
Semiconductor Wafer Bonding: Science, Technology, and Applications 16

Editors:

R. Knechtel
C. S. Tan
T. Suga
H. Baumgart
M. S. Goorsky
F. Fournel
K. D. Hobart
F. Roozeboom

Sponsoring Divisions:

 **Electronics and Photonics**
The Electrochemical Society of Japan
The Japan Society of Applied Physics



Published by
The Electrochemical Society
65 South Main Street, Building D
Pennington, NJ 08534-2839, USA
tel 609 737 1902
fax 609 737 2743
www.electrochem.org

ecstransactions™

Vol. 98, No. 4

Copyright 2020 by The Electrochemical Society.
All rights reserved.

This book has been registered with Copyright Clearance Center.
For further information, please contact the Copyright Clearance Center,
Salem, Massachusetts.

Published by:

The Electrochemical Society
65 South Main Street
Pennington, New Jersey 08534-2839, USA

Telephone 609.737.1902
Fax 609.737.2743
e-mail: ecs@electrochem.org
Web: www.electrochem.org

ISSN 1938-6737 (online)
ISSN 1938-5862 (print)

ISBN 978-1-60768-899-0 (PDF)

Printed in the United States of America.

Table of Contents

Preface *iii*

Chapter 2 **G01 – Fundamentals and Characterization**

Impact of an Amino-Alcohol Organic Molecule on SiO ₂ and Si Bonding Energy <i>F. Fournel, A. Calvez, V. Larrey, G. Eleouet, C. Morales, F. Rieutord</i>	3
Interfacial Analysis of Plasma Fusion Bonded Interfaces Under Various Bonding Conditions by Neutron Reflectometry <i>M. Fujino, K. Takahashi, K. Kikuchi, N. Miyata, T. Yoshida, T. Miyazaki</i>	11
Hetero-Integration of β-Ga ₂ O ₃ and Diamond Substrates by Hydrophilic Bonding Technique <i>T. Matsumae, Y. Kurashima, H. Takagi, H. Umezawa, K. Tanaka, T. Ito, H. Watanabe, E. Higurashi</i>	17
Characterization of Silicon Carbon Nitride for Low Temperature Wafer-to-Wafer Direct Bonding <i>F. Nagano, S. Iacovo, A. Phommahaxay, F. Inoue, E. Sleecckx, S. De Gendt, G. Beyer, E. Beyne</i>	21
Direct Wafer Bonding Methods: A Practical Process Selection Guide <i>V. Dragoi, B. Rebhan, E. Pabo</i>	33
Investigation of Post-Bond Distortion in Direct Wafer Bonding <i>N. Ip, A. Nagata, N. Kohama, N. Wada, K. Motoda</i>	47

Chapter 3 **G01 – Adhesive and Temporary Bonding**

(Invited) Parylene C Based Adhesive Bonding on 6" and 8" Wafer Level for the Realization of Highly Reliable and Fully Biocompatible Microsystems	55
<i>F. Selbmann, M. Baum, C. Meinecke, M. Wiemer, T. Otto, Y. Joseph</i>	
Adhesive Wafer Bonding Using Ultra-Thin Spray-Coated BCB Layers	67
<i>J. Rimböck, J. Gasiorowski, M. Pires, T. Zenger, J. Burggraf, V. Dragoi</i>	

Chapter 4 **G01 – Surface Activated and Low Temperature Wafer Bonding**

Ion Species Dependence on the Interfacial Properties of Silicon Homojunctions Bonded Using an Ion Bombardment Treatment	81
<i>M. E. Liao, K. Huynh, T. Bai, C. Flötgen, M. S. Goorsky</i>	
200 mm Ge Wafer Production for Oxide-Free Si-Ge Direct Wafer Bonding	87
<i>B. Rebhan, J. Vanpaemel, V. Dragoi</i>	

Chapter 5 **G01 – Wafer Bonding for Sensors and MEMS**

The Role of Wafer Edge in Wafer Bonding Technologies	103
<i>R. Knechtel, U. Schwarz, S. Dempwolf, A. Nevin, H. Klingner, G. Lindemann, M. Schikowski</i>	

Chapter 6 **G01 – Si, Ge, and III-V Wafer Bonding**

III-V Thin-Film Solar Cells Bonded to Si Substrates via Metal Grids	117
<i>T. Hishida, J. Liang, N. Shigekawa</i>	
Nanostructural Investigation on GaAs//Indium Tin Oxide/Si Junctions for III-V-on-Si Hybrid Multijunction Cells	125
<i>T. Hara, J. Liang, K. Araki, T. Kamioka, H. Sodabanlu, K. Watanabe, M. Sugiyama, N. Shigekawa</i>	

Silicon Direct Bonding for the European Space Agency's Next X-ray Observatory <i>R. Günther, M. Collon, G. Vacanti, N. Barrière, B. Landgraf, M. Vervest, B. Okma, L. Voruz, L. Keek, L. Babic, A. Bayerle, A. Thete, D. Girou, E. Hauser, G. M. Serrano, N. Eenhoorn, R. van der Hoeven, A. Chatbi, S. Verhoeckx, R. Visser, D. Maks, P. da Silva Ribeiro, M. Bavdaz, E. Wille, I. Ferreira</i>	135
---	-----

Chapter 7 **G01 – Hybrid and 3D Bonding**

(Invited) Hybrid Wafer Bonding – The Fusion of Low Temperature Dielectric and Metal Bonding Technologies <i>S. N. Farrens</i>	145
--	-----

Epitaxial Growth of Active Si on Top of SiGe Etch Stop Layer in View of 3D Device Integration <i>R. Loo, A. Jourdain, G. Rengo, C. Porret, A. Y. Hikavyy, M. Liebens, L. Becker, P. Storck, G. Beyer, E. Beyne</i>	157
---	-----

Fabrication of 3-Layer Stacked Pixel for Pixel-Parallel CMOS Image Sensors by Au/SiO ₂ Hybrid Bonding of SOI Wafers <i>M. Goto, N. Nakatani, Y. Honda, T. Watabe, M. Nanba, Y. Iguchi, T. Saraya, M. Kobayashi, E. Higurashi, H. Toshiyoshi, T. Hiramoto</i>	167
--	-----

Collective Die Bonding: An Enabling Toolkit for Heterogeneous Integration <i>J. Burggraf, T. Uhrmann, M. Pires</i>	173
---	-----

Chapter 8 **G01 – Packaging and Metal Bonding**

Selective Heat Input for Low Temperature Metallic Wafer Level Bonding <i>M. Wiemer, C. Hofmann, K. Vogel</i>	183
---	-----

Ar/N ₂ Plasma Induced Metastable Cu _x N _y for Cu-Cu Direct Bonding <i>L. Hu, S. C. K. Goh, C. S. Tan</i>	203
--	-----

Gas Absorption in Package Using Au/Pt/Ti Bonding Layer <i>T. Matsumae, S. Kariya, Y. Kurashima, H. Takagi, M. Hayase, E. Higurashi</i>	211
---	-----

Layer Configurations for Al-Ge Eutectic Wafer Bonding
J. Visker, L. Peng, S. Kang, B. Vereecke, L. Haspeslagh

217

Author Index

223