

---

# Thin Film Transistors 9 (TFT 9)

---

## Editor:

**Y. Kuo**

Texas A&M University  
College Station, Texas, USA

## Sponsoring Division:



**Electronics and Photonics**



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](http://www.electrochem.org)

**ecs**transactions™

**Vol. 16 No. 9**

---

Copyright 2008 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](mailto:ecs@electrochem.org)  
Web: [www.electrochem.org](http://www.electrochem.org)

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

ISBN 978-1-56677-655-4 (Hardcover)  
ISBN 978-1-60768-008-6 (PDF)

Printed in the United States of America.

---

## Preface

This issue of ECS *Transactions* contains the 55 papers presented at the Ninth Symposium on Thin Film Transistor Technologies (TFT 9), held in Honolulu, Hawaii, October 13-16, 2008. This symposium was sponsored by the Electronics and Photonics Division of the Electrochemical Society.

This symposium was organized into 9 sections: TFT-based Systems, TFT Devices, TFT Reliability, Advanced TFT Processes, Organic TFTs, Metal Oxide TFTs, TFTs on Flexible Substrates, New TFT Applications and Circuits, and Posters. Totally, 69 papers were presented orally and posted by authors from industry, research institutes and universities of 11 countries or regions, i.e., Canada, China, France, Hong Kong, Japan, Korea, Netherlands, Spain, Taiwan, UK, and USA.

In order to present papers in a coherent manner, this issue of ECS *Transactions* was edited into seven sections. All papers are published as original received without alteration of their technical contents except for the format.

The editor wishes to express his sincere appreciation to the following people for their involvement in organizing and conducting the symposium:

- authors and presenters of papers for their participation.
- co-organizers for their contributions in planning and coordinating the program.
- section co-chairs for their conducting the meeting.
- C.-H. Lin and M. R. Coan for their assistance in editing the volume.
- staffs of the Electrochemical Society for their administrative assistance in organizing the symposium and in publishing this volume.

Yue Kuo  
Dow Professor  
Thin Film Nano & Microelectronics Research Laboratory  
Texas A&M University  
College Station, TX  
October 12, 2008

## **Thin Film Transistor Technologies 8 Symposium Co-Organizers**

D. Ast (Cornell University)  
O. Bonnaud (Université de Rennes I)  
S. Fonash (Pennsylvania State University)  
M. K. Han (Seoul National University)  
M. Hatano (Hitachi Ltd.)  
J. Jang (Kyung Hee University)  
Y. Kuo (Texas A&M University)  
M. Matsumura (ALTEDEC)  
A. Nathan (University College London)  
M. Shur (Rensselaer Polytechnic Institute)  
S. Uchikoga (Toshiba Corp.)  
Y. Uraoka (Nara Institute of Science and Technology)

## **Section Chairs and Co-Chairs**

Z. Bao (Stanford University)  
O. Bonnaud (Université de Rennes I)  
G. R. Chaji (IGNIS)  
S. Fonash (Pennsylvania State University)  
M. K. Han (Seoul National University)  
M. Hatano (Hitachi)  
T. Hattori (Hitachi)  
C.-W. Kim (Samsung)  
Y. Kuo (Texas A&M University)  
P.-T. Liu (National Chiao Tung University)  
A. Mimura (AIST)  
T. Mohammed-Brahim (Université de Rennes I)  
S.-H. K. Park (ETRI)  
M. Shur (Rensselaer Polytechnic Institute)  
T. Someya (University of Tokyo)  
S. Tokito (NHK)  
S. Uchikoga (Toshiba)  
C. Williams (Corning)  
F. Yan (Hong Kong Polytechnic University)  
E. Zyambo (Sharp Laboratories of Europe)

## Table of Contents

*Preface* *iii*

### Chapter 1 TFT-Based Display Systems

A Fully Monolithic Wireless Display System *	3
<i>E. Zyambo, L. Lukama, C. Brown, K. Miyata and M. Brownlow</i>	
High Performance Short Channel a-Si:H TFT Device with Cu Electrodes	13
<i>J. Yang, Y. Ahn, J. Bang, W. Ryu, J. Kim, Y. Kang, M. S. Yang, I. Kang and I. Chung</i>	
High-Performance Organic Thin-Film Transistors for Flexible AM-OLED Displays *	23
<i>S. Tokito</i>	
Status and Issues of Organic TFT for Display Applications *	33
<i>C. Kim, I. Kang and I. Chung</i>	
Fabrication of Flexible TFTs on a Heat-Resistant Transparent Polymer using the Standard a-Si TFT Process above 300°C *	39
<i>T. Hattori, M. Kato, M. Wakagi, T. Yoshida and M. Hatano</i>	
Direct Fabrication of a-Si:H Thin Film Transistor Arrays on Flexible Plastic Film and Metal Foil Substrates: Critical Challenges and Enabling Solutions	49
<i>S. O'Rourke, D. Loy, C. Moyer, E. Bawolek, S. Ageno, B. O'Brien, M. Marrs, D. Bottesch, J. Dailey, R. Naujokaitas, J. Kaminski, D. Allee, S. Venugopal, J. Haq and G. B. Raupp</i>	

### Chapter 2 TFT Devices and Reliability

Issues in Microcrystalline Silicon TFTs Processed at T<200oC *	57
<i>T. Mohammed-Brahim, K. Kandoussi, N. Coulon and C. Simon</i>	

The Characteristics of Hot-Carrier Stressed Bottom-Gate Polycrystalline Silicon Thin-Film Transistors Employing Alternating Magnetic-Field-Enhanced Rapid Thermal Annealing <i>W. Lee, H. Shin, K. Cho, J. Choi, C. Kim and M. Han</i>	67
Extraction of the Density of Interface Trap States in Thin-Film Transistors <i>H. Tsuji, Y. Kamakura and K. Taniguchi</i>	73
A DLTS Study of Band Gap States in SLS Poly-Si TFTs <i>L. Michalas, G. Papaioannou and A. Voutsas</i>	79
Visible Light Source Disturbing the Source/Drain Current of CLC Poly-Si n-TFT Device <i>M. Wang, Z. Hsieh, C. Chen, J. Shieh, Y. Lin, S. Lee, S. Chen and H. Huang</i>	85
Enhanced Drain Current Ripple Variation with Vertical and Horizontal Electrical Fields under Optical Illumination <i>M. Wang, Z. Hsieh, Y. Chu, C. Chen, J. Shieh, Y. Lin, S. Lee and H. Huang</i>	93
Analysis of the Hysteresis Behavior in Poly-Si TFTs Using On-the-Fly Measurement <i>T. Kawamura, H. Uchida, M. Matsumura, H. Kageyama and M. Hatano</i>	103
Reliability Analysis of Single Grain Si TFT using 2D Simulation <i>A. Baiano, J. Tan, R. Ishihara and K. Beenakker</i>	109
Instability Behavior of Oxide-based Top-gate TFTs under Electrical and Optical Stress Test <i>J. Cho, J. Jeong, H. Lee, H. Kim, S. Kim and Y. Hong</i>	115
Stability of Microcrystalline Silicon TFTs <i>K. Belarbi, K. Kandoussi, N. Coulon, C. Simon, R. Cherfi, A. Fedala and T. Mohammed-Brahim</i>	121
Mechanisms of Polycrystalline Growth of SiGe in Thermal CVD Processes using Si <sub>2</sub> H <sub>6</sub> and GeF <sub>4</sub> <i>A. Kagatsume, I. Suzumura, M. Wakagi and J. Hanna</i>	131

### **Chapter 3**

#### **Advanced TFT Processes**

Recent Progresses in Ultrahigh-Performance TFT Technologies-Advanced PMELA Method and its TFT Application * <i>T. Endo</i>	139
---	-----

Crystallinity and Internal Strain of One-Dimensionally Long Si Grains by CW Laser Lateral Crystallization <i>S. Fujii, S. Kuroki, X. Zhu, M. Numata, K. Kotani and T. Ito</i>	145
Formation of Location-Controlled Germanium Grains by Excimer Laser <i>A. Baiano, R. Ishihara, J. van der Cingel and K. Beenakker</i>	153
The AMOSFET - A Simple, High Performance FET for Thin Films, Nanowires, and Nanoribbons * <i>P. Garg, Y. Hong, M. Iqbal, P. Migliorato and S. J. Fonash</i>	159
A Vertical Thin Film Transistor Based on Low Temperature Technology (T<600oC) <i>H. D. Toure, T. Gaillard, N. Coulon and O. Bonnaud</i>	165
Highly Stable Bottom-Gate Nanocrystalline Silicon Thin Film Transistor Fabricated Employing ICP-CVD <i>S. Kim, S. Han, J. Kwon, J. Jung and M. Han</i>	171
Formation of Si Nanocrystals in SiOx Films Induced by Thermal Plasma Jet Annealing and Its Application to Floating Gate Memory <i>T. Okada, S. Higashi, H. Kaku, H. Furukawa and S. Miyazaki</i>	177
Microcrystalline Si <sub>1-x</sub> Gex Deposited by Magnetron Sputtering <i>A. Hiroe, T. Goto, A. Teramoto and T. Ohmi</i>	183
Using Chemical Oxide Layer to Getter Nickel inside Nickel-Metal-Induced Lateral Crystallization Polycrystalline Silicon <i>B. Wang, T. Yang, C. Tseng and Y. Wu</i>	193
Etching Treatment of MILC Poly-Si TFTs Using CF <sub>4</sub> Plasma to Improve Electrical Performance <i>C. Chang, Y. Wu, C. Chen and M. Lai</i>	197
Improvement of Electrical Characteristics in SPC-Si TFT Employing H <sub>2</sub> Plasma Treatment <i>S. Park, S. Kim, J. Lee, C. Kim and M. Han</i>	201
Improving the Electrical Properties of NILC poly-Si Films using Gettering $\alpha$ -Si Film Through Contact Holes <i>C. Hu, Y. Chao and Y. S. Wu</i>	207
Effect of Heat-treatment on Reliability of a-Si:H TFTs for Integrated Gate Driver Circuits <i>D. Nam, S. Jeong, Y. Lee, S. Jo, D. Kim, H. Moon, H. Shin and I. Chung</i>	211

## Chapter 4 Organic TFTs

Top-Contact Organic Thin-Film Transistors Fabricated by Picoliter and Sub-Femtoliter Inkjets *	219
<i>T. Sekitani, Y. Noguchi, H. Klauk, U. Zschieschang and T. Someya</i>	
All-solution-processed Organic Thin-film Transistors using Inkjet-printed Silver Electrodes	225
<i>J. Kim, J. Jeong, S. J. Park, S. Kwon, J. Kim and Y. Hong</i>	
Low-Voltage Organic Thin-Film Transistor With High- $\kappa$ LaYOx Gate Insulator	231
<i>C. Deng, C. Cheng and B. Chiou</i>	
Flexible High Mobility Pentacene Transistor with High-k/low-k Double Polymer Dielectric Layer Operating at -5 V	239
<i>K. Lee, K. Lee, G. Lee, M. Oh, J. Choi, S. Im, S. Jang and E. Kim</i>	
Organic Photo Transistors with Drain Bias Modulation Effect	249
<i>H. Zan and S. Kao</i>	
Improved Air-stability of n-Channel Organic Thin Film Transistors via Surface Modification on Gate Dielectrics	253
<i>F. Chen, C. Liao, W. Huang and T. Huang</i>	
All-Organic Thin Film Transistor Circuits with Ink-Jet Printed Electrodes	261
<i>J. Kim, J. Kim, T. Yoon and Y. Kim</i>	
Ink-Jet Printed 6,13-bis(triisopropylsilylethynyl) Pentacene Organic Thin-Film Transistors for Particle Based Electronic Papers	267
<i>Y. Kim, S. Park, S. Park, M. Han and J. Han</i>	
Organic Field-effect Transistors Based on 2,9-Disubstituted Pentacenes	273
<i>Y. Kunugi, Y. Busujima, M. Ikari, K. Okamoto and K. Ogino</i>	
High Performance Organic Thin Film Transistors Made Simple Through Molecular Design and Processing	283
<i>O. D. Jurchescu, M. Feric, B. Hamadani, D. Mourey, S. Subramanian, B. Purushothaman, J. Anthony, T. Jackson and D. Gundlach</i>	
Ba <sub>0.6</sub> Sr <sub>0.4</sub> TiO <sub>3</sub> Thin Films used as Gate Dielectric in Pentacene Transistors	291
<i>G. Dong, Y. Lu, X. Wang and Y. Qiu</i>	

## **Chapter 5**

### **Metal Oxide TFTs**

Highly Stable ZnO TFT: Effect of Substrate Buffer Layer *	297
<i>S. K. Park, C. Hwang, M. Ryu, J. Shin, S. Yang, S. Yoon and H. Chu</i>	
High Performance InGaZnO <sub>4</sub> -based Thin film Transistors Fabricated at Low Temperature	303
<i>W. Lim, Y. Wang, J. Lee, D. P. Norton, F. Ren and S. J. Pearton</i>	
Stability Improvement of Gallium Indium Zinc Oxide Thin Film Transistors by Post-Thermal Annealing	309
<i>J. Jung, K. Son, T. Kim, M. Ryu, K. Park, B. Yoo, J. Kwon, S. Lee and J. Kim</i>	
Low Temperature Post-Annealing of ZnO Thin-Film Transistors with High-k Gate Dielectrics	315
<i>H. Chen, B. B. Yeh and W. Chou</i>	

## **Chapter 6**

### **TFTs on Flexible Substrates**

Fabrication of Poly-Si TFTs on Flexible Quartz Fibers *	325
<i>A. Mimura, T. Nakamura, Y. Sugawara, Y. Uraoka, I. Shuu, T. Ikehara, T. Itoh, R. Maeda, K. Suzuki, A. Nakajima and H. Koaizawa</i>	
The Strain Effects on Flexible a-Si:H TFTs	333
<i>L. Teng, P. Liu, S. Tsai, I. Peng and Y. Chou</i>	
Effect of Passivation Layer on the Reliability of Flexible a-Si:H TFTs	339
<i>Y. Chou, P. Liu, S. Tsai, C. Su and I. Peng</i>	
Reliability of a-Si:H TFTs and Copper Interconnect Lines for Flexible Electronics	345
<i>Y. Kuo, M. R. Coan and G. Liu</i>	

## **Chapter 7**

### **New TFT Applications and Circuits**

Sensors Based on Organic Thin Film Transistors *	355
<i>F. Yan, S. Mok, P. Lin and H. Chan</i>	

An Image Sensor using Photoleakage Current and Feedthrough Voltage of Amorphous Si Thin-film Transistors <i>Y. Hara, A. Kinno and S. Uchikoga</i>	365
Development of Integrated Electronics on Silicon-on-Glass (SiOG) Substrate <i>R. Manley, G. Fenger, P. Meller, K. Hirschman, C. A. Kosik Williams, D. Dawson-Elli, J. Couillard and J. Cites</i>	371
Stable Pixel Circuit for Small-Area High-Resolution a-Si:H AMOLED Displays * <i>G. Chaji and A. Nathan</i>	381
Compensation Pixel Circuit Using LTPS TFT For AMOLED Displays <i>P. Liu, L. Chu and Y. Huang</i>	387
Analog Circuits Design using Polycrystalline Silicon TFTs <i>E. Jacques, F. Le Bihan, S. Crand and T. Brahim</i>	393
Author Index	401

\* *invited paper*



---

## Facts about ECS

The Electrochemical Society (ECS) is an international, nonprofit, scientific, educational organization founded for the advancement of the theory and practice of electrochemistry, electrothermics, electronics, and allied subjects. The Society was founded in Philadelphia in 1902 and incorporated in 1930. There are currently over 7,000 scientists and engineers from more than 70 countries who hold individual membership; the Society is also supported by more than 100 corporations through Corporate Memberships.

The technical activities of the Society are carried on by Divisions. Sections of the Society have been organized in a number of cities and regions. Major international meetings of the Society are held in the spring and fall of each year. At these meetings, the Divisions and Groups hold general sessions and sponsor symposia on specialized subjects.

The Society has an active publications program that includes the following.

**Journal of The Electrochemical Society — JES** is the peer-reviewed leader in the field of electrochemical and solid-state science and technology. Articles are posted online as soon as they become available for publication. This archival journal is also available in a paper edition, published monthly following electronic publication.

**Electrochemical and Solid-State Letters — ESL** is the first and only rapid-publication electronic journal covering the same technical areas as JES. Articles are posted online as soon as they become available for publication. This peer-reviewed, archival journal is also available in a paper edition, published monthly following electronic publication. It is a joint publication of ECS and the IEEE Electron Devices Society.

**Interface — Interface** is ECS's quarterly news magazine. It provides a forum for the lively exchange of ideas and news among members of ECS and the international scientific community at large. Published online (with free access to all) and in paper, issues highlight special features on the state of electrochemical and solid-state science and technology. The paper edition is automatically sent to all ECS members.

**Meeting Abstracts (formerly Extended Abstracts) — Abstracts** of the technical papers presented at the spring and fall meetings of the Society are published on CD-ROM.

**ECS Transactions — This online database** provides access to full-text articles presented at ECS and ECS-sponsored meetings. Content is available through individual articles, or as collections of articles representing entire symposia.

**Monograph Volumes — The Society sponsors** the publication of hardbound monograph volumes, which provide authoritative accounts of specific topics in electrochemistry, solid-state science, and related disciplines.

For more information on these and other Society activities, visit the ECS website:

**[www.electrochem.org](http://www.electrochem.org)**

---