

**MRS**

# BULLETIN

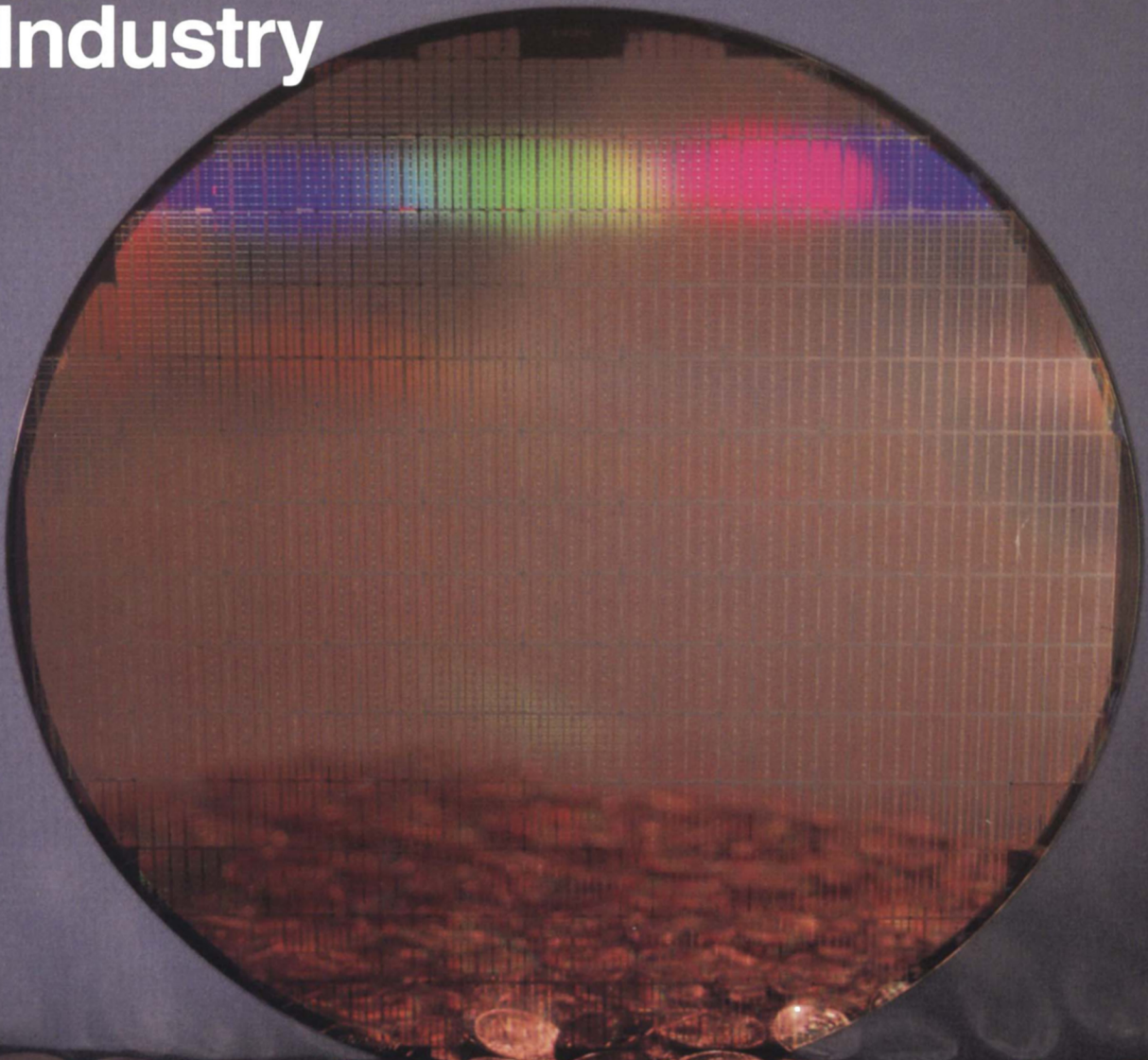
Serving the International  
Materials Research Community

A Publication of the Materials Research Society

August 1994, Volume XIX, No. 8



## Copper Metallization in Industry



# HAVE YOU HEARD THE RUMOUR??

...that High Voltage Engineering is currently developing a 3.5MV/TV -high current- tandem accelerator? Well... **they are not**, because HVEE has already finished the 3.5MV Tandetron and it performs extremely well!

In addition to higher terminal voltages, the HVEE Tandetron accelerators are now available with a novel, patented 90° dual ion source -high current- injector system and full computer control for unattended start-up and operation.

The new HVEE Tandetron accelerator systems can be installed in a single room laboratory without the need of a HV protection cage or additional X-ray shielding.

**Circle no. 1** reader service card for product literature.



DIVISIONS  
GENERAL IONEX  
DOWLISH DEVELOPMENTS



More  
Energy for Research

**HIGH VOLTAGE ENGINEERING EUROPA B.V.**

P.O. Box 99, 3800 AB Amersfoort, The Netherlands. Phone: (+31) 33-619741. Fax: (+31) 33-615291.

For Japan: MARUBUN CORP., 8-1 Nihombashi Odemmacho, Chuo-ku, Tokyo, 103 Japan. Phone 03-3639-9861. Fax 03-3639-3711

A Publication of the Materials Research Society

Volume XIX, Number 8 ISSN: 0883-7694 CODEN: MRSBEA

## **COPPER METALLIZATION IN INDUSTRY**

### **15 Copper-Based Metallization in ULSI Structures**

J. Li, T.E. Seidel, and J.W. Mayer,  
Guest Editors

### **23 Materials Issues in Copper Interconnections**

J.M.E. Harper, E.G. Colgan,  
C-K. Hu, J.P. Hummel,  
L.P. Buchwalter, and C.E. Uzoh

### **30 Barriers Against Copper Diffusion into Silicon and Drift Through Silicon Dioxide**

S-Q. Wang

### **41 Chemical Vapor Deposition of Copper for IC Metallization: Precursor Chemistry and Molecular Structure**

P. Doppelt and T.H. Baum

### **49 Chemical Vapor Deposition of Copper for Advanced On-Chip Interconnects**

A.V. Gelatos, A. Jain, R. Marsh,  
and C.J. Mogab

### **55 Electroless Copper Deposition on Metals and Metal Silicides**

Cecilia Y. Mak

### **63 Planarized Copper Multilevel Interconnections for ULSI Applications**

N. Misawa, T. Ohba, and H. Yagi

### **68 Copper Metallization Technology for Deep Submicron ULSIs**

Y. Arita, N. Awaya, K. Ohno,  
and M. Sato

### **75 European Copper Interconnection Project**

J. Torres

## **INTERNATIONAL UNION OF MATERIALS RESEARCH SOCIETIES**

### **76 C-MRS and E-MRS to Hold Symposium on Electronic and Optoelectronic Materials**

## **MRS NEWS**

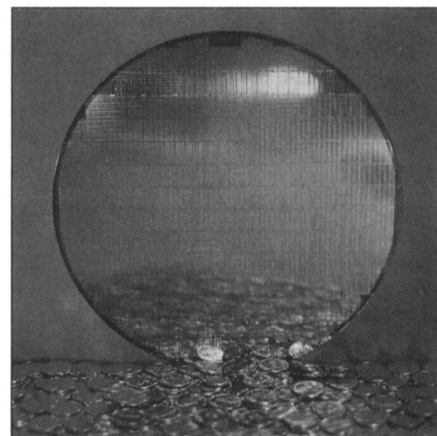
### **77 Courses About Internet and Federal Materials Research Programs Debut at 1994 MRS Fall Meeting**

### **77 Nominations Being Accepted for MRS Outstanding Young Investigator Award**

### **78 Call for Papers - 1995 MRS Spring Meeting**

## **DEPARTMENTS**

- 4 Research/Researchers**
- 10 From Washington**
- 12 Resources**
- 13 Editor's Choice**
- 54 Advertisers in This Issue**
- 81 Upcoming Conferences**
- 83 Education Exchange**
- 85 Historical Note**
- 86 Library**
- 87 Classified**



**ON THE COVER:** A 200 mm (8 inch) diameter silicon wafer with copper interconnections. The copper interconnection structure was developed and fabricated by members of IBM's Research Division and Microelectronics Division. The photograph was taken by D.C. Edelstein and E.G. Colgan. For more information about this topic, see "Materials Issues in Copper Interconnections" by J.M.E. Harper and colleagues on p. 23.

## About the Materials Research Society

The Materials Research Society (MRS), a non-profit scientific association founded in 1973, promotes interdisciplinary goal-oriented basic research on materials of technological importance. Membership in the Society includes nearly 11,600 scientists, engineers, and research managers from industrial, government, and university research laboratories in the United States and nearly 50 countries.

The Society's interdisciplinary approach differs from that of single-discipline professional societies because it promotes information exchange across the many technical fields touching materials development. MRS sponsors two major international annual meetings encompassing approximately 50 topical symposia, and also sponsors numerous single-topic scientific meetings. The Society recognizes professional and technical excellence, conducts short courses, and fosters technical interaction in local geographic regions through Sections and University Chapters.

MRS participates in the international arena of materials research through the International Union of Materials Research Societies (IUMRS). MRS is an affiliate of the American Institute of Physics.

MRS publishes symposium proceedings, *MRS Bulletin*, *Journal of Materials Research*, and other publications related to current research activities.

*MRS Bulletin* (ISSN: 0883-7694) is published 12 times a year by the Materials Research Society, 9800 McKnight Road, Pittsburgh, PA 15237. Application to mail at second class rates has been approved at Pittsburgh, PA and at additional mailing offices. POSTMASTER: Send address changes to *MRS Bulletin* in care of the Materials Research Society, at the address listed; phone (412) 367-3003; Fax (412) 367-4373. Printed in the U.S.A.

Additional copies of articles in the *MRS Bulletin* may be made at \$2.50 per article. This fee can be paid to the Materials Research Society through the Copyright Clearance Center, Inc., 27 Congress Street, Salem, MA 01970.

Membership in MRS is \$75 annually for regular members, \$25 for students and retired members. Dues include an allocation of \$25 (\$15 for students and retirees) to a subscription to *MRS Bulletin*. Individual member subscriptions are for personal use only. Non-member subscription rates are \$112 for one calendar year (12 issues) within the U.S.A. and \$165 elsewhere. Single copies may be purchased for \$16 each. Send subscription orders to Subscription Department, Materials Research Society, 9800 McKnight Road, Pittsburgh, PA 15237.

*MRS Bulletin* is included in *Current Contents/Physical, Chemical & Earth Sciences*<sup>™</sup>, *Research Alert*, and the *Materials Science Citation Index*<sup>™</sup>. Back volumes of *MRS Bulletin* are available in 16mm microfilm, 35mm microfilm, or 105mm microfiche through University Microfilms Inc., 300 North Zeeb Road, Ann Arbor, Michigan 48106.

## MRS BULLETIN

### Publisher

G.A. Oare

### Editor

E.L. Fleischer

### Managing Editor

F.M. Wieloch

### Copy Editors

J. Guenther, L.A. Krysinski, S.W. Morelli, D.M. Varner

### Art Director

C. Love

### Design/Production

T. Aiello, S. Franklin, H.J. Miller

### Editorial Assistants

M.M. Costello, J. Dininny

### Advertising

M.E. Kaufold

### Circulation

S.E. Krasa

### Guest Editors

J. Li, J.W. Mayer and T.E. Seidel

### Special Contributors

K.J. Anderson, A.E. West

### Special Consultant

M. Goodway

### Associate Editor—Europe

I.W. Boyd  
University College London  
Dept. of Electronic and  
Electrical Engineering  
Torrington Place  
London WC1E 7JE, U.K.  
Tel. 71-387-7050 ext. 3956 or 7304

### Book Review Editor

C.J. McHargue  
University of Tennessee  
Knoxville, Tennessee

### MRS Office of Public Affairs

555 13th Street NW, Suite 900 East  
Washington, DC 20004  
Tel. (202) 383-8809, Fax (202) 383-8877

### CHAIRMAN—EDITORIAL BOARDS

E.N. Kaufmann • Argonne National Laboratory • Argonne, Illinois, USA

### INTERNATIONAL ADVISORY BOARD

M. Balkanski  
University of Pierre and Marie Curie  
Paris, France

R.G. Elliman  
Australian National University  
Canberra, Australia

S. Hsu  
Chung Shan Institute of Science  
and Technology  
Taiwan, China

L.C. Ianniello  
U.S. Department of Energy  
Washington, DC, USA

H-D. Li  
National Science Foundation-China  
Beijing, China

P. Rama Rao  
Ministry of Science and  
Technology  
New Delhi, India

R. Roy  
Pennsylvania State University  
University Park, Pennsylvania, USA

T. Sugano  
Toyo University  
Tokyo, Japan

D.L. Weaire  
University of Dublin  
Dublin, Ireland

### TECHNICAL EDITORIAL BOARD

J.C. Bravman  
Stanford University  
Stanford, California, USA

C.W. Draper  
AT&T Engineering Research Center  
Princeton, New Jersey, USA

E. Fogarassy  
Centre de Recherches Nucléaires  
Strasbourg, France

F.Y. Fradin  
Argonne National Laboratory  
Argonne, Illinois, USA

B.M. León  
Universidad de Vigo  
Vigo, Spain

G.L. Liedl  
Purdue University  
West Lafayette, Indiana, USA

S. Namba  
Osaka University  
Osaka, Japan

A.D. Romig Jr.  
Sandia National Laboratories  
Albuquerque, New Mexico, USA

J. Soares  
Universidade de Lisboa  
Lisboa, Portugal

K.C. Taylor  
General Motors Research Laboratories  
Warren, Michigan, USA

### MRS BULLETIN PUBLICATIONS SUBCOMMITTEE

A.J. Hurd  
Sandia National Laboratories  
Albuquerque, New Mexico

M.R. Libera  
Stevens Institute of Technology  
Hoboken, New Jersey

J.M. Phillips  
AT&T Bell Laboratories  
Murray Hill, New Jersey

S.M. Prokes  
Naval Research Laboratory  
Washington, DC

C.W. White  
Oak Ridge National Laboratory  
Oak Ridge, Tennessee

### 1994 MRS EXECUTIVE COMMITTEE

#### President

John C. Bravman  
Stanford University

#### First Vice President and President-Elect

Julia M. Phillips  
AT&T Bell Laboratories

#### Second Vice President

Carl V. Thompson  
Massachusetts Institute of Technology

#### Secretary

Carl C. Koch  
North Carolina State University

#### Treasurer

A. Kay Hays  
Sandia National Laboratories

#### Immediate Past President

S.T. Picraux  
Sandia National Laboratories

#### Executive Director

Materials Research Society  
John B. Ballance

## INTERNATIONAL UNION OF MATERIALS RESEARCH SOCIETIES

### President

Paul Siffert  
Centre de Recherches Nucléaires,  
France  
Tel. (33) 88 28 65 43; Fax (33) 88 28 62 93

### Vice President

Masao Doyama  
Nishi-Tokyo University, Japan  
Tel. (81) 3 3339 0519;  
Fax (81) 3 3310 0931

### Secretary

Rodney C. Ewing  
University of New Mexico, USA  
Tel. (505) 277-4163;  
Fax (505) 277-0090

### Treasurer

Li-Chung Lee  
ITRI, Taiwan  
Tel. (886) 35-820205;  
Fax (886) 35-820247

### Immediate Past President

Secretary General  
R.P.H. Chang  
Northwestern University, USA  
Tel. (708) 491-3598; Fax (708) 491-4181

### IUMRS ADHERING BODIES

Australian Materials Research Society (A-MRS)  
J.S. Williams

Chinese Materials Research Society (C-MRS)  
Hengde Li

European Materials Research Society (E-MRS)  
P.A. Glasow

Materials Research Society (MRS)  
John C. Bravman

Materials Research Society of India (MRS-I)  
P. Rama Rao

Materials Research Society of Japan (MRS-J)  
T. Masumoto

Materials Research Society of Korea (MRS-Korea)  
Min Che Chon

Materials Research Society of Taiwan (MRS-T)  
Li-Chung Lee

Mexican Materials Research Society (Mexican-MRS)  
M.J. Yacamán

# Introducing **e-Vap**<sup>®</sup>

## Electron Beam Sources for Advanced Thin Film Deposition

From the co-inventor of SUPERSOURCE<sup>®</sup> comes **e-Vap**<sup>®</sup> - the next major advance in applied electron beam technology.

**e-Vap**<sup>®</sup> single and multiple crucible electron beam sources offer a consistent, uniform beam spot during the entire x-y sweep, a flush top design to eliminate shadowing, shielded filaments, and heat-sinked emitter assemblies and much more. Replaceable 7cc to 40cc crucible modules are available for use in the same source body.

State of the art all-solid state electronics include compact **e-Vap**<sup>®</sup> constant high voltage switching power supplies and programmable deposition rate controller monitors. Complete turn-key deposition systems are available.

MDC Vacuum Products Corp., 23842 Cabot Blvd.  
Hayward, CA 94545. Phone 510-887-6100 or  
800-443-8817 toll free outside Calif. FAX 510-887-0626

SUPERSOURCE<sup>®</sup> is a registered trademark of TEMESCAL/Edwards High Vacuum Int'l

