por un campo eléctrico externo. En el caso de una red triangular se encontraron bandas prohibidas parcialmente, las cuales presentan el mismo efecto de sintonización. Para ambos tipos de redes se estudiaron los casos de silicio y germanio como medios dieléctricos que rodean a los cilindros, así como el efecto de una transición de fase del CLN.

Este sistema tiene posibles aplicaciones como polarizador, switch o filtro óptico entre otras.

POLARIZED PHOTOLUMINESCENCE OF THE OF $GAINP_2$ LAYERS GROWN ON GAAS SUBSTRATES BY LPE AND MOVPE TECHNIQUES.

Tatiana Prutskij[1)], Claudio Pelosi[2)], Raul A. Brito-Orta[3)].
[1)] *Instituto de Ciencias, BUAP, Apartado Postal 207, 72000 Puebla, Pue., México.*
[2)] *IMEM/CNR, Parco Area delle Scienze 37/A - 43010, Parma, Italy*
[3)] *Instituto de Física "Luis Rivera Terrazas", UAP, Apartado Postal J-48, 72570 Puebla, Pue., México.*

$GaInP_2$ is one of the basic optoelectronic materials, widely used in a number of modern electronic devices. One of the main technological problems affecting the reproducibility of the basic parameters of this material is the formation of an ordered phase within its crystalline structure. The ordering is present in the structures grown by metal-organic vapor phase epitaxy (MOVPE), and not in those grown by liquid phase epitaxy (LPE). Besides, the MOVPE grown samples are never completely ordered, neither are they uniformly ordered, but are formed by domains of varying degree of ordering embedded in a disordered matrix. Several studies have shown that only the luminescence from the regions with the lowest band gap is present in the photoluminescence spectra of the layer.
The ordering of the group III atoms leads to a reduction of the band gap energy and to the splitting of the valence band. These two important parameters of this material can be experimentally determined using polarized photoluminescence spectroscopy, which is one of the basic characterization tools used to study atomic ordering in layers. Anisotropy in the PL emission polarized parallel to [011] and $[0\bar{1}1]$ crystallographic directions of the layer (these directions are respectively parallel to the cleavage facets of the structures) is frequently observed for layers with ordering.
We make a comparative study of the luminescent properties of $GaInP_2$ films grown on GaAs substrates by two different growth techniques: LPE and MOVPE. The grown $Ga_xIn_{1-x}P$ ($x \approx 0.5$) films were nearly lattice matched to GaAs and had the same thickness of approximately 0.5 μm. Photoluminescence (PL) measurements were performed in a wide temperature (10 – 300 K) range for polarization of the emitted radiation along the [011] and $[0\bar{1}\,1]$ directions. Ratio of the PL intensities for [011] and $[0\bar{1}1]$ polarizations was analyzed vs. temperature together with the energy position of the respective PL peak maxima, in order to determine the degree of ordering present in each sample. Observations suggest that the $In_xGa_{1-x}P$ layers in the structures grown by MOVPE present ordering with a different degree from sample to sample, while in the layers grown by LPE no ordering was observed.

MAGNETOEXCITONS IN AN ASYMMETRIC DOUBLE QUANTUM WELL: OPTICAL PROPERTIES

B. Flores Desirena
Facultad de Ciencias Físico-Matemáticas, UAP Puebla, Pue.

We study the optical response of excitons in an asymmetric double quantum well under the action of a strong magnetic field in the growth direction. The optical response is investigated within the framework of Stahl's real-space density-matrix approach, which considers the coupling of the electron-hole interband amplitude with the incident electromagnetic wave. Specifically, we study the correlation between the physical parameters of the asymmetric double quantum well and the reflectivity and absorption spectra.

(*) This work was partially supported by CONACYT under grant 36047-E.

THE PHOTONIC PROPERTIES OF SYNTHETIC AND BIOLOGICAL MATERIALS

A. Ilinski, F. Silva-Andrade, M.A.Escobar-Acevedo
Instituto de Ciencias, Benemérita Universidad Autónoma de Puebla;
Privada 17 norte 3417, Puebla, 72050, MEXICO
ilinskii@siu.buap.mx

E. Shadrin
Ioffe Physico-Technical Institute,
Politekhnicheskaya 26, St.Petersburg 194021, RUSSIA

We have carried out an experimental study of the optical and morphological properties of synthetic composites using opal and natural objects (biological material). Synthetic composites were prepared filling a opal matrix with vanadium dioxide (VO_2) or silver iodine (AgI) to investigate photonic or phase transition properties. The semiconductor-metal phase transition is given between 55-75 ^oC (in the VO_2), or the transition from semiconductor to super-ionic properties occurs between 110-160 ^oC (in the AgI). As biological objects we have used shells of mollusks of the haliotidae family that is well-known as pearly abalone, or feathers of birds of the phasianidae family, class "pavo cristatus", well-known as peacock. By the study of the optical reflection spectra of these materials, we have determined a wide photonic band gap (PBG) in the visible range. The thermal displacement of the position of the PBG has been measured in the synthetic composites during the phase transition; in biological materials -the change of gap position is a consequence of the change of the incident angle of the light or as a consequence of the full filled insterticial places with liquids (water or iso-propilic alcohol) in the structure of the peacock's feather-. In additional we have obtained morphological images of the investigated objects by means of atomic force microscopy (AFM).

ESTUDIO DE DEFECTOS EN CRISTALES FOTÓNICOS UNIDIMENSIONALES

Verónica Cerdán Ramírez[1], Martha Palomino Ovando[1], Felipe Ramos Mendieta[2]
[1] Facultad de Ciencias Físico Matemáticas, Posgrado en Optoelectrónica, Benemérita Universidad Autónoma de Puebla, México.
[2] Centro de Investigaciones en Física, Universidad de Sonora, México.

Se estudia la propagación de radiación electromagnética en un cristal fotónico unidimensional al cual se le ha intercalado un defecto, este defecto puede ser generado a través de modificar el ancho o el índice de refracción de una de las capas que conforman la estructura, se calcula la estructuras de bandas, los espectros de transmisión y se analiza la propagación de paquetes de onda tipo gaussiano en el cristal, se hace una discusión de los efectos que producen la presencia de impurezas en cada caso.

STARK EFFECT OF HYDROGENIC IMPURITIES IN A CUBIC QUANTUM BOX

Gerardo J. Vazquez and M. del Castillo-Mussot
Instituto de Física, Universidad Nacional Autónoma de México,
Apdo. Postal 20-364, 01000 México, D.F., México

Carlos I. Mendoza
Instituto de Investigaciones en Materiales, Universidad
Nacional Autónoma de México, Apdo. Postal 70-360,
04510 México, D.F., México.

H. Spector
Department of Physics, Illinois Institute of Technology,
Chicago, IL 60616}

We extend the model of a cubic quantum box proposed by Ribeiro and Latge [F. J. Ribeiro and A. Latge, Phys. Rev. B50, 4913 (1994)] to carry out a variational calculation of the binding energy of impurities in such a structure as function of an electric field. The binding energy of the impurities increases with the electric field. In addition, the electric field splits the energy of impurities on points of the box which are equivalent in the absence of the electric field.

LOW TEMPERATURE SEMICONDUCTOR ELECTRONICS

Edmundo A. Gutiérrez D.
INAOE, Department of Electronics
Tel: (222) 266 3100, Ext. 2118, E-mail:edmundo@inaoep.mx
Puebla, MEXICO

Abstract.

Since 1990 the technology to fabricate semiconductor integrated circuits has evolved at a large pace. This has resulted in the design and fabrication of integrated circuits, such as computer microprocessors, that pack more than 20 millions of transistors operating at a signal frequency larger than 3 GHz. The trend towards the 2010 year is to integrate more than 100 million of transistors in a single chip, with a capacity to operate signals of different nature, such as; high and low frequency, low and high-voltage, wireless signal processing, digital and analog signals, optical signals, as well as voice and data processing and transmission. This posses a tremendous challenge for the new generations of transistor technologies, such as miniaturization below 20 nano-meters, heat generation and dissipation, signal integrity, IC packaging, interconnects, as well as low-dimensional physics and modeling of transistors. Regarding, the analysis, modeling and simulation of nano-metric transistors, where charge transport may occurs through a few atomic layers, one faces the failure of the traditional Boltzmann and Fermi-Dirac statistics that is the basement for all the charge transport mechanisms that define the electrical behavior of semiconductor devices. Several so-called "quantum effects" occurs when the dimensions of the transistors are below 90 nm. Such an effects are, gate-oxide thickness voltage dependent, 2D charge confinement, non-parabolic effective mass, quantization of energy levels, hot-carrier generation, as well as ballistic transport due to the reduction of the scattering centers. These mechanisms have their corresponding consequences at the electrical behavior level. For instance, reduction of the control current, reduction of frequency operation, that counteracts the velocity overshoot effect cause by the ballistic transport. Most of the times, these mechanisms combine altogether, which makes very difficult to distinguish one from another at room temperature. An optional characterization and modeling technique is the use of low temperature to distinguish and isolate these different mechanisms. By identifying and modeling these "quantum effects" one is capable of proposing technology changes that help improve the electrical performance of nano-metric transistors.

Our findings on these techniques and modeling, which use temperatures as low as 4.2 K, are presented in this article.

EDGE BAND EMISSION FROM MONOCRYSTALLINE SILICON

O. Malik, V. Grimalsky, A. Torres-J. , J. De la Hidalga-W.
National Institute for Astrophysics, Optics, and Electronics, Puebla 72000, Pue., Mexico.
E-mail: amalik@inaoep.mx

Room temperature electroluminescence (EL) corresponding to silicon band gap energy is observed from ITO-nSi surface-barrier diodes fabricated by a spray pyrolysis technique, where ITO is transparent conducting film of tin-doped indium oxide. This film is separated from silicon by a thin interfacial SiO_x layer about of 10 Å thick grown on the silicon surface in hydrogen peroxide solution. The work functions of ITO and Si are such that surface n-type silicon layer is inverted to p type, and induced a p^+-n junction is formed at the surface of the silicon. The tunneling current through SiO_x layer provides an Ohmic contact between ITO and surface-induced p-Si layer.

Distinction of investigated structures is a significant minority-carrier injection ratio about 0.35 determined from examination of ITO-nSi-ITO transistor behavior. The injection ratio can reach the value of 0.8 when the potential barrier height on Si surface is 0.9 eV. High-efficiency EL was investigated under excitation with forward biased short (10-200 μs) current pulses up to 500 A/cm^2. Spectral dependence of EL is connected with radiative recombination of injected electron-hole plasma.

RESONANT EXCITATION OF MICROWAVE ACOUSTIC MODES IN N-GAAS FILM

V.Grimalsky[1], A.Garcia-B.[1], E.Gutierrez-D.[1], S.Koshevaya[2]
[1]*Electronics Department, INAOE, Puebla 72000, Pue., Mexico.*
e-mail: vgrim@inaoep.mx
[2]*Autonomous Univ. of Morelos, CIICAp, Cuernavaca 62210, Mexico.*
e-mail: svetlana@uaem.mx

Resonant excitation of coupled space charge - acoustic waves in thin n-GaAs film is theoretically investigated. The mechanisms of interaction between hypersonic waves and space charge waves are piezoeffect and deformation potential. It is shown that the effective resonant excitation of hypersonic waves is possible due to the both mechanisms. At moderate frequencies ($f < 20 - 30$ GHz) the mechanism due to piezoeffect is dominating, whereas at higher frequencies ($f \sim 40$ GHz) the mechanism due to the deformation potential becomes more essential. The film is placed onto a substrate i-GaAs without an acoustic contact. The film includes two-dimensional electron gas with a high negative differential conductivity.

THEORETICAL STUDY OF VIBRATIONAL MODES OF CH3OH ADSORBED TO MGO SURFACE

J. F. Rivas-Silva [1] and Roxana Licona [2]

[1] Instituto de Física "Luis Rivera Terrazas", Av. San Claudio y 14 Sur, C.U., Apdo. Postal J-48, Puebla, Pue. México. e-mail: rivas@sirio.ifuap.buap.mx

[2] Facultad de Ciencias Químicas BUAP, Av. San Claudio y 14 Sur, C.U., CP 72570, Puebla, Pue. México.

In the present work we present the results of a theoretical investigation of the adsorption of CH3OH on a MgO (001)-(2X2) defective surface using first-principles calculations based on density functional theory and the pseudopotential method. The calculations were developed including slab geometry and periodic boundary conditions, with occupied orbitals expanded in plane waves.

We proposed a simple model for such adsorption, according to the active sites of the surface, which were characterized taking into account the frontier orbitals. As an important result, the infrared frequency modes of the system were obtained in good agreement with spectroscopy observations [1, 2] being the results better than those obtained using DFT cluster calculations [1, 3].

[1] D. Di Valenti, A. Del Vito, G. Pacchioni, S. Abbet, A.S. Wörz, K. Judai and U. Heiz, J. *Phys. Chem. B*, **106**, (2002) 11961.

[2] J. Rudberg and M. Foster, *J. Phys. Chem B,* **108**, 18311 (2004).

[3] M.M. Branda, R.M. Ferullo, P.G. Belelli, N.J. Castellani, *Surf. Sci.* **527**, 89 (2003).

MEDICIÓN DE LA FUNCIÓN DE ONDA DE UN FOTÓN

Dr. Héctor Moya Cessa
Instituto Nacional de Astrofísica, Óptica y Electrónica
Apartado Postal 51 y 216, 72000Puebla, Pue., México.

En una especie de "espectroscopía" inversa, en la que en lugar de usar luz para medir propiedades de materia, uso átomos para medir propiedades de el campo electromagnético, propongo un esquema para medir la función de onda de uno o más fotones en una cavidad que contiene un modo del campo electromagnético.

EL EFECTO FOTORREFRACTIVO Y ALGUNAS APLICACIONES

Rubén Ramos García
Instituto Nacional de Astrofísica, Óptica y Electrónica
Apartado Postal 51 y 216, Puebla, Pue, 72000. Tel 266 3100 ext. 2214
rgarcia@inaoep.mx

El efecto fotorrefractivo en materiales electro-ópticos consiste en la modificación del índice de refracción mediante un campo eléctrico generado por la separación espacial de cargas generadas por iluminación con un haz de luz con distribución espacial no homogéneo. Los cambios en el índice de refracción no lineal en los materiales fotorrefractivos son generalmente grandes (10^{-2}-10^{-5}) con potencias ópticas de sólo unos cuantos microwatts. Por tal razón, los materiales fotorrefractivos tienen potenciales aplicaciones reales ya que son compatibles con láseres semiconductores. Existen una gran cantidad de materiales, tanto orgánicos como inorgánicos, cuya selección depende del tipo de aplicación deseada. Por ejemplo, cristales ferroelectricos son usados si se desea grabar hologramas altamente eficientes, transferencia de energía entre haces y procesado de imágenes entre otras. Si las aplicaciones son en tiempo real, como detección de vibraciones u holografía en tiempo real, entonces se usan semiconductores o selenitas. Sin embargo, el precio que se paga por las grandes no linealidades ópticas es el tiempo de respuesta ya que el efecto fotorrefractivo es un proceso acumulativo, de modo que bajas potencias requieren más tiempos de iluminación. En este trabajo haremos una revisión del efecto fotorrefractivo en varios materiales (ferroeléctricos, selenitas, pozos cuánticos, polímeros fotorrefractivos y cristales líquidos) y algunas de sus aplicaciones mas importantes incluyendo solitones ópticos espaciales, detección de ultrasonido, procesado de imagen y holografía adaptiva entre otros.

CHARACTERIZATION OF NONSTOICHIOMETRIC CDSE FILMS

J. M. Gracia-Jiménez, M.E. Hernández –Torres and R. Silva-González
Instituto de Física-UAP
Apdo. Postal J-48, 72570 Puebla, México
H. Navarro-Contreras and A. Rodríguez
Instituto de Investigación en Comunicación Óptica-UASLP
Álvaro Obregón 64, 78000, S.L.P., México

The aims of this work is to study a set of nonstoichiometric CdSe films grown by the chemical bath deposition method. The techniques used in this study are scanning electron microscopy, energy dispersive spectroscopy, microRaman, photoluminescence and absorption. The films were characterized before and after a thermal treatment carried out in vacuum. A comparison of the results is made to determine the influence of the non stoichiometry in the, photoluminescence and absorption properties of CdSe. It is observed that the position of the phononic line does not present any dependence to the atomic ratio. However, the intensity of the line is diminished as the temperature of the thermal treatment is increased due to the increment in concentration of defects or impurity levels. The photoluminescence results show that the thermal treatments modify the emission mechanisms, which allow that emission levels in the high energy region of the spectra be dominant. When the temperature is increased the band gap shows a tendency to be equal in overstoichiometric and understoichiometric samples.