

- 2) **An N-P-N High Power Fast Germanium Core Driver Transistor***—C. M. Chang, *Sylvania Electric Products, Inc., Woburn, Mass.*

An *n-p-n* alloyed germanium core driver transistor has been designed and developed which has typical turn-on, turn-off, and storage times of 0.2-0.4 μ sec at an output current of 0.5 a, and dissipates 3 watts with the heat sink kept at room temperature. Conflicting electrical and thermal requirements were simultaneously achieved by soldering the germanium wafer on a thick copper tab which was in turn mounted on the metal base. Switching times were improved by reducing the volume available for minority carrier storage. Current gain, which for most units is over 100 at 0.5 a, was increased by optimizing the transistor geometry. The design considerations and transistor performance as well as data of 100°C storage life test are presented.

- 3) **Diffused Emitter and Collector P-N-P and N-P-N Silicon Medium Power Transistors**†—C. Orman and L. White, *Sylvania Electric Products, Inc., Woburn, Mass.*

Silicon *p-n-p* and *n-p-n* transistors for medium power audio use have been fabricated using diffusion of *p* or *n*-type doping elements into *n* or *p*-type silicon wafers to form emitter and collector regions. The wafers are prepared by etching flat circular depressions in silicon dice using a specially developed etchant. Diffused material surrounding the depressions is later removed to delineate the emitter. Dice must be processed to recover minority carrier lifetime. A ring base contact and circular dot emitter and collector contacts are made to the wafer in a one-shot operation. The design permits simple self-jigging for mounting of the unit on the package. Collector to package mount gives efficient removal of heat.

Units will deliver 300 mw power at 100°C with less than 10 per cent distortion and greater than 30-db power gain.

Collector breakdown voltages exceed 60 volts. Collector to base current ratio (B) ranges from 10 to 30 with little fall-off until beyond 200-ma collector current.

Detailed discussions of design consideration and electrical characteristics are given.

- 4) **The Preparation of Semiconductor Devices by Lapping and Diffusion Techniques**—H. Nelson, *RCA, Princeton, N. J.*

A new approach to the fabrication of semiconductor devices has been investigated. This approach allows the processing of large semiconductor wafers to a point where they can be diced into numerous and identical devices. Lapping, instead of etching, is employed for all shaping of the units and the high degree of precision built into the lapping apparatus is passed on to all of the devices prepared. The approach is applicable to the fabrication of a great

variety of semiconductor devices. Unipolar, photounipolar as well as bipolar transistors and negative resistance devices have been fabricated. These devices exhibit superior electrical characteristics. Silicon power transistors have current transfer ratios in the 20-40 range and power gains from 30-40 db. Silicon unipolar transistors have transconductances in the neighborhood of 500 μ mhos and input resistances of about 100 megohms. Silicon photounipolar transistors show a dc photo response of 2-20 amperes per lumen.

- 5) **Four-Layer Silicon Diodes**—S. M. Fok, G. S. Horsley, C. T. Sah, and H. Sello, *Shockley Semiconductor Lab., Mountain View, Calif.*

This paper describes some developmental four-layer silicon diodes which have switching voltages of 20-70 volts and holding currents of less than 1 ma to 100 ma. The speed of these devices is in the microsecond range. Temperature variation of these parameters is discussed. Some problems of design and fabrication techniques which control the electrical characteristics of these devices are presented.

- 6) **Control of Lifetime-Sensitive Device Characteristics By Electron Bombardment**—G. Backenstoss, *Bell Telephone Labs., Inc., Murray Hill, N. J.*

It is known that bombardment of silicon with highly energetic radiation deteriorates the lifetime of minority carriers.¹ In some semiconductor devices, e.g., the *p-n-p-n* transistors, a particular value of the lifetime at a prescribed current density may be required in order to obtain a suitable device characteristic. It is shown that electron bombardment of silicon *p-n-p-n* transistors is a process which is capable of controlling the turn-on current of the device satisfactorily over wide ranges provided the starting lifetime of the material is high enough. Bombardment with electrons from a Van de Graaff accelerator and with β rays of Sr^{90} has been performed. The increase of the turn-on current with bombardment is almost linear over about two orders of magnitude. The rate of increase varies almost linearly with the prebombardment turn-on current. These results are in agreement with the Shockley-Read recombination theory.

- 7) **An 85-Watt Dissipation Silicon Power Transistor**—R. W. Aldrich, R. H. Lanzl, D. E. Maxwell, J. O. Percival, and M. Waldner, *General Electric Co., Syracuse, N. Y.*

Production prototype silicon transistors have been made using large area diffused base structures. Simultaneous diffusion of gallium and phosphorus is used to form the diffused base structures. The geometry and doping level of the structure can be controlled by varying the impurity source composition and temperature. The phosphorus surface concentration is a much less rapidly varying function of source temperature than is the gallium surface concentration and is

determined primarily by the source composition.

Two line base contacts and one line emitter contact are attached to the wafer in a one-shot process in which all contacts are made simultaneously. The structure is then encapsulated in a hermetically sealed package.

The electrical characteristics of a group of units are given. The transistors are capable of dissipating 85 watts at a 25°C mounting base temperature and have been used, as is described, in circuits to deliver 25 watts in Class A and 80 watts in Class B push-pull operation.

PHOTOCONDUCTIVE AND STORAGE DEVICES—SESSION III-C

Session Chairman—A. Rose

Session Organizer—P. E. Pashler

- 1) **Differential Method of Lag Compensation in Photoconductive Devices**—H. Borkan and P. K. Weimer, *RCA, Princeton, N. J.*

The slow response time often observed in devices utilizing photoconductivity may be caused by the slow rise and decay of conductivity in the photoconductor, or by the RC time constant of the photoconductor in its associated circuit. In imaging devices, such as television camera tubes and light amplifiers, the lag is manifested by smearing of the image for moving scenes. This paper describes a method for reducing the effective response time of the device regardless of the source of lag. By taking the difference of the signals from two photoconductive elements having unlike transient responses, a resultant signal can be obtained having a faster response than either element alone.

Measurements have been taken on pairs of vidicons set up to view the same scene simultaneously. The lag-corrected video signal formed by the external combination of the two outputs showed improved speed of response with a moderate loss in signal. Similar results have been obtained with pairs of photoconductive cells. The method can also be applied to light amplifiers and to experimental camera tubes designed to yield a lag-corrected signal directly.

- 2) **Some New Structure-Type Targets for the Vidicon—Analysis of Their Operation**—S. A. Ochs and P. K. Weimer, *RCA, Princeton, N. J.*

Severe physical requirements are imposed on the photoconductive layer used in the conventional vidicon camera tube target. In particular, its resistivity must be of the order of 10^{14} ohm-cm for frame storage operation and its thickness must be sufficient to prevent capacitive lag. New vidicon targets of a complex structure permit a relaxation of these requirements on the photoconductor. Two types of targets are discussed.

- 1) An experimental "lateral-flow" structure in which the photocurrent flows

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¹ G. K. Wertheim, *Phys. Rev.*, vol. 105, p. 1730; 1957.