

February 1997

# A Publication of the Materials Research Society

Volume 22, Number 2 ISSN: 0883-7694 CODEN: MRSBEA

# Gan and related Materials for Device applications

- 17 GaN and Related Materials for Device Applications
  S.J. Pearton and C. Kuo, Guest Editors
- 22 Reactive Molecular-Beam Epitaxy for Wurtzite GaN S.N. Mohammad, W. Kim, A. Salvador, and H. Morkoç
- 29 Blue-Green Light-Emitting Diodes and Violet Laser Diodes

S. Nakamura

36 Implantation and Dry Etching of Group-III-Nitride Semiconductors

J.C. Zolper and R.J. Shul

- 44 GaN/AlGaN Heterostructure Devices: Photodetectors and Field-Effect Transistors M.S. Shur and M.A. Khan
- 51 Defects and Interfaces in GaN Epitaxy
  F.A. Ponce

# INTERNATIONAL UNION OF MATERIALS RESEARCH SOCIETIES

58 ICAM'97/E-MRS'97 to Be Held in Strasbourg, France

## **MRS NEWS**

- 59 Preview: 1997 MRS Spring Meeting
- 60 Peercy to Give Plenary Speech on the Future of Semiconductor Research
- 60 Bowman Receives OYI Award for Work on Polymers

# **ABSTRACTS**

- 77 Abstracts for April 1997

  Journal of Materials Research
- 84 Abstracts of MRS Internet Journal of Nitride Semiconductor Research, Volume 1, Articles 1–14

# **DEPARTMENTS**

- 5 Material Matters
- 8 Research/Researchers
- 12 Washington News
- 13 Public Affairs Forum
- 15 Resources
- 16 Editor's Choice
- 35 Advertisers in This Issue
- 73 Historical Note
- 75 Library
- 87 Classified



**ON THE COVER:** Blue GaN-based laser diode operated at room temperature under pulsed conditions. TOP INSET: Outdoor display in downtown Tokyo, utilizing GaN light-emitting diodes. BOTTOM INSET: GaN-based light-emitting diodes of different InGaN composition, leading to colors from blue to yellow. For more information, see the section that begins on page 17.

#### **About the Materials Research Society**

The Materials Research Society (MRS), a nonprofit scientific association founded in 1973, promotes interdisciplinary goal-oriented basic research on materials of technological importance. Membership in the Society includes over 12,000 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 60 topical symposia, and also sponsors numerous single-topic scientific meetings. The Socio ety recognizes professional and technical ex-cellence 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 a member of the Federation of Materials Societies and 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 periodicals 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 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. Dues include an allocation of \$29 (\$17 for students) to a subscription to MRS Bulletin. Individual member subscriptions are for personal use only. Non-member subscription rates are \$135 for one calendar year (12 issues) within the U.S.A. and \$185 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"/Engineering, Computing, and Technology; Current Contents"/Physical, Chemical, and Earth Sciences, the SciSearch\* online database, Research Alert\*, Science Citation Index\*, and the Materials Science Citation Index™. Back volumes of MRS Bulletin are available in 16 mm microfilm, 35 mm microfilm, or 105 mm microfiche through University Microfilms Inc., 300 North Zeeb Road, Ann Arbor, Michigan 48106.

**Materials Research Society** 9800 McKnight Road Pittsburgh, PA 15237-6006 Tel. (412) 367-3003; Fax (412) 367-4373 http://www.mrs.org/

Editorial Office • 9800 McKnight Road • Pittsburgh, PA 15237-6006 Tel. (412) 367-3004 x522; fax (412) 367-4373; http://www.mrs.org/

Editor E.L. Fleischer

**Managing Editor** J. Meiksin

**Assistant Editor** L.R. Gallagher

**Art Director** 

E. Stiller Design/Production

T. Aiello and S. Franklin

**Editorial Assistants** J. Dininny and

M. Wilmoth

Advertising M.E. Kaufold

Circulation B.J. Alcorn

**Guest Editor** 

S.J. Pearton and C. Kuo

Special Contributors

I. Amato, S. Beckerman, V.M. Oversby, J.M. Phillips, and L.A. Snyder

**Special Consultant** 

M. Goodway

Associate Editor—Europe

I.W. Boyd University College London Dept. of Electronic and Electrical Engineering Torrington Place London WCI E7 JE, U.K.

Tel. 44-171-380-7300 or 7302

**Book Review Editor** 

C.J. McHarque 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

#### CHAIR-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

Chung Shan Institute of Science and Technology, Retired Taiwan, China

L.C. Ianniello U.S. Department of Energy, Retired

Washington, DC, USA

H-D. Li

National Science Foundation-China Beijing, China

P. Rama Rao

Ministry of Science and Technology New Delhi, India

The Pennsylvania State University University Park, Pennsylvania, USA

T. Sugano Toyo University Tokyo, Japan

#### TECHNICAL EDITORIAL BOARD

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

C.W. Draper

AT&T Engineering Research Center Princeton, New Jersey, USA

F. 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

Nagasaki Institute of Applied Science Tokyo, Japan

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

J. Soares Universidade de Lisboa

Lisboa, Portugal

K.C. Taylor General Motors R&D Center Warren, Michigan, USA

#### MRS BULLETIN PUBLICATIONS SUBCOMMITTEE R.L. Fleischer

M. Nastasi, Chair

Los Alamos National Laboratory Los Alamos, New Mexico

F.W. Clinard

Los Alamos National Laboratory Los Alamos, New Mexico

University of New Mexico Albuquerque, New Mexico

Sandia National Laboratories Albuquerque, New Mexico

Troy, New York

M Libera Stevens Institute of Technology Hoboken, New Jersey

Rensselaer Polytechnic Institute

F. Shapiro Drexel University

Philadelphia, Pennsylvania

C.W. White

Oak Ridge National Laboratory Oak Ridge, Tennessee

#### 1997 MRS EXECUTIVE COMMITTEE

President R. Hull

University of Virginia

Vice President and President-Elect R.J. Nemanich North Carolina State University

Secretary K.S. Jones

University of Florida

Treasurer

A. Hurd Sandia National Laboratories

Immediate Past President C.V. Thompson

Massachusetts Institute of Technology

Councillors R. Gibala

University of Michigan

A.I. Taub

Ford Research Laboratory **Executive Director** 

**Materials Research Society** John B. Ballance

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

President M. Doyama Nishi-Tokyo University Tokyo, Japan

Vice President H-D. Li Tsinghua University Beijing, China Secretary Cli

Aviation Industries of China Beijing, China

Treasurer G.M. Crean University College Cork, Ireland

**Immediate Past President** P. Siffert Centre de Recherches Nucléaires Strasbourg, France

**General Secretary** R.P.H. Chang Northwestern University Evanston, Illinois USA

#### **IUMRS ADHERING BODIES**

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

Chinese Materials Research Society (C-MRS) H-D. Li, Tsinghua University

European Materials Research Society (E-MRS) I.W. Boyd, University College London, UK

Materials Research Society (MRS) R. Hull, University of Virginia

Materials Research Society of India (MRS-I) S.K. Joshi, JNCASR, New Delhi

Materials Research Society of Japan (MRS-J) R-I. Yamamoto, University of Tokyo

Materials Research Society of Korea (MRS-Korea) S-J. Park, Seoul National University

Materials Research Society of Russia (MRS-Russia) I.V. Gorynin, Prometey Institute

Materials Research Society of Taiwan (MRS-T) L.J. Chen, National Tsing Hua University

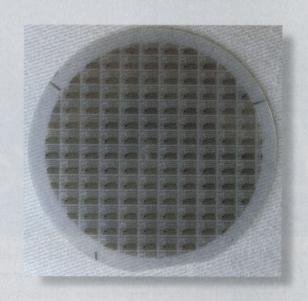
Mexican Materials Research Society (Mexican-MRS) L.M. Gomez, Instituto de Fisica-Cuernavaca, UNAM



# SVT Associates is Leading the Way

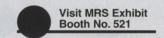
### We offer:

- The first III-Nitride MBE system with guaranteed material specifications
- MBE components
- In-situ characterization techniques
- A laboratory for epi-growth services

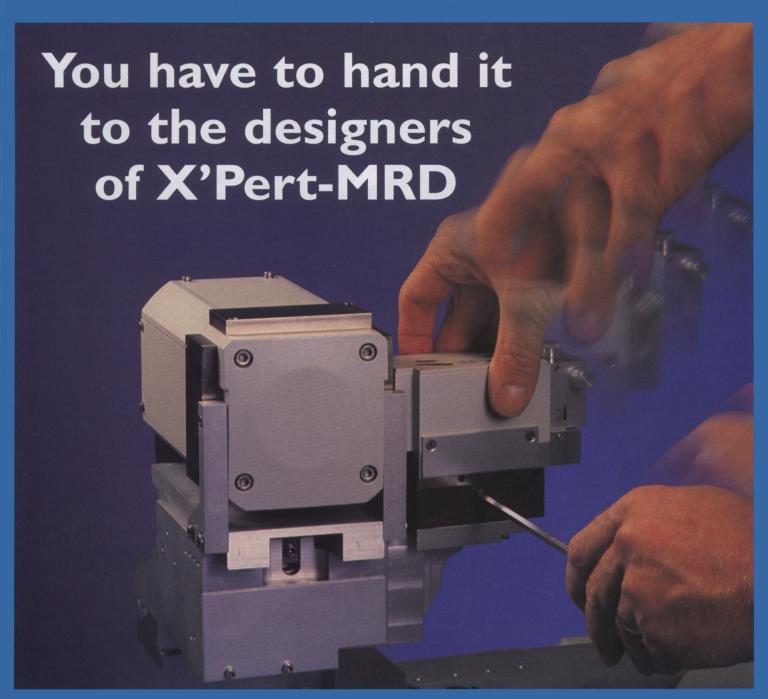


SVT Associates, Inc.
7620 Executive Drive
Eden Prairie, MN 55344 USA
Phone 613 934 3100 Few 613 93

Phone 612-934-2100 Fax 612-934-2737 e-mail: svta@svta.com







# Let's make things better.



X'Pert-MRD, the multi-purpose research diffractometer featuring advanced technologies and a highly original design. With quick-change PREFIX optics you can easily switch between specialised XRD analytical techniques in minutes. It's a flexible, powerful system to answer virtually any materials characterisation need. Single-handed.



# PHILIPS

