

# Eighth annual symposium on electron and laser beam technology

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## Editor's note

*We are indebted to Dr El-Kareh for this account which it has been decided to publish unabridged since the various aspects of controlled radiant energy dealt with at the Symposium represent such elegant examples of vacuum physics and such fruitful sources of process applications.*

The Eighth Annual Symposium on Electron and Laser Beam Technology took place on the campus of the University of Michigan, Ann Arbor, Michigan, and was sponsored by the University of Michigan and the Institute of Electrical and Electronics Engineers. This symposium was held last year at the Pennsylvania State University. About 200 people were present.

## Principal topics were:

- (1) The physics of electron, ion, and light beams.
- (2) The application of energy beams to microminiaturization and thin films, welding and materials, melting and evaporation, microcircuit fabrication research, integrated device construction, analysis of bombardment problems, materials study, and search for new, useful effects and techniques.
- (3) New energy beam equipment and processes.
- (4) Holography.

## Symposium officers

### Co-chairmen

Dr A B El-Kareh, The Pennsylvania State University

Dr. J. E. Rowe, The University of Michigan

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Dr G I Haddad, The University of Michigan, Chairman

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Dr L L Marton, National Bureau of Standards

Dr H Moss, Westinghouse

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Dr C Susskind, University of California

Dr S S White, Texas Instruments

## Introduction

The first meeting on electron-beam technology was organized by the Alloyd Corporation in Boston and at that time the discussion was concerned largely with melting and refining.

## Session I

*Moderator: Dr L L Marton (National Bureau of Standards, Washington, DC)*

### Fundamentals and applications of holography

So far the main interest in holography has arisen from the possibility of three-dimensional reconstruction of optical fields, and from the almost perfect "noise-like" coding in holograms. But it deserves attention also because of the amplification principle contained in it, which makes it possible to see or to photograph objects with very reduced exposures. Other still new and unexplored possibilities are *recoding* (translating a sign A into a sign B) and applications to ultrasound, electromagnetic waves and X-rays. The purpose for which holography was originally invented, improvement of electron micro-

During the subsequent meetings, additional fields such as electron beam welding, recording, machining and evaporating, became major topics of conversation. The interactions of electron beams with materials soon began to occupy a substantial part of these symposia. Today, as the above principal topics clearly show, the field covers a large area which affects the efforts of various professional groups. The whole subject can be loosely defined as the generation, focusing and control of radiant energy for the purpose of modifying the shape or nature of materials.

The first session was devoted almost entirely to holography. A hologram is a recording of an interference pattern reflected from an object. From this recording the object image can be reconstructed in three dimensions.

The keynote speaker was Dr Dennis Gabor, Professor at the Imperial College of Science and Technology, University of London. Professor Gabor, generally recognized as the father of holography, reviewed his laboratory's early efforts in holography in 1948 when lack of coherent light prevented any appreciable advances in the field. He pointed to pattern recognition as an important application of holography and said electron microscopy for which holography was invented is still waiting exploration. Otherwise, Professor Gabor saw no commercial applications!

The next two speakers, Dr Stroke and Dr Leith, represented two laboratories at the Institute of Science and Technology of the University of Michigan. Professor George W Stroke of the Electrical Engineering department is Head of the Electro-Optical Group and Professor E N Leith is Head of the Optics Group of Radar and Optics Laboratory.

Since the development of the laser, interest in holography was revived. The laboratories at the University of Michigan have conducted a broad research effort in the holography area designed to both enlarge the scope of the field through basic research and find applications.

scopy, is also still waiting for exploitation. The fundamentals of holography and various possible applications will be discussed.

**D Gabor**,  
*Imperial College of Science and Technology,  
University of London*

### Theoretical and experimental foundations for some new ramifications of holography

Five particularly fruitful areas of holography introduced since 1963 by the author with his students (in part with D Gabor) include: Fourier-transform holography, a posteriori resolution-retrieving compensation, holography with incoherent light, double-exposed

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holograms (for image-synthesis, coding and interferometry), and now a new type of "reflection hologram" observable in white light.

**G W Stokes**

*Electrical Engineering Department  
The University of Michigan  
Ann Arbor, Michigan*

### Recent results in holography

A survey of the current holographic activity in our laboratory is given. The topics covered are: theory of holographic interferometry, its application to vibration and surface deformation measurements, surface contour generation on holographic images, the use of three-dimensional storage media for holographic recording, the animation of holographic images, and the attainment of high quality imagery through diffusing media.

**E N Leith**

*Electrical Engineering Department  
The University of Michigan  
Ann Arbor, Michigan*

### Lasers for length measurement

Because of their high intensity and coherence, lasers are superior light sources for interferometric length measurements. Good wavelength stability as well as an accurate knowledge of the laser wavelength are prerequisites to provide the high precision required of such measurements.

Experiments will be described which led to the first successful measurement of a standard meter bar with a helium-neon laser used as a light source.

**K D Mielenz**

*National Bureau of Standards  
Washington, DC*

## Session II

*Moderator: Dr Harold Katz (Tecumseh Products, Ann Arbor, Michigan)*

### The use of lasers in signal processing for radar and communications

Lasers have been used in a large variety of signal processing optical equipments. The basic ideas will be reviewed and then applied to a number of problems in radar processing and communications signal processing.

The major ideas involving the use of optics for radar will be applied to the process of generating a synthetic antenna whereby a resolution significantly finer than that of a radiated beam-width is achieved. In the application of optics to communications, it is shown that many of the coding-decoding and synchronization operations can be mechanized optically.

**L J Cutrona**

*Electrical Engineering Department  
The University of Michigan and Conductron Corporation  
Ann Arbor, Michigan*

### Airborne investigations of clear-air turbulence with laser radars

Over 1300 experiments have been performed with a laser radar mounted in a light twin-engine airplane. Ancillary equipment included an accelerometer, thermistor, data recording equipment, and a forward-looking camera for recording the local meteorology. The studies were performed in mountain waves near Denver, in the severe storm activity of Oklahoma, and the local Detroit area. A description of the equipment will be given, together with examples of the data.

**P A Franken, J A Jenney and D M Rank**

*Physics Department  
The University of Michigan  
Ann Arbor, Michigan*

### Zapping paper for monitoring the temporal and spatial distribution of laser energy

A novel and simple method for monitoring the temporal and spatial distribution of pulsed laser energy by means of a multilayer coated paper is described.

**J H Myer**

*Hughes Aircraft Company  
Newport Beach  
California*

### The application of lasers in thermophysical properties measurements

The application of a ruby laser as the pulsed energy source for the flash technique of measuring the thermophysical properties of materials is discussed. The advantages and limitations of its application, as well as other related problems, are treated and the results of measurements performed are presented.

**M M Nakata**

*Atomics International  
Canoga Park, California*

### Charge compensator site in laser $\text{CaWO}_4$

This paper is intended to give certain preliminary results of the program to investigate the role of charge compensators in laser  $\text{CaWO}_4$ . Vanadium, which lies above niobium in the periodic table, is introduced as the charge compensator and micro-probe. Electron spin resonance measurements show that vanadium occupies W- and/or Ca-sites depending upon the relative concentration of vanadium to rare-earth. These and the preliminary optical results will be discussed.

**C Kikuchi and N Mahootian**

*Department of Nuclear Engineering  
University of Michigan  
Ann Arbor, Michigan*

**W Wiehmann**

*Harry Diamond Laboratories  
Washington, DC*

### The effect of internal reflection in a corner cube upon the polarization of a reflected beam

Graphical and matrix methods are presented for analyzing the change in state of polarization of a light beam which undergoes successive internal reflections. The techniques are applied to the design of a laser cavity incorporating internal reflectors which are both self-aligning and highly efficient.

**P J Walsh and I Krause**

*University Associates, Union  
New Jersey*

## Session III

*Moderator: Dr A B El-Kareh (The Pennsylvania State University, University Park, Pennsylvania)*

### Laser machining

This paper presents the results of an experimental program to define the current status of pulsed lasers as machine tools for material removal. The laser machining systems used for the test were sufficiently flexible so that an extensive study could be made of the effects of energy, power, pulse duration, beam divergence and focusing of the beam on machining capability. The machining tests were limited to the following materials: Rene-41, Inconel 713, L-605, Titanium 6-4, Aluminium Oxide, Hastelloy X, C-2 Carbide, Stellite 19, and D-6 Steel.

**W V Trammel**

*GM Defense Research Laboratories  
Santa Barbara, California*

### Laser piercing of diamond dies on a production basis

This paper will describe the development of a production line facility for piercing holes in diamond wire-drawing dies with a laser. The development of a method for piercing diamonds without structural damage will be discussed. The specifications of the laser and the design characteristics of the unique closed circuit television viewing system will be covered.

**R W Dyer and J P Epperson**

*Western Electric Company, Inc  
Princeton, New Jersey*

**J C Grzywa**

*Western Electric Company, Inc  
Buffalo, New York*

### Design of a production-worthy laser microwelder

The evolutionary steps in the design and construction of a production-worthy, safe, and economical laser microwelder are described. A novel, modular, liquid-cooled, cylindrical ruby laser head as well as