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Jonathan Allen

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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

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1.

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 organized 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.

PUBLICATIONS ACKNOWLEDGING JOINT SERVICES SUPPORT

Published, Accepted for Publication, or Submitted

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Model on the Square Lattice

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June 1, 1980 to November 1, 1982

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- J.G. Fujimoto, "Construction and Application of a Synchronous Streak Camera System," M.S. and E.E. Thesis, Department of Electrical Engineering and Computer Science, May, 1981.
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