

2007 INTERNATIONAL IMAGE SENSOR WORKSHOP

June 7-10, 2007
The Cliff House Resort & Spa
Ogunquit, Maine USA

Organized by:

ImageSensors Inc.
www.imagesensors.org

Technical Co-Sponsors:

IEEE Electron Devices Society
Institute of Television Engineers of Japan (ITEJ)
Jet Propulsion Laboratory
Siimpel Corporation
Walter Kosonocky Award



Welcome to the 2007 International Image Sensor Workshop

It is a pleasure to extend a hearty welcome to all of you to the 2007 International Image Sensor Workshop at The Cliff House Resort & Spa in Ogunquit, Maine USA. As you have noticed the workshop (formerly titled IEEE Workshop on Charge Coupled Devices and Advanced Image Sensors) has a new name – International Image Sensor Workshop. It is organized by ImageSensors Inc., a non-profit Public-benefit organization.

It is 21 years since the first workshop took place in 1986 at Columbia University's Arden House in Harriman, New York. Much has changed in these 21 years. Electronic imaging has undergone an explosive growth. The workshop (held every other year) has firmly established itself as the key forum on image sensor technology – discussing recent research results on a wide variety of image sensors, providing in-depth discussion and insight on technical issues of common concern, and stimulating thinking about new research directions and activities. The 2007 workshop – 11th in the series – continues in the same tradition, but with a new name. Considering the world-wide popularity and stature of this forum, and the breadth of image sensor related topics covered in the workshop, the International Image Sensor Workshop is certainly a more appropriate name for this forum.

For the statistically minded, we had a record number of abstracts submitted to the 2007 workshop – 110 in total. It will also have a record number of papers presented - 88 in all, consisting of 32 regular papers, 38 poster papers, 12 short papers, and 6 discussion/tutorial papers. 32 of these papers are from the continent of Asia, 26 from North America, and 30 from Europe, including a number of papers that consist of authors from multiple continents.

We have a diverse and exciting program. We have added an extra day to the 2007 workshop to permit longer discussions and more informal meeting time. In addition, we have introduced a new category of papers called discussion/educational papers. The purpose of these presentations is to stimulate discussion in areas of emerging technologies and/or in areas of common interest that are just outside the normal scope of the workshop. To further facilitate discussion, we have devoted 10 minutes for Q&A after each regular paper. There is also a period devoted entirely for poster viewing and discussion with the authors. We hope that active interaction and exchange of information among the participants will only make the workshop even more exciting.

The workshop will feature the 5th Walter Kosonocky Award that was established in memory of a great contributor to the field, who passed away on November 2, 1996.

As in previous years, we have tried to limit attendance to less than 150 people, based on the desire of the organizing committee to keep the workshop small and more personal. Although previous workshops have always sold out, what happened this year was quite unprecedented. Registration got filled up within just a couple of days of opening the pre-registration. Due to this overwhelming demand, we could not offer seats to a number of people who had sent in their

requests. We sincerely apologize to those who could not attend, and hope to see you at next workshop in 2009.

We would like to acknowledge our technical co-sponsors: IEEE Electron Devices Society, Institute of Television Engineers of Japan, Jet Propulsion Laboratory, Siimpel Corporation, and the Walter Kosnocky Award. We are extremely grateful to the Jet Propulsion Laboratory for its financial support in organizing the workshop.

This workshop could not have been organized without contribution from a number of people. I would like to thank Dr. Eric Fossum, Dr. Nobukazu Teranishi, and Dr. Albert Theuwissen of Organizing Committee for their support and guidance in planning the workshop. I would also like to thank all members of the technical program committee for soliciting papers, for ranking them, and for serving as session chairs, and especially Dr. Alex Krymski, the technical program committee chairman, for assisting me with the difficult job of selecting the papers, and putting the together an outstanding program. I am grateful to Ms. Angela McNamee of Siimpel Corporation for her time and enthusiastic support, as well as to my colleagues at the Jet Propulsion Laboratory for their efforts in making this workshop a success. Finally, I would like to express my sincere gratitude to Dr. Eric Fossum - not only for taking care of the local arrangements, and but for supporting and advising me through every detail of the workshop planning and organization.

Best wishes for a great and memorable workshop.

Bedabrata Pain
General Chairman

2007 International Image Sensor Workshop

organized by ImageSensors Inc.

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Nobukazu Teranishi (Matsushita, Japan)

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2007 INTERNATIONAL IMAGE SENSOR WORKSHOP

Ogunquit, ME
June 6-10, 2007

PROGRAM

June 6 (Wed)

18:00-20:00 **Early Registration**

June 7 (Thu)

9:00-10:00 **Registration**

10:00-10:15 **Opening Remarks**

Eric Fossum – Remarks on behalf of the Organizing Committee
Bedabrata Pain – Chairman’s remarks

Session 01 Discussion Session – I

Session chair: Alex Krymski

10:20-11:00 Image Sensors and Image Quality in Mobile Phones 1
Juha Alakarhu (Nokia, Tampere, Finland)

Session 02 Image Sensors with Super-Small Pixels – I

Session Chair: Johannes Solhusvik

11:00-12:10 A 3 Mega-Pixel Back-illuminated Image Sensor in 1T5 Architecture with 1.45 5
 μm Pixel Pitch
Jens Prima¹, Francois Roy¹, Perceval Coudrain¹, Xavier Gagnard¹, Josep Segura¹, Yvon Cazaux¹, Didier Herault¹, Nicolas Virollet¹, Norbert Moussy², Benoit Giffard², Pierre Gidon² (¹FTM Imaging, STMicroelectronics, Crolles, France; ²CEA Léti-MINATEC, Grenoble, France)

11:20-11:40 A 1.75 μm Square Pixel IT-CCD using Gate Oxide Insulator Composed by a 9
Single Layer Electrode Structure
Junji Yamane, Yoshiaki Kitano, Keita Suzuki, Keita Hondo, and Nobuhiro Karasawa (Semiconductor Business Group, Sony Corporation; *Sony Semiconductor Kyusyu Corporation, Japan)*

11:40-12:00 Optoelectronic Investigation for High Performance 1.4 μm pixel CMOS Image 13
Sensors
Seong-Ho Cho, Gibum Kim, Hyunpil Noh, Chang-Rok Moon, Kangbok Lee, Kwangok Koh, and Duckhyung Lee (Samsung Electronics Ltd, Yongin-city, Korea)

12:00-12:06	Active Pixel Sensor Arrays in 90/65 nm CMOS-Technologies with Vertically Stacked Photodiodes <i>S. Henker, C. Mayr, J-U. Shlussler, R. Schuffny, U. Ramacher, and A. Heitmann (University of Dresden, Institute of Circuits and Systems, Dresden, Germany)</i>	16
12:10-13:40	Lunch	
Session 03	Discussion Session – II <i>Session Chair: Albert Theuwissen</i>	
13:40-14:20	Auto Focus Technology <i>R.C. Gutierrez, T.K. Tang and E.R. Fossum (Siimpel Corp, Pasadena, USA)</i>	20
Session 04	High Dynamic Range Image Sensors <i>Session Chair: Shou-Gwo Wu</i>	
14:25-14:45	A Wide Dynamic Range CMOS Image Sensor with Resistance to High Temperatures <i>Koichi Mizobuchi¹, Satoru Adachi¹, Tomokazu Yamashita¹, Seiichiro Okamura¹, Hiromichi Oshikubo¹, Nana Akahane² and Shigetoshi Sugawa² (¹DISP Development, Texas Instruments Japan, Inashiki, Japan, ²Graduate School of Engineering, Tohoku University, Sendai, Japan)</i>	26
14:45-15:05	A 121.8dB Dynamic Range CMOS Image Sensor using Pixel-Variation-Free Midpoint Potential Drive and Overlapping Multiple Exposures <i>Yusuke Oike, Atsushi Toda, Tadayuki Taura, Akihiko Kato, Hiroki Sato, Masanori Kasai, and Tadakuni Narabu (Sony Corporation, Atsugi, Japan)</i>	30
15:05-15:25	A High Dynamic Range Digital Linlog CMOS Image Sensor Architecture Based on Event Readout of Pixels and Suitable for Low Voltage Operation <i>Alexandre Guilvard^{1,2}, Pierre Magnan¹, Josep Segura³, Philippe Martin-Gonthier¹ (¹Supaero, Toulouse, France; ²STMicroelectronics, Crolles, France)</i>	34
15:25-15:45	Coffee Break	
Session 05	Discussion Session – III <i>Session Chair: Nobukazu Teranishi</i>	
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P1	Highlight Scene FPN on Shared Pixels and a Reduction Technique <i>Takashi Watanabe, Katsuji Kimura, Masamitsu Taki, Mitsuru Homma, Shoko</i>	39

	<i>Daikoku, and Tetsuya Fujimoto, and Kiyotoshi Misawa (Imaging and Sensing Module Division, LSI Group, Sharp Corporation, Japan)</i>	
P2	¼ Inch 2Mega CMOS Image Sensor Fabrication <i>Se Jung Oh*, Keun Hyuk Lim**, Jae Young Rim*, Chan Ki Kim*, An Sik Choi*, Do Young Lee* (* SiliconFile Technologies Inc. Seoul, Korea, **DongBu Electronics, Korea)</i>	43
P3	Implementing a CMOS Image Sensor Noise Performance Model <i>Keith Findlater¹, Ryan Gow², David Renshaw³, Lindsay Grant⁴, John Hart⁴, Stuart McLeod⁴, Robert Nicol⁴</i> (¹ Gigle Semiconductor, Edinburgh, UK; ² University of Oxford, Oxford, UK; ³ University of Edinburgh, Edinburgh, UK; ⁴ STMicroelectronics Imaging Division, Edinburgh, UK)	47
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P5	A 2.3e- Read Noise 1.3Mpixel CMOS Image Sensor with Per-Column Amplifier <i>Kwang-Bo Cho, Chiajen Lee, Siri Eikedal, Hai Yan, Taehee Cho, Tien-Min Miao, Jason Song, Christopher Zeleznik, Alexander Mokhnatyuk, and Sandor Barna (Micron Technology Inc, Pasadena, USA)</i>	55
P6	Continuous Time Column Parallel Readout for CMOS Image Sensor <i>G.G. Storm, M.D. Purcell, A. Laflaquiere, R.A. Elliott, L.A. Grant, T.Lule¹, F. Mutze¹, M.Sommer¹ (STMicroelectronics, Edinburgh, UK, ¹STMicroelectronics, Imaging Division, Grenoble, France)</i>	58
P7	Analysis of Source Follower Random Telegraph Signal Using nMOS and pMOS Array TEG <i>K. Abe¹, S. Sugawa¹, R. Kuroda^{1,4}, S. Watabe¹, N. Miyamoto², A. Teramoto², T. Ohmi², Y. Kamata³ and K. Shibusawa³ (¹Graduate School of Engr., Tohoku University, Sendai, Japan; ²New Industry Creation Hatchery Center, Tohoku University, Japan; ³Miyagi Oki Electric Co, Japan; ⁴JSPS Research Fellow)</i>	62
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P13	Dynamic Range Extension of CMOS Imager With Linear Response by Hybrid Use of Active and Passive Pixel Readouts <i>Keiichiro Kagawa¹, Yudai Adachi¹, Yugo Nose², Kuniyuki Tani², Atsushi Wada², Masahiro Nunoshita¹, and Jun Ohta¹ (¹Graduate School of Materials Science, Nara Institute of Science and Tech., Ikoma, Japan; ²Sanyo Electric Co., Japan)</i>	86
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18:15-20:15

Dinner

Session 07 Poster Papers – II

Session Chair: Hidekazu Takahashi

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- P24 An Optical/Potential/Voltammetric Multifunctional CMOS Image Sensor for On-Chip Biomolecular/Neural Analytical Applications 129
T. Tokuda, S. Sato, K. Kagawa, M. Nunoshita, and J. Ohta (Graduate School of Material Science, Nara Institute of Science and Technology, Ikoma, Japan)
- P25 Design and Packaging of an Implantable CMOS Neural Imaging and Interface Device 133
D. C. Ng¹, T. Nakagawa¹, T. Mizuno¹, T. Tokuda¹, M. Nunoshita¹, H. Tamura², Y. Ishikawa², S. Shiosaka², and J. Ohta¹ (¹Graduate School of Materials Science, ²Graduate School of Biological Sciences, Nara Institute of Science and Technology, Ikoma, Japan)
- P26 An Efficient Capacity and Image Lag Simulation Method of CMOS Image Sensor 137
Kee-Hyun Paik, Jongcheol Shin, Seok-Ha Lee*, Chang-Rok Moon*, Chang-Hyo Koo, Keun-Ho Lee, Duckhyung Lee*, Young-Kwan Park, and Moon-Hyun Yoo (CAE Team, Technology Development Team*, Memory Division, Samsung Electronics Co., Hwasung City, Korea)*
- P27 3-D Wave Optical Simulation of Light Wave-guide Structures by LBEM 141
Hideki Mutoh and Shigetoshi Sugawa (Link Research Corporation, Tokyo, Japan; *Graduate School of Engineering, Tohoku University, Aramaki, Japan)*

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9:30-9:50	Back-Illuminated, Three-Dimensionally Integrated CMOS Imager with In-Pixel CDS <i>V. Suntharalingam, G. Prigozhin, R. D’Onofrio, S. Kissel, and M. Bautz (MIT Lincoln Laboratory, Lexington, USA)</i>	155
9:50-10:10	Wafer-Level Thinned CMOS Imagers in a Bulk-CMOS Technology <i>Bedabrata Pain, Chao Sun, Paula Vo, Bruce Hancock, Thomas J. Cunningham, Chris Wrigley, Risaku Toda, Victor White, Amrita Banerjee* and Durgmadhab Misra* (Jet Propulsion Laboratory, Pasadena, USA; *Dept of ECE, New Jersey Institute of Technology, Newark, USA)</i>	158
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P29	Crosstalk, Color Tint and Shading Correction for Small Pixel Size Image Sensor <i>Alexander Getman, Timofei Uvarov, YongIn Han, Bumsuk Kim, JungChak Ahn, YongHee Lee (Samsung Electronics Ltd, Yongin-City, Korea)</i>	166
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	<i>Session Chair: Junichi Nakamura</i>	
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8:50-9:10	Characterization of the Buried Channel n-MOST Source Followers in CMOS Image Sensors <i>Xinyang Wang, Padmakumar R. Rao, and Albert J.P. Theuwissen (Delft University of Technology, Delft, The Netherlands)</i>	223
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9:42-9:48	Evaluation of a Small Negative Transfer Gate Bias on the Performance of 4T CMOS Image Sensor Pixels. <i>Hyungjun Han, Hongjoo Park, Parker Altice, Woonil Choi, Younsub Lim, Sangjoo Lee, Seok Kang, Jaeyeong.kim, Smith Yoon and Jerry Hyneczek (Magnachip Semiconductor Ltd, Cheongju, Korea)</i>	238
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Centre for Scientific and Technological Research, Trento, Italy)

11:30-11:50	A TOF Range Image Sensor with an Ambient Light Charge Drain and Small Duty-Cycle Light Pulse <i>Tomonari Sawada¹, Shoji Kawahito¹, Masakatsu Nakayama¹, Kana Ito¹, Izhal Abdul Halin¹, Mitsuru Homma², Takeo Ushinaga², and Yasunari Maeda³</i> <i>(¹Shizuoka University, Hamamatsu, Japan; ²Sharp Corporation, Nara, Japan; ³Suzuki Motor Corporation, Hamamatsu, Japan)</i>	254
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13:40-14:20	Color Processing Pipeline <i>Albert J. P. Theuwissen (DALSA, The Netherlands)</i>	
Session 16	Alternative On-Chip Color Capture Approaches <i>Session Chair: Shoji Kawahito</i>	
14:20-14:40	High Sensitivity Color CMOS Image Sensor with White-RGB Color Filter Array and a Novel Color Separation Process Using Edge Detection <i>Hiroto Honda¹, Yoshinori Iida¹, and Yoshitaka Egawa²</i> (<i>¹Corporate Research and Development Center, Toshiba Corp., Japan; ²Semiconductor Company, Toshiba Corp, Japan</i>)	263
14:40-15:00	IR/Color Composite Image Sensor with VIPS (Vertically Integrated Photodiode Structure) <i>Jeong-Ho Lyu, Seok Choi¹, Jae Heon Choi, Jung Hyun Nam¹, and Jin Bok Jung¹</i> (<i>¹Miru Data System Co., Suwon, Korea; Maru LSI Co., Suwon, Korea</i>)	267
15:00-15:20	Gr Gb difference in 3M CMOS Image Sensor with 1.75 μ m pixel <i>Bumsuk Kim, Yoonho Jang, Kyoungsik Moon, Eun-Gyu Lee, Alexander Getman, JungChak Ahn, and YongHee Lee</i> (<i>Samsung Electronics Co. Ltd, Yongin-City, Korea</i>)	271
15:20-15:40	CMOS Color Image Sensor with Overlaid Organic Photoconductive Layers: Depression of Dark Current <i>Shunji Takada, Mikio Ihama, and Masafumi Inuiya</i> (<i>Fujifilm Corp, Kanagawa, Japan</i>)	275

15:40-15:46	A Buried Triple Junction Self-Reset Pixel in a 0.35µm High Voltage CMOS Process <i>Thomas Ross, Robert K. Henderson, Bruce Rae, and David Renshaw (Institute of Micro and Nano Systems, Univ of Edinburgh, Edinburgh, UK)</i>	279
15:46-16:20	Coffee break	
Session 17	Integrated Image Sensors on a chip (ISOC)	
	<i>Session Chair: Tetsuo Nomoto</i>	
16:20-16:40	An SXGA CMOS Image Sensor with 8 Gbps LVDS Serial Link <i>T. Cools¹, P. Deruytere¹, J. De Bondt¹, R. Sankhe¹, T. Geurts¹, K. Takada², T. Yamamoto² (¹Cypress Semiconductor, Mechelen, Belgium; ²NED, Osaka, Japan)</i>	283
16:40-17:00	A 600x600 Pixel, 500 FPS CMOS Image Sensor with a 4.4 µm Pinned Photodiode 5-Transistor Global Shutter Pixel <i>I. Takayanagi, Y. Mo*, H. Ando, K. Kawamura, N. Yoshimura, K. Kimura, T. Otaka, S. Matsuo, T. Suzuki, F. Brady**, and J. Nakamura (Micron Japan, Tokyo, Japan, * Micron Technology, Inc., Pasadena, USA, ** Micron Technology, Inc., Boise, USA)</i>	287
17:00-17:20	2Mpix 2.6 µm Pixel Size Image Sensor in AIC Technology <i>T. Lulé, F. Mütze, M. Sommer, J. Prima¹, F. Roy¹, B. Glück¹, D. Thomas¹, R. Nicol² (STMicroelectronics, Imaging Division, Crolles, France; ¹STMicroelectronics, France; ²STMicroelectronics, Edinburgh, UK)</i>	291
17:20-17:40	52 Mega-pixel APS-H-size CMOS Image Sensor for Super High Resolution Image Capturing <i>Masaaki Iwane, Takashi Matsuda, Takashi Sugai, Koichi Tazoe, Takashi Okagawa, Toshiaki Ono, Takanori Watanabe, Katsuhisa Ogawa, Hidekazu Takahashi, and Shunsuke Inoue (Canon Inc, Ayase-shi, Japan)</i>	295
17:40-18:00	A CMOS Image Sensor for Earth Observation with High Efficiency Snapshot Shutter <i>Gérald Lepage¹, Alex Materne², Christophe Renard³ (¹Cypress – FillFactory, Mechelen, Belgium; ²CNES, Toulouse, France; ³Thales Alenia Space, Cannes La Bocca, France)</i>	299
18:00-18:06	Variability Limits the Advantage of Photo Diode's Zero Bias Operation <i>Bart Dierickx (Caeleste, Antwerp, Belgium; IMEC, Leuven, Belgium)</i>	303
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Session 18	Image Sensors with Super-Small Pixels – II	
	<i>Session Chair: Robert Henderson</i>	
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9:40-10:00	Improved Design of 1T Charge-Modulation Pixel Structure for Small-Size and Low-Dark-Current Achievements <i>Arnaud Tournier^{1,2}, François Roy¹, Guo-Neng Lu², Benoît Deschamps¹ (¹STMicroelectronics, Crolles, France; ²Université de Lyon, Institut des Nanotechnologies de Lyon, Villeurbanne, France)</i>	315
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	<i>Session Chair: Craig Keast</i>	
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11:00-11:20	High Performance CMOS Image Sensor for Low Light Imaging <i>Xinqiao (Chiao) Liu, Boyd Fowler, Hung Do, Steve Mims, Dan Laxson, and Brett Frymire (Fairchild Imaging, Milpitas, USA)</i>	327
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11:35-11:40	Closing Remarks	

