

TK  
7874  
A3356  
1993

PROCEEDINGS



SPIE—The International Society for Optical Engineering

# *Advanced Techniques for Integrated Circuit Processing II*

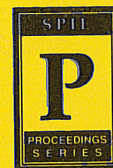
James Bondur  
Gary Castleman  
Lloyd R. Harriott  
Terry R. Turner  
*Chairs/Editors*

21–23 September 1992  
San Jose, California

RECEIVED

JUN 23 1993

UNIVERSITY LIBRARY



Volume 1803

**DOCKET  
ALARM**

Find authenticated court documents without watermarks at [docketalarm.com](http://docketalarm.com).



 **PROCEEDINGS**  
SPIE—The International Society for Optical Engineering

# *Advanced Techniques for Integrated Circuit Processing II*

James Bondur  
Gary Castleman  
Lloyd R. Harriott  
Terry R. Turner  
*Chairs/Editors*

21–23 September 1992  
San Jose, California

*Sponsored and Published by*  
SPIE—The International Society for Optical Engineering

CLASS SEP.

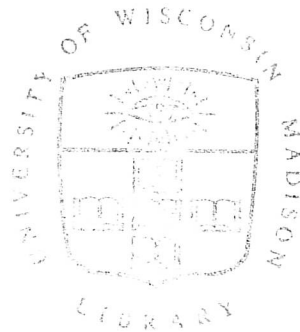


**Volume 1803**

SPIE (The Society of Photo-Optical Instrumentation Engineers) is a nonprofit society dedicated to the advancement of optical and optoelectronic applied science and technology.

KURT F. WENDT LIBRARY  
COLLEGE OF ENGINEERING  
UNIVERSITY OF WISCONSIN  
MADISON, WI 53706

Intel Corp. et al. Exhibit 1008



The papers appearing in this book comprise the proceedings of the meeting mentioned on the cover and title page. They reflect the authors' opinions and are published as presented and without change, in the interests of timely dissemination. Their inclusion in this publication does not necessarily constitute endorsement by the editors or by SPIE.

Please use the following format to cite material from this book:

Author(s), "Title of paper," in *Advanced Techniques for Integrated Circuit Processing II*, James Bondur, Gary Castleman, Lloyd R. Harriott, Terry R. Turner, Editors, Proc. SPIE 1803, page numbers (1993).

Library of Congress Catalog Card No. 92-62653  
ISBN 0-8194-1001-2

Published by  
**SPIE—The International Society for Optical Engineering**  
P.O. Box 10, Bellingham, Washington 98227-0010 USA  
Telephone 206/676-3290 (Pacific Time) • Fax 206/647-1445

Copyright ©1993, The Society of Photo-Optical Instrumentation Engineers.

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$4.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 27 Congress Street, Salem, MA 01970. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0-8194-1001-2/93/\$4.00.

Printed in the United States of America.

## A Closed-Loop Temperature Control System for a Low-Temperature Etch Chuck

D.R. Wright, W.D. Clark, D.C. Hartman, U.C. Sridharan<sup>†</sup>, SEMATECH, Austin, TX;  
M. Kent, R. Kerns, GS/DRYTEK, Wilmington, MA.

<sup>†</sup>Now at HEWLETT-PACKARD, Palo Alto, CA.

### ABSTRACT

A closed-loop temperature control system has been developed for use in a low-temperature ( $-135^{\circ}\text{C}$ ) plasma etch system. The system employs an optical fluorescence probe on the chuck (a second probe monitors the wafer temperature as well) to provide feedback to the heating element on the input line of the chuck closed-loop coolant fluid. A simple proportional-integral-derivative (PID) controller with a learn mode controls the rate of current pulses applied to the heater. Innovations include the direct measurement of chuck temperature for the control signal, and the coupling of large cooling and heating capacities in close proximity to the chuck along with a fast fluid flow to guarantee quick response.

The system has been tested in prolonged etch runs of many wafers. It provides reliable, tight temperature control ( $3\sigma$  as low as  $0.6^{\circ}\text{C}$ ). This level of control is significantly tighter than could be achieved by merely monitoring chiller bath temperatures.

### 1. INTRODUCTION

As semiconductor features become smaller and process requirements become stricter, advanced plasma etch systems require tighter control over their process factors. A recent project at SEMATECH worked to develop an etch system that would provide tight control of wafer temperature for low-temperature etch applications.

This paper discusses the hardware for both the sensors and control systems, as well as results of the temperature stability, over various extended runs of hundreds of wafers.

### 2. SUPPORTING HARDWARE

#### 2.1 Fiber optic temperature probe

The fluoroptic thermometric technique developed by Luxtron uses the photoluminescent response of a magnesium fluorogermanate phosphor to blue light pulses transmitted down a fiber optic cable probe. The rate of decay of the fluorescence is measured and correlated to temperature. Two types of fluoroptic



probes are available. The first type ("remote" or non-contacting) uses a phosphor dye painted on the sample and receives the data into the fiber from a distance. The second type ("contact") uses the phosphor in an encapsulation at the end of the fiber. Surrounded by a protective coating, this probe is used to make physical and thermal contact with the sample. For the application investigated during the project, either type could have been used for the electrode probe. The etch system used in the project had two chambers, each with separate "contact" probes for monitoring electrode temperature and wafer temperature.

The electrode temperature was monitored to determine the stability of the cooling system. The wafer temperature was used to determine the interaction of the etch process and the cooling system.

## 2.2 Chiller systems

Two different cooling systems were used in the tool. For the  $-70^{\circ}\text{C}$  chamber, a standard bath-type chiller was chosen. This style of chiller controls the temperature of a bath through which a heat transfer fluid circulates on its way to the electrode (some 5 to 10 meters away).

For the  $-135^{\circ}\text{C}$  chamber, a system from Polycold was chosen. This cryo-cooler was unique in two ways. First, the refrigerant (a mixture of Freons and argon) was circulated through the electrode. This afforded a higher heat removal efficiency than circulating a heat transfer fluid between a refrigerated bath and the electrode. Second, there was no built-in feedback system for temperature control. These systems are normally run at "maximum output" for high-vacuum cold-trap applications, with the temperature controlled by the composition of the refrigerant mixture. This made it necessary to add a separate system for controlling the electrode temperature.

## 3. HEATER/CONTROLLER DESIGN

The throttling approach to temperature control consisted of a valved coolant path that bypassed the chuck, allowing some of the cooling fluid to be diverted away from the chuck in order to lower the effective cooling power of the Polycold system. This approach failed for three main reasons:

- Large valves that work reliably at  $-150^{\circ}\text{C}$  are prohibitively expensive.
- The chuck cooling capacity was lowered (since most of the coolant would be bypassed).
- The two-phase nature of the refrigerant meant different mixtures of constituents flowed in the main and bypass lines, also lowering cooling efficiency.

# 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.