650 Efficient Two-Stage Energy Transfer to Cr^{3+} in Infrared Emitting Aluminate Phosphors: *C. L. R. Catherall* and *M. J. Fuller,** GE-Thorn Lamps Ltd., Enfield, Middx, England EN1 1SB

There is an increasing use of infrared (650-800 nm) emitting fluorescent lamps. $LiAlO_2:Fe^{3+}$ is the standard phosphor for such lamps, but does have limitations in lamp processing and depreciation characteristics. The two Cr^{3+} activated hexagonal aluminate systems described represent a considerable advance over $LiAlO_2:Fe^{3+}$ in terms of ease of processing and superior maintenance behavior. Despite involving double sensitization processes; $Ce^3 \rightarrow Mn^{2+} \rightarrow Cr^{3+}$ and $Eu^{2+} \rightarrow Mn^{2+} \rightarrow Cr^{3+}$, the two new phosphors in lamps show equivalent initial infrared output to $LiAlO_2$:Fe.

651 GaN Thin Films Prepared by Reactive DC Magnetron Sputtering: *O. J. Gregory,** Dept. of Chemistry and Materials Engineering, University of Rhode Island, Kingston, RI 02881, *E. E. Crisman* and *C. B. Roberts,* Dept. of Physics, Brown University, Providence, RI 02912, *D. C. Morton,* U.S. Army LABCOM, Electronics and Device Laboratory, Fort Monmouth, NJ 07702, *P. J. Stiles,* Dept. of Physics, Brown University, Providence, RI 02912

Gallium nitride, a III-V direct bandgap semiconductor, is receiving renewed interest both for device applications and for basic materials investigation. Most GaN prepared to date has been formed on sapphire substrates at elevated temperatures by chemical vapor transport techniques and has resulted in stoichiometric, n-type material. Intentional doping during deposition with acceptor impurities usually resulted in semi-insulating and not p-type material, as anticipated. In the study reported here, GaN was deposited onto various substrates by reactive dc magnetron sputtering of Ga and Zn or Mg doped Ga in the presence of N_2, NH_3 or mixtures of these with argon. By varying the gas composition and power density, not only semi-insulating but also both n-type and p-type material was produced. This is the first known reporting of all resistivity "types" of material prepared in the same apparatus. The range of resistivity and resistivity "type" were found to be much more dependent on preparation conditions than on intentionally added impurities (Zn and Mg). The relationships between sputtering conditions, resistivity and crystallinity are presented in this paper.

652 Grain Size Effect on the Cathode-Ray Efficiency of Y_2O_3:Eu: *T. Welker** and *H. T. Hintzen,* Philips Research Laboratories, W 5100 Aachen, Germany

Investigations on the cathode-ray efficiency of the red emitting phosphor Y_2O_3:Eu for particle sizes between 1.5 and 5 μm are presented. Samples with a median grain diameter of 2.2 μm exhibit an efficiency comparable to that of a well-optimized commercial phosphor. The decrease of the efficiency for samples having grain diameters less than 2.2 μm was found to be accompanied by a reduction of the bulk diffusion length of the electron-hole pairs, as deduced from the acceleration voltage dependence of the efficiency.

653 Improvement of the Maintenance of LaOBr:Tb in CRTs by Codoping with Cl or Br: *C. R. Ronda,** *H. Bechtel, U. Kynast,* and *T. Welker,* Philips GmbH Forschungslaboratorium Aachen, W 5100 Aachen, Germany

LaOBr:Tb is an efficient, green emitting, cathode-ray phosphor. Its too strong degradation under cathode-ray excitation prevents its use in projection television tubes. By codoping LaOBr:Tb with iodine or chlorine, a strong improvement of the maintenance was obtained. A comparative study of LaOBr:Tb and the mixed halide phosphors, in the latter case showed a strong reduction in halide desorption under electron bombardment. In addition, contrary to LaOBr:Tb, degraded mixed halides do not show F-center absorption.

NONLINEAR OPTICS AND MATERIALS

Luminescence and Display Materials/Dielectric Science and Technology

654 Nonlinear Optics at the Liquid-Solid Interface: *P. Guyot-Sionnest,* LURE, Centre Universitaire Paris-Sud, Orsay 91405, France

This paper reviews the nonlinear optical processes of second harmonic generation and sum-frequency generation with particular emphasis on their applications to the study of liquid-solid and electrochemical interfaces.

655 What Can SHG Tell us About Surface Atomic and Electronic Structure of Metal Surfaces?: *G. L. Richmond,** *R. Bradley, R. Georgiadis, A. Friedrich,* and *E. Wong,* Chemical Physics Institute, University of Oregon, Eugene, OR 97403

Over the past several years we have been conducting experiments to determine whether optical second harmonic generation (SHG) can provide information about the surface order and symmetry of single crystal metal surfaces in an aqueous environment. We recently have extended this effort to examining the wavelength dependence of the SH response from these metal electrode surfaces in an effort to measure the electronic properties of these surfaces by resonant SHG. Critical to the interpretation of these electrochemical studies have been our corresponding SHG studies conducted on these crystals in ultrahigh vacuum. This paper summarizes the results of many of these measurements for Cu, Ag, and Au single crystal surfaces. Related studies of underpotential deposition and potential induced reconstruction of these surfaces are also discussed.

656 Nonlinear Optical Reflectance Spectroscopy of a Single Crystal Metal Electrode: *T. E. Furtak,** *Y. Tang,* and *L. J. Simpson,* Physics Dept., Colorado School of Mines, Golden, CO 80401

We have measured the optical second harmonic generation efficiency of Ag(111) as a function of the incident photon energy for a range of electrode potentials. The results demonstrate that predictions based upon time-dependent local density functional models seriously overestimate the nonlinear response. We have identified features associated with surface states and have also observed phenomena which we have interpreted as a potential induced surface reconstruction.

657 Nonlinear Spectroscopy of Thin Epitaxial ZnSe Films on GaAs(100): *M. S. Yeganeh, A. G. Yodh,** and *M. C. Tamargo,* Dept. of Physics, University of Pennsylvania, Philadelphia, PA 19104

We have measured the frequency-dependent second-order nonlinear optical response of epitaxially grown ZnSe[100] films on GaAs[100] by resonance three wave mixing. The interface data exhibit sharp peaks at 2.72 and 2.90 eV. These peaks were identified as two photon resonances. At present we believe these peaks respectively correspond to E_0 transitions of ZnSe immediately above the buried interface and E_1 transitions of the GaAs immediately below the buried interface.

658 Coherent Interferometric Analysis of the Molecular Orientations Based on the Optical Second Harmonic Generation: *O. Sato,** *R. Baba, K. Hashimoto,* and *A. Fujishima,* Dept. of Synthetic Chemistry, Faculty of Engineering, University of Tokyo, Hongo 7-3-1, Bunkyo-ku, Tokyo 113, Japan

Interferometric study of the optical second harmonic generation from LB films was performed. It was demonstrated that the inversion of a molecule in the film made its SH radiation totally inverted in the time phase, and the deprotonation reaction of hemicyanine monolayer could successfully be monitored as the change of a fringe pattern.

659 Femtosecond Time-Resolved Desorption of Molecules from a Surface: *J. A. Prybyla,** *H. W. K. Tom,* and *G. D. Aumiller,* AT&T Bell Laboratories, Holmdel, NJ 07733

We time-resolve the laser-induced desorption of CO molecules from a Cu(111) surface with 100 fs time resolution. The molecules are found to desorb in <325 fs after the 100 fs pump pulse. This can only be explained by hot electron and not by thermally assisted mechanisms of desorption. Furthermore, the ultrafast desorption time combined with a measurement of desorption yield *vs.* absorbed laser fluence has allowed us to identify the specific hot electron mechanism which operates.

660 Surface Diffusion and Desorption of Hydrogen on Silicon Probed by Second-Harmonic Generation: *T. F. Heinz,** *U. Höfer,* and *G. A. Reider,* IBM Research Div., T.J. Watson Research Center, Yorktown Heights, NY 10598-0218

Second-harmonic generation provides a probe of semiconductor surfaces with submonolayer sensitivity. The technique has been applied to examine the motion of hydrogen on silicon surfaces. The desorption process has been investigated through isothermal measurements. These studies revealed a marked departure from the second-order kinetics expected for the recombinative desorption of the monohydride adsorbed species to yield H_2 molecules. The process of surface diffusion has been investigated by means of second-harmonic diffraction from silicon surfaces with a spatially modulated density of adsorbed hydrogen. A barrier for lateral motion of H/Si(111)7 × 7 of 1.5 eV, ~50% of the H-Si binding energy, has been established.

661 Vibrational Dynamics of Hydrogen Terminated Stepped Si(111) Surfaces: The Role of Interadsorbate Energy Transfer: *M. Morin,** *N. J. Levinos,* and *A. L. Harris,* AT&T Bell Laboratories, Murray Hill, NJ 07974

The vibrational dynamics of H-terminated stepped Si(111) surfaces was studied using transient sum frequency generation. The first excited state of the terrace Si-H stretching mode on a dihydride stepped surface is found to relax more rapidly than on a monohydride stepped surface, also a two-color transient experiment reveals fast interadsorbate energy transfer. These results strongly suggest that the dihydride step act as a trap for the vibrational energy of the terrace mode; interadsorbate energy transfer is an efficient process on these stepped surfaces.

662 Transient Vibrational Relaxation of Surface Adsorbates Using Nonlinear Optics: *L. Rothberg,** *A. L. Harris, L. Dhar, L. H. Dubois,* and *N. J. Levinos,* AT&T Bell Laboratories, Murray Hill, NJ 07974

The bleaching recovery time of the C-H stretching vibration of methyl thiolate in an ordered overlayer on Ag(111) is measured by picosecond sum frequency generation. A biexponential decay of the excited vibration is observed, with the slow component exhibiting a temperature dependent rate. We establish that the energy initially leaves the mode by coupling into other adsorbate vibrations and speculate on the detailed mechanism.