

Abstracts of Papers by Bell System Authors Published in Other Journals

CHEMISTRY

Assignment of a Ligand in Stellacyanin by a Pulsed Electron Paramagnetic Resonance Method. W. B. Mims and J. Peisach, *Biochemistry*, 15, No. 17 (1976), pp. 3863-3869.

The electron spin echo decay envelope for the blue copper protein, stellacyanin, and for a number of other Cu(II) complexes has been studied. Particular attention was given to the form of the "nuclear modulation" patterns, which show the effects of coupling between the electron spin and the neighboring nuclei. The envelopes for the hydrated cupric complex and for copper(II) glycylglycine were essentially the same and indicative of the coupling to protons. The peptide complex contains nitrogen nuclei coupled directly to Cu(II), but the coupling constant is so large for these nuclei that a modulation pattern ascribable to ^{14}N is not seen. For copper(II) bovine serum albumin, on the other hand, a contribution due to the coupling of the remote nitrogen belonging to a histidyl imidazole ligand was observed. The modulation pattern for this complex and for stellacyanin closely resembled one another, strongly suggesting that an imidazole is ligated to the copper in this blue protein.

Auger Studies of Au Diffusion Through Pt Films: Dependence on Pt Thickness and Annealing Ambient. C. C. Chang and G. Quintana, *Appl. Phys. Lett.*, 29, (Nov. 1976), pp. 453-454.

The outdiffusion kinetics of Au through Pt/Au couples with ~ 2000 Å to $\sim 10,000$ Å Pt films, heat treated between 250 and 350°C in 1 atm. N_2 and in vacuum, were determined using Auger electron spectroscopy. The Au outdiffusion time, in 1 atm. N_2 ambient, was approximately proportional to $d^{1.3}$ for Pt thickness $2000 \leq d \leq 10,000$ Å. Au was found to outdiffuse through $\sim 10,000$ Å Pt at a rate *fifteen* times faster in 1 atm. N_2 than in vacuum, at 350°C.

Electrodeposition of Gold. Depolarization Effects Induced by Heavy Metal Ions. J. D. E. McIntyre and W. F. Peck, Jr., *J. Electrochem. Soc.*, 123 (December 1976), pp. 1800-1813.

Addition of trace quantities (ppm) of heavy metal ions such as Pb(II) or Tl(I) to soft gold electroplating baths induces a marked cathode depolarization effect that extends the current density range in which bright, uniform, fine-grained deposits can be obtained. It is shown that this phenomenon arises from a catalytic electrochemical displacement reaction made possible by the underpotential deposition of depolarizer adatoms on gold and specific adsorption of depolarizer ions in the double-layer.

Photovoltage Studies of Clean and Oxygen Covered Gallium Arsenide. S. C. Dahlberg, *Surface Sci.*, 59 (1976), pp. 83-96.

The photovoltage of GaAs was measured by the retarding potential electron beam technique. The photovoltage light-intensity dependence deviates from steady state models. The photovoltage shows additional structure near the bandgap and in the below bandgap region; it is lower for uncleaned surfaces. Work function shows that oxygen adsorption is second order.

Photovoltage Studies of n-Type InP (100). S. C. Dahlberg, *Surf. Sci.*, 60 November (1976), pp. 231-238.

The photovoltage of InP (100) decreases as the intensity and/or duration of the light exposure decreases. The photovoltage spectra has been studied as a function of temperature and it shows considerable structure above the bandgap energy. Both the photovoltage and work function decrease sharply after Ar bombardment, probably due to preferential sputtering of P.

Polycrystalline Thin Film InP/CdS Solar Cells. K. J. Bachmann, J. L. Shay, S. Wagner, and E. Buehler, *Appl. Phys. Lett.*, 29, No. 2 (July 15, 1976), pp. 121-123. Polycrystalline films of p-type InP were prepared via chemical vapor deposition on glass, molybdenum, and carbon substrates. Cd or Zn were used as dopants yielding net acceptor concentrations $N_A - N_D \leq 2 \times 10^{18} \text{ cm}^{-3}$. Polycrystalline InP/CdS solar cells fabricated by evaporating CdS onto such InP films on carbon have a solar power conversion efficiency of 3 percent.

ELECTRICAL AND ELECTRONIC ENGINEERING

Spin Flip Raman Laser at Wavelengths Up to 16.8 μm . C. K. N. Patel, T. Y. Chang, and V. T. Nguyen, *Appl. Phys. Lett.*, 28, No. 10 (May 15, 1976), pp. 603-605. An InSb spin flip raman (SFR) laser is pumped with an optically pumped NH_3 laser line at 780.515 cm^{-1} to obtain tunable first Stokes laser radiation at wavelengths up to 16.8 μm . We report results on the power output, tunability, and preliminary spectroscopy of UF_6 .

MATERIALS SCIENCE

Low-Field Depoling Characteristics of $\text{Pb}(\text{Zr,Ti})\text{O}_3$ Ceramics. J. B. Koenenman, 59, No. 9-10 (September-October 1976), pp. 59-61. Low-electric-field depoling measurements were made on $\text{Pb}(\text{Zr,Ti})\text{O}_3$ ceramics. The apparent activation energy for the depoling process was calculated to be 33 kcal/mol. The data indicate that the materials tested should be very stable when subjected to depoling fields on the order of one-fourth of the coercive field.

Oxidation Induced Stacking Faults in n- and p-Type (100) Silicon. S. P. Murarka and G. Quintana, *J. Appl. Phys.*, 48 (January 1977), pp. 46-51. The formation of stacking faults during thermal oxidation of silicon has been investigated. The length and the density of stacking faults, in both n- and p-type 2-inch-diameter (100) silicon wafers obtained from various manufacturers, were determined as a function of time and temperature of oxidation in dry and steam ambients. Two categories of stacking faults were established.

A Simple Titanium and Nickel Sublimation Pump (TNSP). C. A. Haque, 13, No. 5 (September/October 1976), pp. 1088-1090. One filament of a commercially available Titanium Sublimation Pump (TSP) was replaced with a nickel filament on a tungsten support. This Titanium and Nickel Sublimation Pump (TNSP) besides having the attributes of a TSP, effectively minimizes the hydrogen contamination problem omnipresent in most stainless steel ultrahigh vacuum chambers, with nickel acting as a getter for hydrogen.

Sources of Oxidation Induced Stacking Faults in Czochralski Silicon Wafers: A One-to-One Correlation With Native Defects. G. A. Rozgonyi, S. Mahajan, M. H. Read, and D. Brasen, *Appl. Phys. Lett.*, 29 (November 1, 1976), pp. 531-533. Using optical microscopy/etch pit techniques for the delineation of defects in [100] Czochralski silicon wafers, we have made a one-to-one correlation between bulk stacking faults in oxidized wafers and etch hillocks identified at the same sites before oxidation. Transmission electron microscopy of the hillock defects shows them to be clusters of precipitates ranging in size from 0.01 μm to 0.3 μm .

MATHEMATICS AND STATISTICS

On the Set of Distances Determined by the Union of Arithmetic Progressions. F. R. K. Chung and R. L. Graham, *Ars Combinatoria*, 1 (1976), pp. 57-76. Suppose a set of real numbers $A = \{a_1 < a_2 < \dots < a_t\}$ is a union of $n \geq 2$ arithmetic progressions, each with common difference 1. Let $\Delta(A)$ denote $\{a_{k+1} - a_k : 1 \leq k < t\}$. It is shown that $|\Delta(A)|$, the number of elements of $\Delta(A)$, satisfies $|\Delta(A)| \leq 3n - 3$ and that this inequality is best possible. A similar result with $3n - 3$ replaced by $3n$ holds when A lies on a circle.

Simulation and Extension of a Minimum Mean Squared Error Estimator in Comparison With Stein's. H. D. Vinod, *Technometrics* 18 (November 1976), pp. 491-496. We discuss a fixed point solution of the iterative process underlying Farebrother's minimum mean squared error (MSE) estimator. A simulation study favors Stein's

shrunk least squares estimator and our fixed point solution over ordinary least squares. Farebrother's estimator almost never has the minimum MSE.

MECHANICAL AND CIVIL ENGINEERING

Optimal Aseismic Design of Building and Equipment. S. C. Liu, M. R. Dougherty, F. Neghabat, J. Eng. Mech. Div., *EM3*, (June 1976), pp. 395-414. A method for earthquake-resistant design was developed and applied to the problem of protecting industrial equipment in multistory buildings. In contrast with deterministic methods of analysis, attention is focused on the random properties of the environment and structural response. This approach has the advantage of including earthquake damage cost, protection cost, and reliability with conventional design factors. The results disclose cost effective and optimal designs.

PHYSICS

The A. C. Stark Shift for High Light Intensities. P. F. Liao and J. E. Bjorkholm, *Bull. Amer. Phys. Soc.*, 36, No. 26 (June 28, 1976), pp. 1543-1545. We report measurements of optically induced energy-level shifts produced by nonresonant light in sodium vapor. Intensities are sufficiently high such that the shifts depart substantially from the linear behavior predicted by second-order perturbation theory.

Determination of Nonradiative Decay Rate in Electron-Hole Drops in Ge at 1.6°K. R. F. Leheny, J. Shah, and M. Voos, *Solid State Commun.* 20 (November 1976), pp. 819-821. We show that microwave photoconductivity measurements of optically excited carriers in Ge at 1.6°K can be used to determine the importance of nonradiative recombination within electron-hole liquid drops. Our results show that the nonradiative lifetime is 80 μ s from which we calculate a radiative efficiency of 0.5 ± 0.1 for the condensed phase. *Groupe de Physique des Solides, De L'Ecole Normale Supérieure, Paris, France.

Grain-Boundary Electromigration in Thin Films. I. Low-Temperature Theory. K. L. Tai and M. Ohring, *J. Appl. Phys.*, 48, No. 1 (January 1977), pp. 28-35. A macroscopic mathematical theory is presented accounting for grain-boundary diffusion and electromigration in the presence of a simultaneous flux of atoms into the surrounding bulk lattice. The model employs a semi-infinite bicrystal geometry with a constant source at the origin, and both integral and numerical solutions to the subsequent non-steady-state transport equations are given. A comparison between the present theory and a previous treatment based on an extension of the Fisher analysis will be made. Application to recent results in thin films will be discussed. *Department of Metallurgy, Stevens Institute of Technology.

Grain-Boundary Electromigration in Thin Films. II. Tracer Measurements in Pure Au. K. L. Tai and M. Ohring, *J. Appl. Phys.*, 48, No. 1 (January 1977), pp. 36-45. The first *direct* measurement of the grain-boundary ion drift velocity in thin Au films over the temperature range 120-250°C is reported. Central regions on the narrow stripe conductors were selectively embedded with ¹⁹⁵Au tracer atoms and the extent of the subsequent transport were evaluated by a high-resolution autoradiography technique employing the scanning electron microscope. *Department of Metallurgy, Stevens Institute of Technology.

The Nucleation and Growth of an Epitaxial Monolayer of Cd on Ge(111): A Simultaneous Rheed-MB Study. K. J. Matysik, *J. Appl. Phys.*, 47 (October 1976), pp. 4359-4363. The correlation between structures and mass spectrometric molecular beam spectra is presented. The spectra are discussed in terms of the atomistic rate theory of nucleation. The results suggest that a convention of nucleation rate theory, that growing clusters act as monomer capture centers which increase in capture efficiency with time, does not hold at submonolayer coverages.

A Photometric Ellipsometer for Measuring Flux in a General State of Polarization. D. E. Aspnes, *Surface Sci.* 56 (June 1976), pp. 161-9. The theory and operation of a rotating analyzer/compensator ellipsometer capable of measuring all four Stokes parameters of generally polarized flux is described. Applications presented include an investigation of the effects of internally and externally stray and scattered light and surface roughness on measured values of the dielectric function.

Photovoltaic Properties and Junction Formation in CuInSe₂. B. Tell and P. M. Bridenbaugh, J. Appl. Phys. 47, No. 2 (February 1976), pp. 619-620. Studies of diffusion and photovoltaic effects in CuInSe₂ pn junctions are reported. Junctions were formed by annealing Zn, Cd, and Cu plated p-type samples at temperatures from 200-450°C. The most efficient junctions are formed by 5-10 minute anneals at 200°C with a calculated interdiffusion coefficient $\sim 5 \times 10^{-10}$ cm²/s.

SYSTEMS ENGINEERING AND OPERATIONS RESEARCH

Sea Plow IV—An Underseas Vehicle for Burying Ocean Cable. G. S. Cobb, Oceans, September 1976, pp. 19B1-19B6. A newly developed SG cable system, schedule for TAT-6, will have 1½ times the channel capacity of all present transatlantic cables combined, meaning significantly higher cost of providing interim service in the event of a trawler break. To provide the cable protection required for TAT-6 both in terms of burial performance and operating-depth capability, SEA PLOW IV was designed and tested over a 18-month period beginning in January, 1974 and was successfully used to bury both shore ends of TAT-6 during August and October, 1975.