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BASIC AND APPLIED RESEARCH IN THE FIELD OF
ELECTRONICS AND COMMUNICATIONS

FINAL TECHNICAL REPORT

Submitted by
Jonathan Allen

June 1, 1980 to November 1, 1982

U.S. Army Research Office
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Research Laboratory of Electronics
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

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REPORT ON RESEARCH

This report summarizes research accomplishments for the period June 1, 1980 through October 31, 1982. The Joint Services Electronics Program at MIT brings together faculty in Electrical Engineering, Physics and Chemistry to work on fundamental electronics-related processes. Research is organised in seven work units entitled Picosecond Optics, Chemical Dynamics, Surface Physics and Phase Transitions, Applied Optics, Atomic and Molecular Physics, Submicrometer Artificial Microstructures and Applications, and Electromagnetics.

During this contract period, research in Picosecond Optics continued to be a major thrust area. Modelocking of semiconductor lasers has been demonstrated as well as passive ways of producing trains of picosecond pulses by modulating a CW optical source with an external modulator driven at microwave frequencies. A theory of noise of free electron lasers has also been developed during this period since such phenomena were found to play an important role in the modelocking of semiconductor lasers. During this period, a new facility for picosecond and subpicosecond diagnostics was built up. A femtosecond laser system is now operational and has been applied to several different femtosecond dynamic studies. For example, picosecond studies of carrier dynamics in quaternary semiconductors, such as InGaAsP have also been started. The ability to use pulses in this regime to investigate a wide variety of transient phenomena is being exploited throughout the Laboratory in a variety of JSEP supported projects.
Work in the semiconductor surfaces group continues at a very strong level, involving participation by both theorists and experimentalists within the Physics Department as well as participation from the Chemistry Department. Basic work on the fundamental properties of surface and interface electronic excitations has been carried out in a way that provides a complete quantum mechanical description of the elementary excitations of the various systems studied. Under JSEP sponsorship, the development of theoretical understanding for total energy calculations as well as phase transitions in chemisorbed systems has produced very strong results that are naturally complementary to our extensive experimental investigations.

In the experimental surface area, high resolution X-ray scattering has been used to model surface systems, smectic liquid crystals, and intercalant materials. This research has revealed a broad variety of new phenomena including structures which are solid in one directions and fluid in the other. The combined theoretical and experimental thrust of this work is leading to a careful atomic level understanding of practical surface and interface systems.

The Atomic Physics program is a basic research effort aimed at understanding atomic and molecular processes. A particular focus has been the study of the interaction of highly excited atoms with radiation. In this connection Rydberg Atoms have been characterized in a variety of environments, including the development of Rydberg Atom millimeter wave radiation detectors, of considerable practical significance. Techniques
were even developed to inhibit spontaneous emission from these atoms, providing new insights. Work also continues in this field on atom field interactions leading to the creation of time frequency standards, as well as the exceedingly accurate measurement of fundamental constants.

A particularly strong focus of the JSEP program continues to be the Submicron Structures Laboratory which was established under JSEP support. An incredible variety of submicron structures have been developed through the utilization of X-ray techniques. Creating patterns with periods below 1000 Å have been demonstrated as well as fundamental contributions to reactive ion etching and holographic lithography. Studies in this area have also included investigations of MOS channel conduction, the growth of graphoepitaxial monocrystalline films, and the confirmation of a model for the enhanced Ramon effect based on the excitation of plasmon resonances in silver particles on a submicron grid. In addition to providing a wide variety of important results, this laboratory is also a major resource for the provision of structures used by many investigators within the JSEP program.

Finally, two projects focus on electromagnetic phenomena. These have included the study of propagation through a variety of media involving many diverse geometries and nonlinear effects. We have also been studying propagation through magnetostatic structures, including sophisticated control of the propagation modes in order to yield appropriate dispersion characteristics.
In addition to the studies already described, new activity under the heading of chemical dynamics is building up. Apparatus for the utilization of molecular beams directed at semiconductor surfaces in order to measure reaction products is underway, and we expect that this facility will provide fundamental understanding of such practical processes as reactive ion etching.

The fundamental studies carried out under the JSEP program at MIT continue to exhibit novel and sometimes startling results which are being incorporated into current theories, together with practical knowledge appropriate for the fabrication of high performance electronic systems. We continue to retain this emphasis and direct these results to the enhancement of contemporary integrated circuit processes.
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Papers Published


Meeting Papers Presented

1980 International IEEE AP-S Symposium, USNC URSI Meeting, Universite Laval, Quebec, Canada
June 2-6, 1980

Abstracts in Proceedings

W.C. Chew and J.A. Kong, Input Impedance and Radiation Characteristics of a circular Microstrip Antenna (p. 190)


T.M. Habashy, J.A. Kong, and W.C. Chew, Electromagnetic Fields of a Dipole Submerged in a Two-Layer Conducting Medium in the ELF Regime (p. 150)


D. H. Staelin and J. H. Lang, Electrostatically-Controlled Antennas (p. 354)

M.A. Zuniga and J.A. Kong, Modified Radiative Transfer Theory for a Two Layer Random Medium (p. 263)


International Topical Conference on the Physics of MOS Insulator,
North Carolina State University, Raleigh, North Carolina
June 18-20, 1980

Papers in Proceedings

C. W. Gee and M. Kastner, Time Decay of Photoluminescence from Amorphous SiO₂ (pp. 132-136)
June 23-26, 1980

J. Thomas, Direct Observation of Diamagnetic in CO₂ 
10.6 Band Zeeman Spectra Using a Stabilized Twin Laser 
Spectrometer

The 3rd International Conference on Ferrites, Kyoto, Japan 
September 29 - October 2, 1980

Papers in Summaries
F.R. Morgenthaler, Novel Devices Based Upon Field Gradient 
Control of Magnetostatic Modes and Waves (pp. 220-221)

International Conference on Microlithography, Amsterdam 
September 30-October 2, 1980

Papers in Proceedings
H.I. Smith, The Impact of Submicrometer Structures in Research 
and Applications

19th IEEE Conference on Decision and Control, Albuquerque, New Mexico 
December 10-12, 1980

Papers in Proceedings
J.H. Lang, A Perturbation Analysis of Spillover in Closed-Loop 
Distributed-Parameter Systems (pp.750-754)

J.H. Lang and D.H. Staelin, Electrostatically-Controlled 
Large-Aperture Reflecting Satellite Antennas (pp. 991-993)

Symposium uber Microstrukturforschung, Institut fur Hableitertechnik, 
Aachen, Federal Republic of Germany 
March 5-6, 1981

H.I. Smith, Submicrometer Structures Technology

Workshop on the Interaction of Laser Radiation with Surfaces for 
Application to Microelectronics, MIT, Cambridge, Massachusetts 
May 4-5, 1981

H.I. Smith, Review of Conventional Submicrometer Fabrication 
Techniques

16th Symposium on Electron, Ion, and Photon Beam Technology, Dallas, 
Texas 
May 26-29, 1981

H.H. Efremov, N.P. Economou, K. Bezjian, S.S. Dana, and
H.I. Smith, A Simple Technique for Modifying the Profile of Resist Exposed by Holographic Lithography

A.M. Hawryluck, N.M. Ceglio, R.H. Price, J. Melngailis, and H.I. Smith, Gold Transmission Gratings with Submicrometer and Thicknesses >0.5μm

C.M. Horwitz and J. Melngailis, Reactive Sputter Etching and Si, SiO₂, Cr, and Al with Gas Mixtures Based on CF₄, Cl₂, and CiCl₄

N. Tsunita, J. Melngailis, A.M. Hawryluck, and H.I. Smith, Fabrication of X-ray Masks Using Anisotropic Etching of (110) Si and Shadowing Techniques

Topical Conference on Low Energy X-ray Diagnostics, Monterey, California
June 8-10, 1981

Papers in Proceedings
H.I. Smith, Fabrication of Diffractive Optical Elements for X-ray Diagnostics

Washington, D.C.
June 8-10, 1981

Abstracts in Digest

1981 International IEEE MTT-S and AP-S Symposium and National Radio Science Meeting, Los Angeles, California
June 15-19, 1981

W.C. Chew and J.A. Kong, Asymptotic Eigenequations for the Dispersion Characteristics of Open, Wide Microstrip Line

Fifth International Conference on Laser Spectroscopy, Alberta, Canada
June 29-July 3, 1981


D. Kleppner, Turning Off the Vacuum (pp.292-293)

B.W. Pease, B.H. Tench, P.R. Hemmer, J.E. Thomas, and S. Ezekiel, Precision Studies in 3-Level Systems (pp. 251-254)
Fifth International Conference on Vapor and Epitaxy and Fifth American Conference on Crystal Growth, Coronado, California
July 19-24, 1981

S.S. Dana and H.I. Smith, Studies for Graphoepitaxy by CVD and Solution Growth

AIAA Guidance and Control Conference, Albuquerque, New Mexico
August 19-21, 1981

Papers in Proceedings
J.H. Lang, Experiments on the Electrostatic Control of a Flexible Membrane and Their Relation to Membrane-Antenna Figure Control (pp. 187-191)

Workshop on All-Optical Processing Elements in Integrated Optics, London, England
September 17-18, 1981

H.A. Haus and A. Lattes, Optical Logic Gates and Possible Applications

Thirteenth Annual Meeting of the Division of Electron and Atomic Physics, American Physical Society, New York, New York
December 3-5, 1981

D. Kleppner, A.G. Vaidyanathan, and W.P. Spencer, Turnoff of Blackbody Absorption (p.1317)

Tropical Meeting on Integrated and Guided-Wave Optics, Asilomar Conference Center, Pacific Grove, California
January 6-8, 1982

Papers in Technical Digest
H.A. Haus, Picosecond Sampling in Optical Waveguides (paper WA1-1-WA1-4)

A. Lattes, C. Gabriel, and H.A. Haus, Doubly Degenerate Four-Wave Mixing in Optical Waveguide (paper ThA4-1 - ThA4-3)

1982 Meeting, American Physical Society, Dallas, Texas
March 8-12, 1982

A.R. Kortan, High Resolution X-ray Study of Reentrant Nematic 60 CB-80 CB Mixtures (p.366)


H.A. Haus, High Speed Optical Waveguide Switching

A.M. Hawryluk, H.I. Smith, R.M. Osgood, and D.J. Ehrlich, Spatial-Period-Division Using and ArF Laser

XII International Quantum Electronics Conference, Munich, Germany June 22-25, 1982

H.A. Haus, A. Lattes, E.P. Ippen, and F.J. Leonberger, Optical Exclusive OR Gate

H.A. Haus, A. Lattes, C. Gabriel, E.P. Ippen and F.J. Leonberger, Doubly Degenerate Four-Wave Mixing in LiNbO₃ Waveguides

1982 March Meeting, American Physical Society, Dallas, Texas March 8-12, 1982

A.M. Barker, Commensurate-Incommensurate Phase Diagrams From the Helical Potts Model (invited paper) (p.140)

NATO Advanced Research Institute Microelectronics, Les des Alpes, France March 15-19, 1982

H.I. Smith, New Approaches to Single-Crystal Thin Films for Devices and Systems Using Surface Patterns

NATO Workshop on Target Background Modelling Techniques at Millimeter Wavelengths, Harry Diamond Laboratories, Adelphi, Maryland May 11-12, 1982

J.A. Kong, Active and Passive Remote Sensing of Earth Terrain at Millimeter Wavelength

47th Statistical Mechanics Meeting, Rutgers University, New Brunswick, New Jersey May 13-14, 1982

M. Kardar, Phase Boundaries of the Isotropic Helical Potts Model on the Square Lattice
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June 1, 1980 to November 1, 1982


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