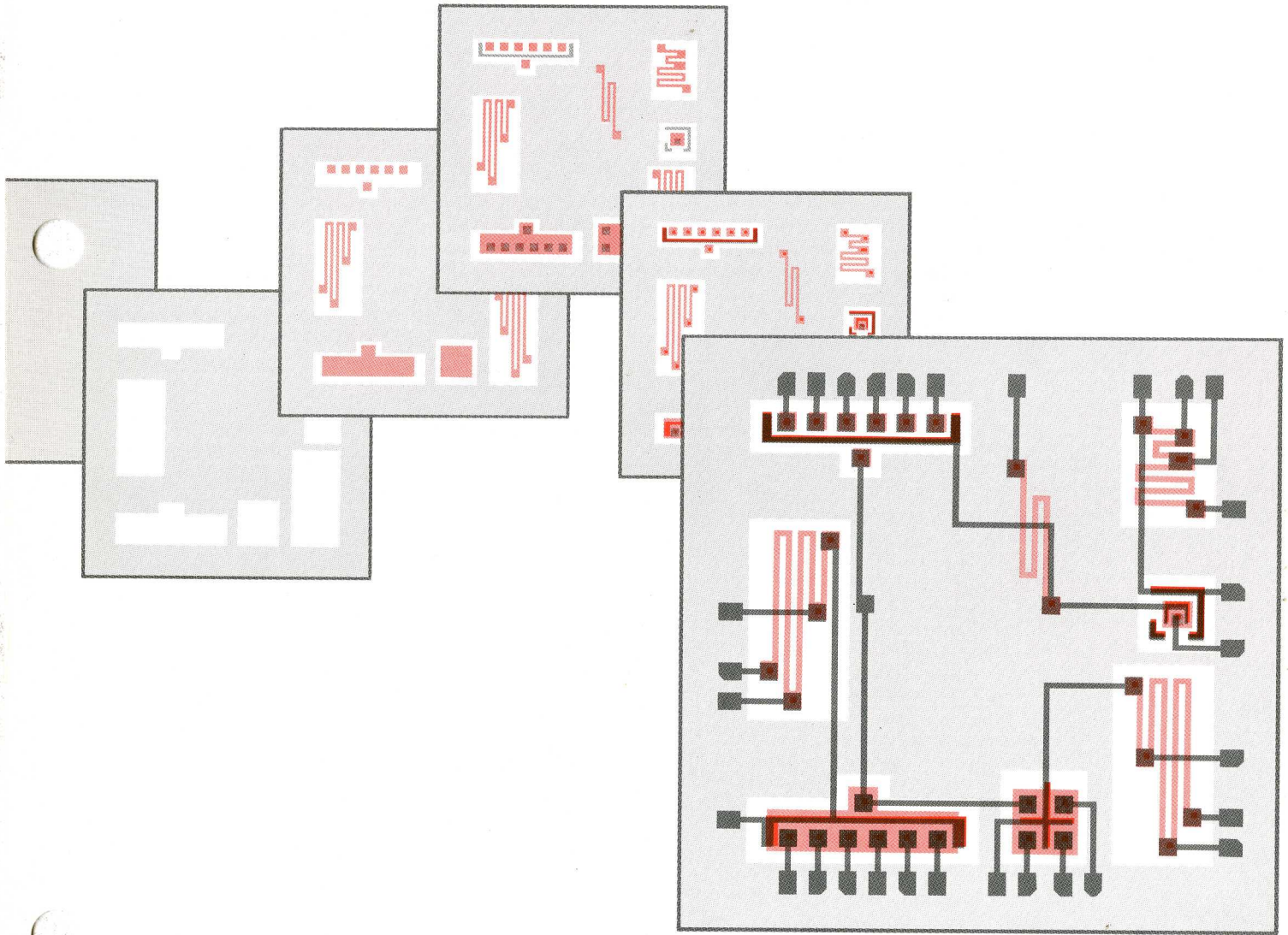
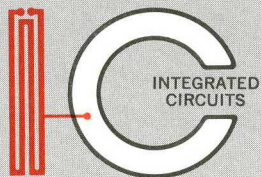
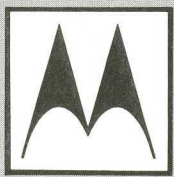


Advanced fabrication techniques for
MOTOROLA
INTEGRATED CIRCUITS

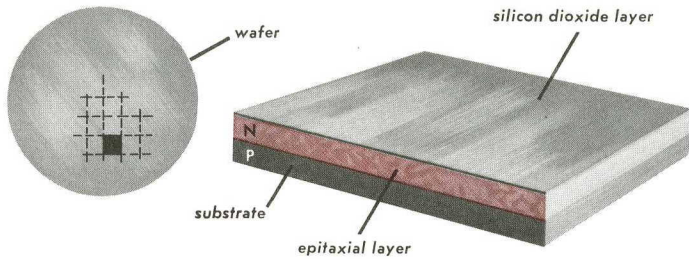


MOTOROLA
Semiconductor Products Inc.



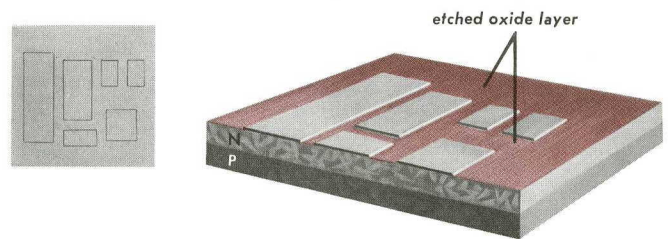
FABRICATION OF MOTOROLA INTEGRATED CIRCUITS

1 EPITAXIAL WAFER



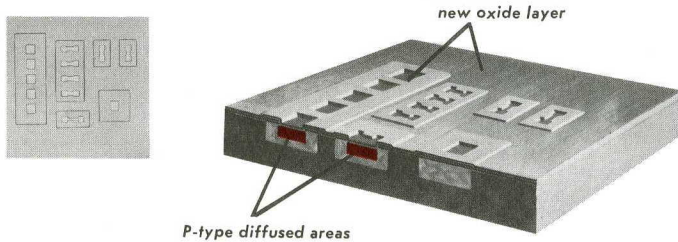
A layer of N-type silicon is epitaxially grown on a P-type silicon substrate, becoming a single crystal extension of the substrate wafer. This provides a PN junction at the point where the layers join. The entire surface is then protected with a silicon dioxide (glass) layer. The epitaxial layer ultimately becomes the collector for transistors or an element for diodes or junction capacitors.

2 ISOLATION MASKING



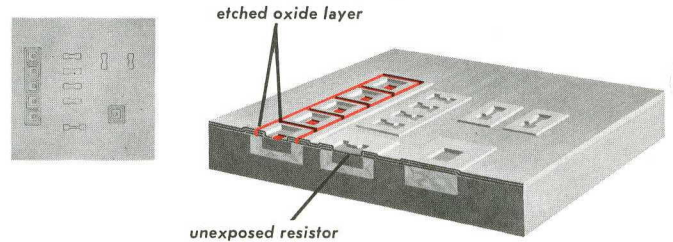
"Windows" are selectively etched through the oxide coating to prepare for isolation diffusion. The surrounding oxide is masked against the etching process by microphotolithographic techniques. These advanced processes make possible uniform, precise placement of multiple integrated circuit patterns during Motorola's "batch" processing of many wafers at one time.

5 SECOND DIFFUSION



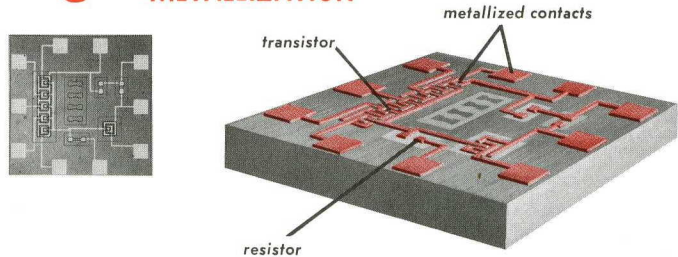
A P-type diffusion of much shorter duration than the previous isolation diffusion process forms the transistor base regions, resistors, and diode and capacitor anodes for the final circuit elements. Note that as the diffused material enters the wafer it also diffuses laterally, forming each junction on the surface at a protected location under the oxide coating.

6 EMITTER/CATHODE/CROSSOVER MASKING



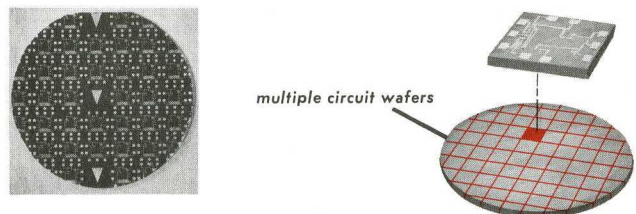
Again the oxide coating is selectively etched (using microphotolithographic techniques) at locations precisely indexed to the partial components laid down during the previous diffusion procedure. In the case of resistors (which were deposited in the last diffusion process), no further formation is required. Hence, these areas will remain beneath the oxide during this masking step.

9 METALLIZATION



A thin, even coating of metal is evaporated over the entire surface of each wafer. Following another precise photo-masking step, the metal layer is selectively etched to leave a pattern of interconnections between transistors, resistors, diodes, and other circuit elements. Some layer areas of metal may be left to form silicon oxide dielectric capacitors in conjunction with the underlying substrate.

10 WAFER SCRIBING

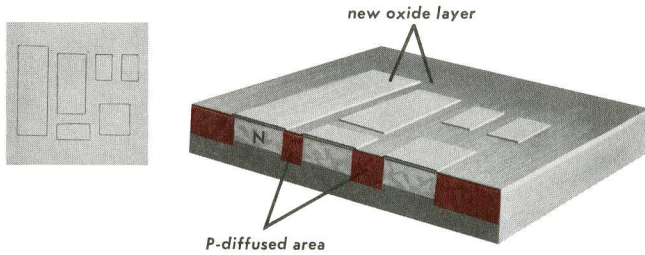


At this point all components and interconnections of the circuits have been formed. Wafers are then scribed into individual circuits for mounting to the ten-lead headers. All preceding fabrication processes are applied to wafers containing many integrated circuits, and the simultaneous processing of a large number of wafers, makes possible large-volume, low-cost circuits with a high degree of uniformity.

Production processes used in fabricating Motorola's advanced integrated circuits are given here as a guide in understanding typical processing techniques. The methods outlined

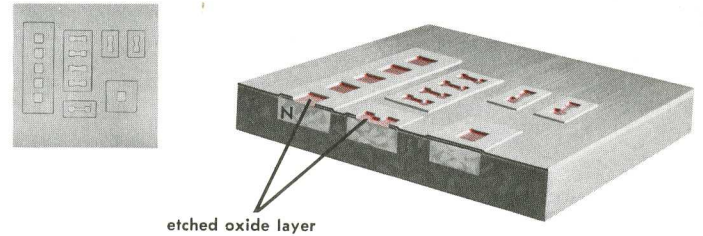
are not limited to any single Motorola circuit type, but are descriptive of the general approach used in custom and standard integrated circuits being produced by Motorola.

3 FIRST DIFFUSION



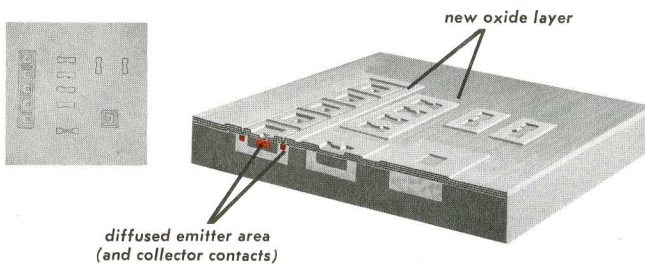
Diffusion of a P-type impurity into the exposed wafer areas provides isolation where needed in the final circuit by forming "channels" through to the basic P-type substrate. The isolated "islands" of N-type silicon thus formed make possible the deposition of multiple elements on the same wafer without creating unwanted common connections between elements. A new oxide layer is formed over the exposed areas after isolation diffusion is completed.

4 RESISTOR/BASE/ANODE MASKING



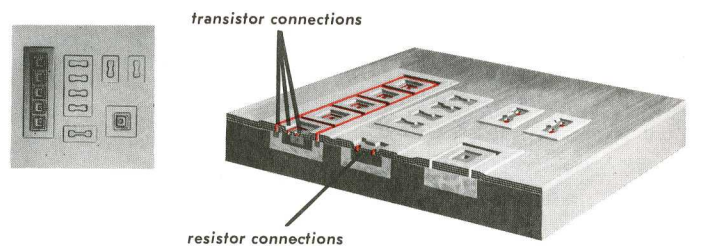
Windows are etched through the second oxide layer at locations suitable for positioning of transistor base regions, resistors, and the anode portions of diodes and junction capacitors which are to be used in the completed circuit. Precise masking and alignment techniques used at the various process points maintain exact placement of the multiple components to be used in each of hundreds of circuits.

7 THIRD DIFFUSION



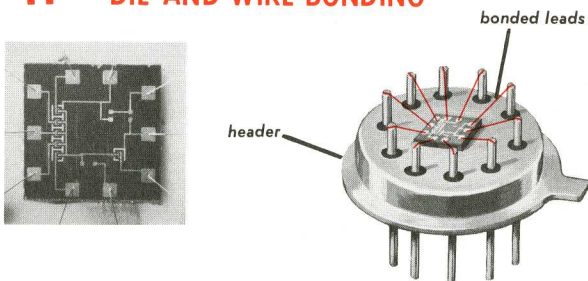
Diffusion of an N+ material forms transistor emitter areas, cathode regions for diodes and capacitors, degenerative layers for circuit contacts, and crossovers. In some circuit types, low value resistors are also formed at this time. The formation of a number of different circuit functions simultaneously, in this manner, lends itself to close control of overall circuit performance.

8 INTERCONNECTION MASKING



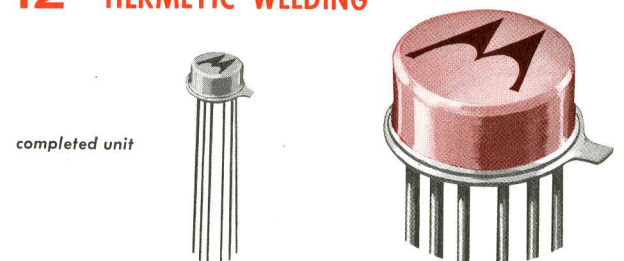
Patterns to form the connections between circuit components are etched on each wafer. This step exposes each circuit component at the proper point to allow for "wiring" of the circuit during metallization. Again as in all previous masking steps, precision masking protects any component junctions formed during foregoing diffusion processes. Tin oxide or other thin film resistors may be deposited on the silicon dioxide if needed for proper circuit performance. Additional photo-masking and etching steps produce the proper geometry.

11 DIE AND WIRE BONDING



After separation into individual circuits, each chip is mounted on a ceramic wafer, then to a header by means of a very high temperature eutectic solder. Short wires, .001" in diameter, are bonded from the circuit to the proper header leads. This rugged mounting method and the advanced wire bonding techniques used make it possible for Motorola circuits to withstand severe centrifuge, shock and vibration conditions.

12 HERMETIC WELDING



The addition of a welded cap, providing a hermetic seal for each Motorola integrated circuit, completes the fabrication process. Each unit then undergoes a 3-foot drop test on a maple block, stabilization baking, and 20,000 g centrifuge testing in accordance with military specifications to assure ruggedness and reliability.



PROVEN RELIABILITY TECHNIQUES

The processes utilized in fabricating Motorola integrated circuits are those developed for production of high reliability Motorola silicon transistors. Through the *exclusive* use of these transistor-proven techniques, completed integrated circuits are expected to have equally high reliability.

Another factor adding to the expectation of highly reliable circuits is the use, at Motorola, of production processes which are virtually free of error due to the human factor. All processing equipment for integrated circuits is designed so that no human control is involved in any fabricating step. Once the production

equipment has been prepared for a further processing step on circuit wafers, the operator of such equipment is merely a bystander and exercises no influence over the process itself.

The combination of the above two factors in Motorola integrated circuits — the use of time and field tested fabrication techniques used for many years in transistor manufacturing and the absence of human error in production processing — give promise of the same high level of reliability in Motorola integrated circuits that has been achieved in individual components in the past.



MOTOROLA Semiconductor Products Inc.

5005 EAST McDOWELL ROAD • PHOENIX 8, ARIZONA A SUBSIDIARY OF MOTOROLA INC.