THE BELL SYSTEM
TECHNICAL JOURNAL

DEVOTED TO THE SCIENTIFIC AND ENGINEERING
ASPECTS OF ELECTRICAL COMMUNICATION

Volume 49 November 1970 Number 9

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Device Photolithography

Foreword

The fabrication of semiconductor and thin-film integrated circuits requires the delineation of precisely defined patterns in various materials in order to obtain the required functional performance of the device. Photolithographic processing has primarily been used for this purpose, requiring that masks be generated as the basic "tool" for producing integrated circuits. This issue is devoted to a detailed description of a new mask-making system intended to satisfy the Bell System's requirements for increasing numbers of increasingly complex masks. The system features high precision and large throughput made possible by a specially designed family of machines linked together by a computer-controlled information system.

The heart of the system is the primary pattern generator (PPG) which produces the original artwork by scanning a tv-like raster pattern on a photographic plate with a focused laser beam. The horizontal deflection of the beam is provided by reflecting it off a spinning polygonal mirror while the vertical motion of the plate is provided by a precision stepping table. The laser beam is modulated by an acousto-optic element under the control of a digital data stream which contains the topographic information. The machine is capable of generating a 22-cm by 18-cm pattern with an address structure of 32,000 by 26,000 units in about 10 minutes. It provides a reproducibility of one

part in 25,000 and an absolute accuracy greater than one part in 10,000. The reduction cameras and step-and-repeat camera that complete the system were designed to fully exploit the high-speed and accuracy capabilities of the PPG. Looking ahead to future device applications in which the higher resolution offered by an electron beam generator could be of importance, development work on such a unit is also described.

The articles in this issue discuss: (*i*) the overall system, including the engineering considerations that led to the choice of pattern generation; (*ii*) the computer programs required to transform topographic information into a digital data stream suitable for control of either the PPG or the electron beam pattern generator; (*iii*) the PPG, including the optical, mechanical and electrical design features; (*iv*) the electron beam pattern generator; (*v*) electron-sensitive materials for use with the electron beam machine; (*vi*) the design and characteristics of the lenses used in the mask-making system; (*vii*) the optical and mechanical design of the reduction cameras; (*viii*) the optical and mechanical design of the computer-controlled step-and-repeat camera; (*ix*) the thin photosensitive materials required for use in the above cameras; (*x*) the specially designed coordinate-measuring machine used to inspect masks and to maintain the mask-making system; and (*xi*) the information system which controls the flow of work through the mask laboratory.

Many people, too numerous to mention, throughout Bell Laboratories and Western Electric Company, have made significant contributions to the development of this mask-making system. Their efforts have led to the successful installation and operation of two mask laboratories, one at Murray Hill, New Jersey, and one at Allentown, Pennsylvania.

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