TECHNOLOGY
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Silicon Device Processing

Proceedings of a Symposium
Held at Gaithersburg, Maryland
June 2-3, 1970

Charles P. Marsden, Editor

Institute for Applied Technology
National Bureau of Standards
Washington, D.C. 20234

Under the Sponsorship of Committee F-1
of the
American Society for Testing and Materials
and
The National Bureau of Standards

National Bureau of Standards Special Publication 337

Nat. Bur. Stand. (U.S.), Spec. Publ. 337, 467 pages (Nov. 1970)
CODEN: XNBSA

Issued November 1970

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
(Order by SD Catalog No. C 13.10:337), Price $5.50

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Mechanical Damage - Its Role in Silicon Surface Preparation

R. B. Soper

Semiconductor Processing Co., Inc.
Hingham, Mass. 02043

Silicon is mechanically damaged during the centerless grinding, slicing, lapping and mechanical polishing operations used to shape the ingot into wafers. Surface damage, removed by chemical processes and peripheral defects such as conchoidal fractures, indents, and microcracks are discussed. A comparison of various polishing methods and how they relate to mechanical damage is given.

Key Words: Centerless grinding, etching, lapping, mechanical damage, peripheral damage, polishing, silicon, slicing, surface damage, surface preparation.

1. Introduction

The silicon surface quality sufficient for the manufacture of different devices varies widely; for instance, a simple diode may require only a surface obtained from the free etching of a sawn slice, whereas the slice used for the vidicon image tube should be of precise diameter, polished on both sides, free of any peripheral or surface damage, thin (four to six mils), flat and parallel.

To prepare the high quality silicon surface required for today's sophisticated devices, consideration must be given to the damage created by the necessary abrasive operations such as centerless grinding, orientation flat generation, slicing and lapping. Operations such as polarity probing, resistivity measurements, thickness measurement and handling with tweezers can also cause thermal or impact damage to the silicon surface. Abrasive, thermal and impact damage is best removed by chemical processes. The final polishing operation should leave the surface as damage-free as possible.

In the last decade mechanical damage induced in semiconductor materials has been investigated by many workers. (1-10)[1] There has been a difference in the depths of damage reported by different workers because of the variables involved in the abrasive operations and in the techniques used to determine the depth of the damaged layer. These points will be further discussed by others at this meeting.

The primary concern of this paper will be the damage created at the periphery of the wafer and how it can be controlled.

2. Peripheral Damage

Below is a description of the different types of mechanical damage which is located or is generated at the periphery of the wafer.

Conchoidal Fracture - A conchoidal fracture is a spalled flake of silicon. It may be shallow or deep, and multiple fractures may be on both sides of the wafer. In some cases partial spalling results due to incomplete fracturing.

Indent - An indent fracture is any irregularity from the normal profile of the wafer. It may be bounded by crystallographic planes or be random in shape.

Microcrack - A microcrack is a minor break which does not involve any appreciable separation of silicon. The depth usually penetrates the entire thickness of the wafer. The break normally follows a crystalographic plane, but the initiating force can be directed so as to yield a multi-directional break.

[1] Figures in brackets indicate the literature references at the end of this paper.

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