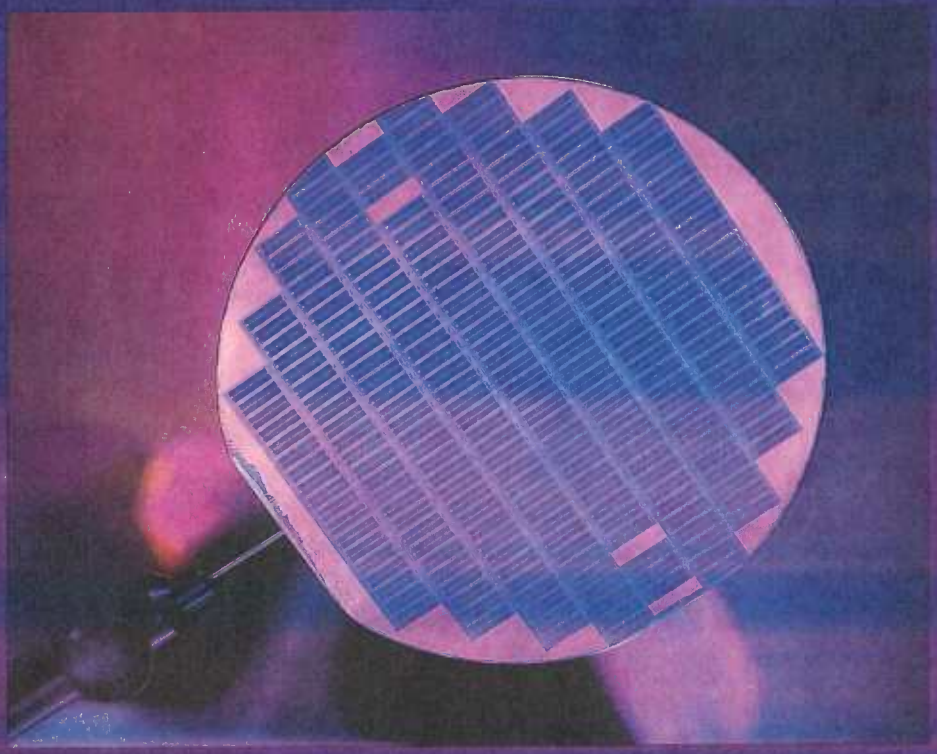
MICROCHIP FABRICATION

A PRACTICAL GUIDE TO SEMICONDUCTOR PROCESSING



PETER VAN ZANT

SECOND EDITION

Library of Congress Cataloging-in-Publication Data

Van Zant, Peter.
Microchip fabrication : a practical guide to semiconductor processing / by Peter Van Zant. — 2nd ed.

p. cm.
ISBN 0-07-067194-X
1. Semiconductors—Design and construction. I. Title.
TK7871.85.V36 1990
621.381'52—dc20 89-36002
CIP

3 4 5 6 7 8 9 0 DOCDOC 9 5 4 3 2

ISBN 0-07-067194-X

The sponsoring editor for this book was Daniel A. Gonneau, the editing supervisor was David E. Fogarty, the designer was Naomi Auerbach, and the production supervisor was Suzanne W. Babeuf. This book was set in Century Schoolbook. It was composed by the McGraw-Hill Professional and Reference Division composition unit.

Printed and bound by R. R. Donnelley & Sons Company.

Batch Number	Broken Wafer	Scratch	Contamination	Pinholes	MA	Bridging	Lifting Resist	Under Exposed	Incomplete Develop	No Resist	Resist Running	Wrong Mask	C.D.	Reject

Figure 9.13 Typical develop inspect log.

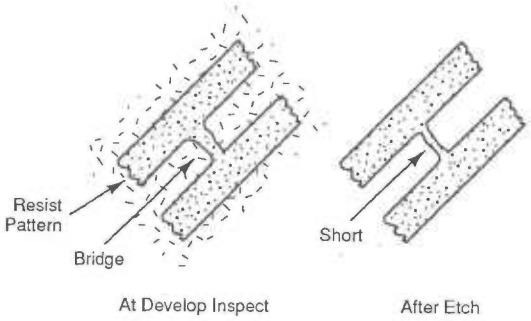


Figure 9.14 Bridged conduction lines.

from an overexposure, poor mask definition, or a resist film that is too thick.

Etch

At the completion of the develop inspect step, the mask (or reticle) pattern is defined in the photoresist layer and is ready for etch. During the etch step the image will be permanently transferred into the surface layer on the wafer. The goal is an exact transfer of the image into the resist layer. The degree of exactness is dependent on several factors which will be explored as a preparation for discussion of the dif-

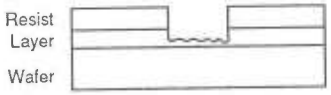


Figure 9.15 Incomplete etch.

ferent etch methods. The factors affecting image transfer are incomplete etch, overetching, undercutting, and selectivity.

Incomplete etch

Incomplete etch is a situation in which a portion of the surface layer still remains in the pattern hole or on the surface (Fig. 9.15). The causes of incomplete etch are too short an etch time, the presence of a surface layer that slows the etching, or an uneven surface layer that results in incomplete etch in the more thickly coated portions of the wafer. If wet-chemical etching is used, a lowered temperature or weak etch solution will cause incomplete etch. If dry plasma etching is used, a wrong gas mixture or an improperly operated system can cause the same effect.

Overetch and undercutting

The opposite condition to incomplete etch is overetch. In any etch process there is always some degree of overetch planned into the process. This is necessary to ensure complete removal of the thickest portions of the the layer and to allow for the etch to break through any slow-etching layers on the top surface.

The ideal etch leaves vertical sidewalls in the layer (Fig. 9.16). Etch techniques that produce this ideal result are said to be *anisotropic*. However, the etching chemical dissolves the top of the sidewall for a longer time than the bottom of the hole. The result is a hole wider at the top than the bottom with a sloped sidewall. Etching techniques that produce this result are called *isotropic*. This action of the etching chemical is called *undercutting* (Fig. 9.17) since the surface layer is undercut below the resist edge. Circuit layout designers take undercutting into account when planning the circuit. Adjacent patterns must be separated a certain distance to prevent shorting. The amount of undercutting must be calculated when the pattern is designed.

An ongoing goal of the etch step is the control of undercutting to an acceptable level. Severe undercutting (or overetch) takes place when the etch time is excessive, the etch temperature is too high, or the etch mixture is too strong. Undercutting is also present when the adhesion bond between the photoresist and the wafer surface is weak. This is a constant worry, and the purpose of the dehydration, prime, soft bake,

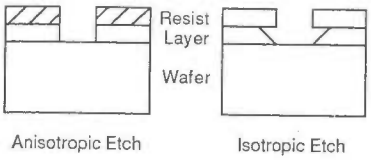


Figure 9.16 Anisotropic and isotropic etch.

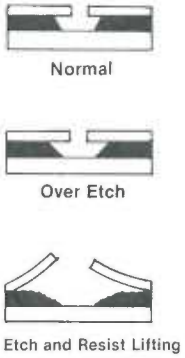


Figure 9.17 Degrees of undercutting.

and hard bake steps is to prevent this type of failure. Failure of the resist bond at the edge of the etch hole can result in severe undercutting. If the bond is very poor, the resist can lift from the wafer surface, causing catastrophic undercutting.

Selectivity

Another goal of the etch step is the preservation of the surface underlying the etched layer. If the underlying surface of the wafer is partially etched away, the physical dimensions and electrical performance of the devices are changed. The property of the etch process that relates to preservation of the surface is *selectivity*. High selectivity implies little or no attack of the underlying surface. In wet etching techniques an etchant acid that will not attack the underlying material is chosen.

Wet Etching

For over 30 years the traditional method of etching has been by immersion techniques using wet etchants. The procedure is similar to the preoxidation clean-rinse-dry process (Chap. 7) and immersion development. The emergence of feature sizes less than 3 μm has seen the shift from wet to dry etching techniques. However, keep in mind that within a circuit whose smallest dimensions are 3 μm or less, there are still mask levels with dimensions well above that level. In many cases dry etching is employed for small dimensions and wet etching for the larger ones.

For wet etching, the wafers are loaded into an etch-resistant boat and immersed in a tank of the etchant. After a predetermined time in the etch tank they are processed through the rinsing and drying steps.

DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS
Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS
Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS
Sync your system to PACER to automate legal marketing.