2019 INTERNATIONAL IMAGE SENSOR WORKSHOP
Snowbird Resort, Utah, USA
June 24-27, 2019

PROGRAM

<table>
<thead>
<tr>
<th>Sunday, June 23rd 2019</th>
<th>18:00-</th>
<th>Registration</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Monday, June 24th 2019</th>
<th>08:00-08:30</th>
<th>Registration / Welcome</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>08:30-08:45</td>
<td>Opening</td>
</tr>
</tbody>
</table>

**Session 01: Stacking and Small Pixels**
Session Chairs: Yusuke Oike (Sony); Dun-Nian Yaung (TSMC)

| 08:45-09:00 | R01 | The State-of-the-Art of Smartphone Imagers
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ray Fontaine, TechInsights Inc., Canada</td>
</tr>
</tbody>
</table>

| 09:00-09:15 | R02 | A new 0.8µm CMOS image sensor with low RTS noise and high full well capacity
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Takuma Hasegawa(^2), Kazufumi Watanabe(^1), Y. Jay Jung(^1), Nagataka Tanaka(^2), Takashi Nakashikiryo(^2), Wu-Zang Yang(^3), Alan Chih-Wei Hsiung(^1), Zhiqiang Lin(^1), Sohei Manabe(^1), Vincent C. Venezia(^1), Lindsay A. Grant(^1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(^1) OmniVision Technologies, Santa Clara, CA, USA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(^2) OmniVision Technologies Japan, Kanagawa, Japan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(^3) OmniVision Technologies Taiwan, Hsinchu, Taiwan</td>
</tr>
</tbody>
</table>

| 09:15-09:30 | R03 | A Small-size Dual Pixel CMOS Image Sensor with Vertically Broad Photodiode of 0.61 µm pitch
|-------------|-----|-------------------------------------------------------------------------------------------|
|             |     | Jungbin Yun\(^1\), Kyungho Lee\(^1\), Junghyung Pyo\(^1\), Kyungduk Lee\(^1\), Seungjoon Lee\(^1\), Masato Fujita\(^1\), Kyoung Mok Son\(^2\), Junseok Yang\(^2\), Younguk Song\(^2\), Hyejung Kim\(^2\), Younghwan Park\(^1\), Sungsoo Choi\(^1\), Eun Sub Shim\(^1\), Jeongjin
<p>|             |     | Cho(^1), Seungjin Lee(^1), Seokgy Yoon(^1), Sangil Jung(^2), Takashi Nagano(^1), Chang-Rok Moon(^1), and Yongin Park(^1) |
|             |     | (^1) System LSI Division, Samsung Electronics Co., Ltd |
|             |     | (^2) Foundry Division, Samsung Electronics Co., Ltd |</p>
<table>
<thead>
<tr>
<th>Session 02</th>
<th>Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session Chair: Bumsuk Kim (Samsung)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:30-09:45</td>
<td>World first mass productive 0.8μm pixel size image sensor with new optical isolation technology of to minimize optical loss for high sensitivity</td>
<td>Yunki Lee¹, Jonghoon Park¹, Bumsuk Kim¹, Jungsaeng Kim¹, Hyungeun Yoo¹, Seungjoo Nah², Donghyuk Park¹, Taesung Lee¹, Bomi Kim¹, Dongmin Keum¹, Heegeun Jeong², Heesang R04 Kwon¹, Myoungsun Kim², Sangil Jung², Yitae Kim¹, Changrok Moon¹ and Yongin Park¹</td>
</tr>
<tr>
<td>09:45-10:00</td>
<td>Digital Pixel Image Sensors with Linear and Wide-Dynamic-Range Response Developed by Pixel-Wise 3-D Integration</td>
<td>Masahide Goto¹, Yuki Honda¹, Toshihisa Watabe¹, Kei Hagiwara¹, Masakazu Nanba¹, Yoshinori Iguchi¹, Takuya Saraya², Masaharu Kobayashi², Eiji Higurashi³, Hiroshi Toshiyoshi², and Toshiro Hiramoto² R05 NHK Science and Technology Research Laboratories, Tokyo, Japan, The University of Tokyo, Tokyo, Japan, National Institute of Advanced Industrial Science and Technology, Ibaraki, Japan</td>
</tr>
<tr>
<td>10:00-10:15</td>
<td>0.8μm-pitch CMOS Image Sensor with Dual Conversion Gain Pixel for Mobile Applications</td>
<td>Dongyoung Jang, Donghyuk Park, Seungwon Cha, Heesang Kwon, Mihye Kim, Seungwook Lee, Haewon Lee, Seonok Kim, Nakyung Lee, Jinhwa Han, Daehyang Lee, Kwanyoung Oh, Minseong Lee, Ina Yun, Hana Lee, Seokyong Hong, Yitae Kim, Chang-Rok Moon and Yongin Park R06 System LSI Division, Samsung Electronics Co., Ltd, Yongin-city, Gyeonggi-do, Korea</td>
</tr>
<tr>
<td>10:15-10:40</td>
<td>Break</td>
<td></td>
</tr>
</tbody>
</table>

### Session 02: Noise

<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:40-10:55</td>
<td>Modelling Measured 1/f Noise in Quanta Image Sensors (QIS)</td>
<td>Wei Deng¹ (Student), Dakota Starkey¹ (Student), Jiaju Ma² and Eric R. Fossum¹ R07 Thayer School of Engineering, Dartmouth College, Hanover, NH, USA</td>
</tr>
<tr>
<td>10:55-11:10</td>
<td>Several Process Techniques &amp; Pixel Source Follower Schemes to improve the Pixel Temporal Noise</td>
<td>ManLyun Ha, Dongjun Oh, SeEun Park, WooSung Choi, HanGyu Lee, ByeungYeup Lee, Dongil Kim, ChangHun Han, YongChun Kim, Juii Lee, and YoonJong Lee R08 CIS Process Development Team, DB HiTek EumSung, Choongbuk, Korea</td>
</tr>
<tr>
<td>11:10-11:25</td>
<td>Active optical sensing with randomized coded light for intentional interference tolerance</td>
<td>Unghyun Kim, Makoto Ikeda R09 Department of Electrical Engineering and Information Systems, Graduate School of Engineering, The University of Tokyo, Japan</td>
</tr>
</tbody>
</table>
Identifying the Sources of Random Telegraph Noises in Pixels of CMOS Image Sensors

Calvin Yi-Ping Chao\textsuperscript{1}, Meng-Hsu Wu\textsuperscript{1}, Shang-Fu Yeh\textsuperscript{1}, Kuo-Yu Chou\textsuperscript{1}, Honyih Tu\textsuperscript{1}, Chi-Lin Lee\textsuperscript{1}, Yin Chin\textsuperscript{1}, Philippe Paillet\textsuperscript{2}, and Vincent Goiffon\textsuperscript{3}

\textsuperscript{1}Taiwan Semiconductor Manufacturing Company, Hsinchu, Taiwan
\textsuperscript{2}CEA, DAM, Arpajon, France
\textsuperscript{3}ISAE-SUPAERO, Université de Toulouse, France


Y. Sacchettini\textsuperscript{1,2}, J.-P. Carrère\textsuperscript{1}, R. Dura\textsuperscript{1}, J.-P. Oddou\textsuperscript{1}, V. Goiffon\textsuperscript{2} and P. Magnan\textsuperscript{2}

\textsuperscript{1}STMicroelectronics, France
\textsuperscript{2}ISAE-SUPAERO, Université de Toulouse, France

Random Telegraph Noise Caused by MOSFET Channel Traps and Variable Gate Induced Leakage with Multiple Sampling Readout

Shang-Fu Yeh, Meng-Hsu Wu, Chih-Lin Lee, Chin Yin, Kuo-Yu Chou, Calvin Yi-Ping Chao
Taiwan Semiconductor Manufacturing Company, Hsinchu, Taiwan

Session 03  Poster Presentations

<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
<th>Authors</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>P01</td>
<td>Study of Multilayer FEP Characteristics Using Second Harmonic Generation Measurement</td>
<td>Sung-Kun Park, Ming Lei\textsuperscript{1}, Youngwoong Do, Dong-Hyun Kim, Jae-Hyun Kim, Hyungbok Choi\textsuperscript{2}, Seung-Han Lee\textsuperscript{2}, Kyung-do Kim, Heon-Joon Kim, Sung-Bo Hwang, Hoon-Sang Oh, Sung-Joo Hong and Kyung-Dong Yoo\textsuperscript{3}</td>
<td>SK hynix, Technology Development Group, Korea</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\textsuperscript{1}Femtometrix Inc., USA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\textsuperscript{2}Wonik-IPS Inc., Korea</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>\textsuperscript{3}Hanyang University, Nanoscale Semiconductor Engineering, Korea</td>
</tr>
</tbody>
</table>

| P02     | A Reconfigurable 40nm CMOS SPAD Array for LiDAR Receiver Validation | Sarrah M. Patanwala\textsuperscript{1,2}, Istvan Gyongy\textsuperscript{1}, Neale A.W. Dutton\textsuperscript{2}, Bruce R. Rae\textsuperscript{2}, Robert K. Henderson\textsuperscript{1} | School of Engineering, Institute for Integrated Micro and Nano Systems, University of Edinburgh, UK, EH9 3FF |
|         |       |         | \textsuperscript{2}STMicroelectronics Imaging Division, 1 Tanfield, Edinburgh, UK |
P03 A 110nm CMOS process with fully depleted high resistivity substrate for NIR, X-ray and charged particle imaging
Lucio Pancheri\textsuperscript{1,2}, J. Olave\textsuperscript{3,4}, S. Panati\textsuperscript{3,4}, A. Rivetti\textsuperscript{3}, F. Cossio\textsuperscript{3,4}, M. D. Da Rocha Rolo\textsuperscript{3}, N. Demaria\textsuperscript{3}, P. Giubilato\textsuperscript{5,6}, D. Pantano\textsuperscript{5,6}, S. Mattiazzo\textsuperscript{5,6}
\textsuperscript{1}Università di Trento, Trento, Italy, \textsuperscript{2}TIFPA, Trento, Italy, \textsuperscript{3}INFN Torino, Torino, Italy, \textsuperscript{4}Politecnico di Torino, DET, Torino, Italy, \textsuperscript{5}Università di Padova, Padova, Italy, \textsuperscript{6}INFN Padova, Padova, Italy

P04 Intrinsic Si Quantum Efficiency, Responsivity, and Other Parameters Temperature Dependence for BSI Image Sensors
Sergey Velichko\textsuperscript{1}, Bob Gravelle\textsuperscript{1}, Daniel Tekleab\textsuperscript{2}, Michael Guidash\textsuperscript{2}, Scott Johnson\textsuperscript{1}, Minseok Oh\textsuperscript{2}, Hung Chih Chang\textsuperscript{2}
\textsuperscript{1}ON Semiconductor, Meridian, ID, USA, \textsuperscript{2}ON Semiconductor, Santa Clara, CA, USA

P05 Electrostatic surface passivation for p-type BSI image sensors
T.Dalleau, R.Duru, D.Benoit, A.Suler, C.Chaton, F.Roy, G.N.Lu
\textsuperscript{1}STMicroelectronics, 850 rue J. Monnet BP16, 38926 Crolles Cedex, France
\textsuperscript{2}Institut des Nanotechnologies de Lyon, Univ. Claude Bernard Lyon 1, 69622 Villeurbanne, France

P06 Floating Diffusion Dark Current and Dark Signal Non-Uniformity Reduction for High Dynamic Range Overflow Collection Pixels in High Temperature Applications
M. Guidash, M. Oh, D. Collins, R. Mauritzson, D. Tekleab, W. Xu, S. Nicholes
\textsuperscript{1}ON Semiconductor; \textsuperscript{1}Santa Clara, CA, \textsuperscript{2}Meridian, ID

P07 A large-area a-IGZO 256x256 imager using a current-mode transimpedance readout for mammography applications
Florian De Roose, Sandro Tedde, Kris Myny, Siavash Ardakani, Manoj Nag, Marc Ameys, Albert van Breemen, Jan-Laurens van der Steen, Roy Verbeek, Hylke Akkerman, Gerwin Gelinck, Tim Piessens, Jan Genoe, Wim Dehaene, Soeren Steudel
\textsuperscript{1}imec, Leuven, Belgium, \textsuperscript{2}Siemens Healthcare, Erlangen, Germany, \textsuperscript{3}Holst Centre / TNO, Eindhoven, The Netherlands, \textsuperscript{4}ICsense, Leuven, Belgium, \textsuperscript{5}KULeuven, Leuven, Belgium

P08 Parameter-free Simulation of Photon-detection Probability in CMOS Single-photon Avalanche Diodes
Chin-An Hsieh and Sheng-Di Lin
Institute of Electronics, National Chiao Tung University, Taiwan

P09 CMOS Single-photon Avalanche Diodes using Gated Reset Circuit with On-chip Pulse Width Modulation
Chun-Chang Hsu, Chia-Ming Tsai, and Sheng-Di Lin
Institute of Electronics, National Chiao Tung University, Taiwan

P10 Fast Charge Transfer in 100µm long PPD Pixels
Ajit Kumar Kalgi, Arne Crouwels, Bart Dierickx, Walter Verbruggen, Dirk Van Aken
Caeleste, Mechelen, Belgium
P11  Long Distance Ranging Performance of Gen3 LiDAR Imaging System based on 1x16 SiPM Array 88
Salvatore Gneccchi, Colin Barry, Stephen Bellis, Steve Buckley, Carl Jackson
ON Semiconductor, Cork, Ireland

P12  A Low Noise Single-Slope ADC with Signal-Dependent Multiple Sampling Technique 92
Sanguk Lee, Seunghyun Lee, Bumjun Kim, Seong-Jin Kim
Ulsan National Institute of Science and Technology, South Korea

P13  Pixel with nested photo diodes and 120 dB single exposure dynamic range 95
Manuel Innocent, Angel Rodriguez, Deb Guruaribam, Muhammad Rahman, Marc Sulfridge, Swarnal Borthakur, Bob Gravelle, Takayuki Goto, Nathan Dougherty, Bill Desjardin, David Sabo, Marko Mlinar and Tomas Geurts
ON Semiconductor, Belgium/USA

P14  Fully Depleted SiPMs Optimized for Automotive NIR ToF in 180nm Technology 99
Amos Fenigstein and Tomer Leitner
TowerJazz, Migdal Ha’emek, Israel

P15  Pixel Design Utilized P-type Substrate to Achieve Superior NIR Sensitivity and Resolution with Low Dark Noise 103
Takanori Usuki, Masayuki Saeki, Takefumi Konishi, Hiroshi Iwata, Kenichi Nagai, and Toshio Yoshida Semiconductor Business Unit, Sharp Fukuyama Semiconductor Co., Ltd., Hiroshima, Japan

P16  A 132 by 104 10µm-Pixel 250µW 1kefps Dynamic Vision Sensor with Pixel-Parallel Noise and Spatial Redundancy Suppression 107
Chenghan Li1, Luca Longinotti1, Federico Corradi2, Tobi Delbruck3
1 iniVation AG, 2 iniLabs GmbH, 3 INI UZH&ETH, Zurich, Switzerland

P17  Extending Image Sensor Dynamic Range by Scene-aware Pixelwise-adaptive Coded Exposure 111
Huifeng Ke1, Navid Sarhangnejad1, Rahul Gulve1, Zhengfan Xia1, Nikita Gusev1, Nikola Katic1, Kiriakos N. Kutulakos2, Roman Genov1
University of Toronto, Ontario, Canada.
1 Department of Electrical and Computer Engineering
2 Department of Computer Science

P18  A versatile 3D stacked vision chip with massively parallel processing enabling low latency image analysis 115
Stéphane Chevobbe1, Maria Lepecq1, Karim Benchehida1, Mehdi Darouch1, Thomas Dombek1, Fabrice Guellec2, Laurent Miller2
1 CEA LIST Department, CEA LIST, Centre CEA Saclay, Gif-sur-Yvette, France
2 CEA LETI Department, CEA LETI, MINATEC Campus, Grenoble, France
A 2-Mpixel CMOS Image Sensor with Device Authentication and Encryption Key Generation based on Physically Unclonable Function

Shunsuke Okura¹, Ryota Ishiki², Syohei Takano², Masayoshi Shirahati², Takaya Kubota², Mitsuru Shiozaki², Kenichiro Ishikawa¹, Isao Takayanagi¹, and Takeshi Fujino²
¹Brillnics Japan Inc., Tokyo, ²Research Organization of Science and Engineering Ritsumeikan

A high dynamic range, 1.9 Mpixel CMOS image sensor for X-ray imaging with in-pixel charge binning and column parallel ADC

M. Sannino, A. Bofill-Petit, G. Pinaroli¹ and R. Turchetta
IMASENIC Advanced Imaging S.L., Barcelona, Spain
¹Also with Università degli Studi di Udine, Via delle Scienze 206, 33100 Udine, Italy

A Novel Threshold Calibration Methodology for Quanta Image Sensors (QIS)

Dakota A. Starkey¹, Jiaju Ma², Saleh Masoodian² and Eric R. Fossum¹
¹Thayer School of Engineering, Dartmouth College, Hanover, NH, USA
²Gigajot Technology Inc., Pasadena, CA, USA

15:30-15:55 Break

DUV Optimized CCD with Oxide Micro-lenses

Joseph Summa, Tom Carducci, Brian Douglas, Eric Meisenzahl, Chris Parks, Dean Seidler, Scott Vanallen
ON Semiconductor, Rochester, NY, USA

Optimization of fully-depleted gated PPD pixel for achieving high-speed charge transfer

Yun-Tzu Chang¹,², Pierre Boulenc², Linkun Wu², Maarten Rosmeulen², Pol Van Dorpe¹,², Chris Van Hoof², Andreas Süss²,³
¹KU Leuven, ESAT, Leuven, Belgium
²Imec, Leuven, Belgium
³now at OmniVision Technologies, Santa Clara CA, USA

Large Format Global Shutter CMOS Image Sensors

Tomas Geurts, Cedric Esquenet, Stefan Janssens, Anilkumar Prathipati, Mukesh Engla Rao Syam, John McCarten, Hung Doan
ON Semiconductor, Belgium/USA

Leakage Current Non-Uniformity and Random Telegraph Signal in CMOS Image Sensor Floating Diffusions used for In-Pixel Charge Storage

Alexandre Le Roch⁴,⁵, Vincent Goiffon⁴, Philippe Pailler⁵, Jean-Marc Belloir⁵, Pierre Magnan⁶, and Cédric Virmontois⁶
⁴ISAE-SUPAERO, Université de Toulouse, Toulouse, France
⁵Centre Nationale d’Etudes Spatiales (CNES), Toulouse, France
⁶CEA, DAM, DIF, Arpajon, France
Demonstration of Monolithically Integrated Pixel Sensors Based on Optical Back Biasing in 28nm node FDSOI Technology

L. Kadura¹, O. Rozeau¹, A. Ayres¹*, L. Grenouillet¹, N. Rambal¹, A. Chelnokov¹ and M. Vinet¹
¹ Univ. Grenoble-Alpes, CEA, LETI, 17 Avenue des Martyrs, 38000 Grenoble, France
* Now with STMicroelectronics, Crolles, France

Imaging by single quantum processing: large pixels with brains or attopixels without?

Rafael Ballabriga, Benedikt Bergmann, Michael Campbell, Vladimir Gromov, Erik Heijne, Thanushan Kugathasan, Xavier Llopart, Petr Manek, Tuomas Poikela, Stanislav Pospisil, Walter Snoeys, Viros Sriskaran, Lukas Tlustos and John Vallerga
CERN EP Department, Switzerland
Nikhef, Science Park 105, Amsterdam, Netherlands
IEAP at Czech Technical University, Prague, Czech Republic
Space Sciences Laboratory at the UC Berkeley, CA, USA

SPAD array sensitivity improvement by diffractive microlens enhancement by diffractive microlens

J. Vaillant*, L. Masarotto*, R. Paquet*, V. Lecoutre*, C. Pelle*, N. Moussy* and S. Jouan*
* Univ. Grenoble Alpes, CEA, LETI, DOPT, LIS, F-38000 Grenoble
† TR&D, STMicroelectronics, 850 rue Jean Monnet, F-38920 Crolles

SPAD based imaging of Cherenkov light in radiation therapy

A Pétusseau¹,², P Bruza¹, S Tisa², S Gioux², B W Pogue¹
¹ Thayer School of Engineering, Dartmouth College, Hanover, NH 03755 USA
² Telecom Physique Strasbourg, University of Strasbourg, Pôle API, 67400 Illkirch-Graffenstaden, France
³ Micro Photon Devices srl, Via Stradivari 4, 39100 Bolzano, Italy

A 2.5μm 9.5 Mpixel high framerate CMOS imager with hybrid output multiplexer and 58Gb/s datarate

Jeroen Rotte¹, Arnaud Defernez¹, Rik Visser¹, Ruud van Ree¹, Huul van den Heijikant¹, Frank van der Wegen¹, Klaas-Jan Damstra¹, Peter Centen¹, Adi Birman², Dmitry Veinger², Simon Louwsma³
¹ Grass Valley a Belden brand, Breda, the Netherlands
² TowerJazz, Migdal Haemek, Israel
³ Teledyne DALSA, Enschede, the Netherlands

A CMOS Image Sensor with In-Pixel Temperature Sensors for Dark Signal Non-Uniformity Compensation

Shuang Xie¹, Accel Abarca Prouza¹, Albert Theuwissen¹,²
¹ Electronic Instrumentation Laboratory Delft University of Technology
² Harvest Imaging Bree, Belgium

High speed 25M global shutter image sensor with 2.5um pixel

C. Ma¹, Y. Guo¹, Z. Li¹, G. Xin¹, H. Yin¹, Y. Liu¹, Y. Li¹, Q. Zhou¹, J. Bogaerts¹,², X. Wang¹,²
¹ Gpixel INC, Yingkoulu 588, Changchun, China
### Session 04  
**Pixels & Optics**  
*Session Chair: Hidekazu Takahashi (Canon)*

<table>
<thead>
<tr>
<th>Time</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:30-08:45</td>
<td>Back Side Illuminated, Fully Depleted, Pinned Trench Photo MOS for Imaging Applications</td>
<td>François Roy¹, Andrej Suler¹, Jihane Arnaud¹, Yvon Cazaux², Laurent Montes³, Panagiota Morfouli³</td>
</tr>
</tbody>
</table>
| R13                 |                                                                      | STMicroelectronics, 850 Rue Jean Monnet, BP. 16, 38921 Colles, France  
                      |                                                                      | CEA Léti, 17 rue des Martyrs, 38054 Grenoble, Cedex 9, France  
                      |                                                                      | Grenoble INP, IMEP-LaHC, 3 Parvis Louis Néel, 38016 Grenoble, France |
| 08:45-09:00         | Pixel Technology for Improving IR Quantum Efficiency of Backside-illuminated CMOS Image Sensor | Jonghoon Park¹, Yunky Lee¹, Bomi Kim¹, Junsung Park¹, Yunju Yeom¹, Yunji Jung¹, Taehan Kim¹, Hansik Yoon², Yongho Kim², Jinsu Park², Bumsuk Kim³, Chang-Rok Moon¹, and Yongin Park¹ |
| R14                 |                                                                      | System LSI Division, Samsung Electronics Co., Ltd  
                      |                                                                      | Foundry Division, Samsung Electronics Co., Ltd. Yongin-city, Gyeonggi-do, Korea. |
| 09:00-09:15         | An 8-tap CMOS Lock-in Pixel Image Sensor for Short-Pulse Time-of-Flight Measurements | Yuya Shirakawa¹, Keita Yasutomi², Keiichiro Kagawa³, Satoshi Aoyama³, and Shoji Kawahito²,³ |
| R15                 |                                                                      | Graduate School of Medical Photonics, Shizuoka University, Hamamatsu, 432-8011, Japan  
                      |                                                                      | Research Institute of Electronics, Shizuoka University, Hamamatsu, 432-8011, Japan |
| 09:15-09:30         | A technique for phase-detection auto focus under near-infrared-ray incidence in a back-side illuminated CMOS image sensor pixel with pyramid textured interfaces for diffraction | Tatsuya Kunikiyo, Yotaro Goto, Fumitoshi Takahashi, Hidenori Sato, Takeshi Kamino, Koji Izuka, Yutaka Akiyama and Tomohiro Yamashita |
| R16                 |                                                                      | Renesas Electronics Corporation  
                      |                                                                      | 751 Horiguchi, Hitachinaka, Ibaraki, 312-8504, Japan |
| 09:30-09:45         | Electrical characterization of the backside interface on BSI global shutter pixels with Tungsten-shield test structures on CDTI process | C.Doyen¹,², S.Riéq¹, P.Magnan², O.Marcelot², M.Barlas¹, S.Place¹ |
| R17                 |                                                                      | STMicroelectronics, 850 rue Jean Monnet, 38920 Crolles, France  
<pre><code>                  |                                                                      | ISAE-SUPAERO, Université de Toulouse, 10 Avenue Edouard Belin, 31055 Toulouse, France |
</code></pre>
<table>
<thead>
<tr>
<th>Time</th>
<th>Session 5</th>
<th>Topic</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:45-10:00</td>
<td>R18</td>
<td>Image Artifacts in Backside Illumination CMOS Image Sensors Associated with Electrostatic Charge</td>
<td>Tom Frank, Tom Carducci, Bill Desjardim; ON Semiconductor, Rochester, NY, USA; David Price, Rick Jerome, Jeff Gambino; ON Semiconductor, Gresham, OR, USA; Rusty Winzenread; ON Semiconductor, Santa Clara, CA, USA; Thad Smith; ON Semiconductor, Pocatello, ID, USA</td>
</tr>
<tr>
<td>10:00-10:25</td>
<td></td>
<td>Break</td>
<td></td>
</tr>
<tr>
<td>10:25-10:45</td>
<td>R19</td>
<td>Photon Counting</td>
<td></td>
</tr>
<tr>
<td>10:45-11:00</td>
<td>R19</td>
<td>Photon-Counting Imaging with Multi-Bit Quanta Image Sensor</td>
<td>Jiaju Ma, Yu-Wing Chung, Abhiram Gnanasambandam, Stanley H. Chan, Saleh Masoodian; Gigajot Technology Inc., Pasadena, CA 91107, USA</td>
</tr>
<tr>
<td>11:00-11:15</td>
<td>R20</td>
<td>Dual Layer 3D-Stacked High Dynamic Range SPAD Pixel</td>
<td>Tarek Al Abbas¹, Danial Chitnis, Francesco Mattioli Della Rocca, and Robert K. Henderson; School of Engineering, Institute for Integrated Micro and Nano Systems, University of Edinburgh, Edinburgh, UK, EH9 3FF; now with Sense Photonics, Edinburgh, UK</td>
</tr>
<tr>
<td>11:15-11:30</td>
<td>R21</td>
<td>Iterative Image Reconstruction for Quanta Image Sensor by using Variance-based Motion Estimation</td>
<td>Kiyotaka Iwabuchi, Tomohiro Yamazaki and Takayuki Hamamoto; Graduate School of Engineering, Tokyo University of Science, 6-3-1 Niijuku, Katsushika, Tokyo, 125-8585 Japan</td>
</tr>
<tr>
<td>11:45-12:00</td>
<td>R23</td>
<td>High Dynamic Range Imaging using Quanta Image Sensors</td>
<td>Abhiram Gnanasambandam¹, Jiaju Ma² and Stanley H. Chan¹;¹ School of Electrical and Computer Engineering, Purdue University, West Lafayette, IN 47907;² Gigajot Technology Inc., Pasadena, CA 91107, USA</td>
</tr>
<tr>
<td>12:00-12:30</td>
<td></td>
<td>Lunch / Social Event</td>
<td></td>
</tr>
</tbody>
</table>
A Direct TOF Sensor with In-Pixel Differential Time-to-Charge Converters for Automotive Flash LiDAR and Other 3D Applications

Yibing M. Wang\(^1,2\), Lilong Shi\(^1\), Chunji Wang\(^1\), Kwang Oh Kim\(^1\), Ilia Oviannikov\(^1,2\), and Sungwoo Hwang\(^2\)

\(^1\)Samsung Semiconductor, Inc., Pasadena, CA, USA
\(^2\)Samsung Advanced Institute of Technology, Suwon, Korea

1kFPS Time-of-Flight Imaging with a 3D-stacked CMOS SPAD Sensor

Istvan Gyongy\(^1\), Sam W. Hutchings\(^1\), Max Tyler\(^2\), Susan Chan\(^2\), Feng Zhu\(^2\), Robert K. Henderson\(^1\), Jonathan Leach\(^2\)

\(^1\)The University of Edinburgh, Institute for Integrated Micro and Nano Systems, Edinburgh, U.K.
\(^2\)Heriot-Watt University, Institute of Photonics and Quantum Sciences, Edinburgh, U.K.

A Close-in LiDAR for Diffusive Media based on a 32 × 32 CMOS SPAD Image Sensor

Scott Lindner\(^1,2\), Chao Zhang\(^3\), Alexander Kalyanov\(^2\), Martin Wolf\(^2\), Claudio Bruschini\(^1\), Edoardo Charbon\(^1\)

\(^1\)EPFL, Neuchâtel, Switzerland
\(^2\)University of Zurich, Zurich, Switzerland
\(^3\)TUDelft, Delft, The Netherlands

Analysis of a modular SPAD-based direct time-of-flight depth sensor architecture for wide dynamic range scenes in a LiDAR system

Preethi Padmanabhan\(^1\), Chao Zhang\(^2\) and Edoardo Charbon\(^1,2\)

\(^1\)Advanced Quantum Architecture Laboratory (AQUA), EPFL, Neuchâtel, Switzerland
\(^2\)Applied Quantum Architecture Laboratory (AQUA), Delft University of Technology, The Netherlands

A Time-Resolved Lock-in Pixel Image Sensor Using Multiple-Tapped Diode and Hybrid Cascade Charge Transfer Structure

Shoji Kawahito\(^1,2\), Keita Kondo\(^2\), Keita Yasutomi\(^1,2\), Keiichiro Kagawa\(^1,2\)

\(^1\)Research Institute of Electronics, Shizuoka University, Hamamatsu, 432-8011, Japan
\(^2\)Graduate School of Engineering, Shizuoka University, Hamamatsu, 432-8011, Japan

Pandion: A 400 × 100 SPAD sensor for ToF LiDAR with 5 Hz median DCR and 11 ns mean dead-time

Darek Palubiak\(^1\), Salvatore Gnegchi\(^1\), Carl Jackson\(^1\), Silei Ma\(^2\), Orit Skorka\(^2\), Radu Ispasoiu\(^2\)

\(^1\)SensL Division, Intelligent Sensing Group, ON Semiconductor, Cork, Ireland
\(^2\)Intelligent Sensing Group, ON Semiconductor, Santa Clara, USA

Break
<table>
<thead>
<tr>
<th>Time</th>
<th>Title</th>
<th>Authors</th>
<th>Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:25-10:40</td>
<td>A High Optical Performance 2.8µm BSI LOFIC Pixel with 120ke FWC and 160µV/e Conversion Gain</td>
<td>Ken Miyauchi†, Shunsuke Okura†, Kazuya Mori†, Isao Takayanagi†, Junichi Nakamura† and Shigetoshi Sugawa†</td>
<td>Brillnics Japan Inc., 6-21-12 Minami-Oi, Shinagawa-ku, Tokyo, 140-0013 Japan</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Graduate School of Engineering, Tohoku University, 6-6-11-811, Aza-Aoba, Aramaki, Aoba-ku, Sendai, Miyagi, 980-8579 Japan</td>
</tr>
<tr>
<td>10:40-10:55</td>
<td>Sub-pixel Architecture of CMOS Image Sensor Achieving over 120 dB Dynamic Range with less Motion Artifact Characteristics</td>
<td>T. Asatsuma¹, Y. Sakano¹, S. Iida¹, M. Takami², I. Yoshiba¹, N. Ohba², H. Mizuno¹, T. Oka¹, K. Yamaguchi¹, A. Suzuki¹, K. Suzuki¹, M. Yamada¹, Y. Tateshita¹, and K. Ohno¹</td>
<td>Sony Semiconductor Solutions, Kanagawa, Japan</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sony Semiconductor Manufacturing, Kumamoto, Japan</td>
</tr>
<tr>
<td>10:55-11:10</td>
<td>A 1280x960 2.8µm HDR CIS with DCG and Split-Pixel Combined</td>
<td>Johannes Solhusvik¹, Trygve Willassen¹, Sindre Mikkelsen¹, Mathias Wilhelmsen¹, Sohei Manabe², Duli Mao², Zhaoyu He², Keiji Mabuchi², and Takuma Hasegawa³</td>
<td>OmniVision Technologies, Oslo, Norway</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>OmniVision Technologies, Santa Clara, USA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>OmniVision Technologies, Yokohama, Japan</td>
</tr>
<tr>
<td>11:10-11:25</td>
<td>A scalable 12b-16b charge-domain multi-slope column ADC for HDR imagers with 86dB DR at 1µs conversion time</td>
<td>Simon Louwsma¹, Rinus Boor¹, Paul Veldhorst¹, Jeroen Beijer¹, Martin Vasterink¹, Daniel Groeneveld¹, Jeroen Rotte², Rik Visser², Peter Centen²</td>
<td>Teledyne DALSA, Enschede, The Netherlands</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Grass Valley, Breda, The Netherlands</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Grass Valley, Breda, The Netherlands</td>
</tr>
<tr>
<td>11:25-11:40</td>
<td>3.0µm Backside illuminated, lateral overflow, high dynamic range, LED flicker mitigation image sensor</td>
<td>Minseok Oh¹, Steve Nicholes², Maheedhar Suryadevara³, Lin Lin¹, Hung-Chih Chang¹, Daniel Tekleab¹, Michael Guidash¹, Shaheen Amanullah¹, Sergey Velichko², Manuel Innocent³, Scott Johnson²</td>
<td>ON Semiconductor, Santa Clara, CA, USA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ON Semiconductor, Meridian, ID, USA,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ON Semiconductor, Bangalore, India</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ON Semiconductor, Mechelen, Belgium</td>
</tr>
<tr>
<td>11:40-13:15</td>
<td>Lunch</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Session 8**  
**High Speed**  
Session Chair: Alex Krymski (Alexima)

13:15-13:30  
Over 100 Million Frames per Second 368 Frames Global Shutter Burst CMOS Image Sensor with In-pixel Trench Capacitor Memory Array  
*Manabu Suzuki, Rihito Kuroda, and Shigetoshi Sugawa*  
Graduate School of Engineering, Tohoku University 6-6-11-811, Aza-Aoba, Aramaki, Aoba-ku, Sendai, Miyagi, Japan 980-8579

13:30-13:45  
Multi-tap macro-pixel based compressive ultra-high-speed CMOS image sensor  
*Keiichiro Kagawa¹, Tomoya Kokado², Yuto Sato³, Futa Mochizuki³, Hajime Nagahara⁴, Taishi Takasawa¹, Keita Yasutomi¹, Shoji Kawahito¹*  
¹Research Institute of Electronics, Shizuoka University  
²Graduate School of Integrated Science and Technology, Shizuoka University  
³Formerly, Shizuoka University  
⁴Institute for Datability Science, Osaka University

13:45-14:00  
Evolution of BSI Multi-Collection-Gate Image Sensors -From Light-in-Flight imaging to Giga-fps Continuous Imaging-  
*T. Goji Etoh¹, Nguyen Ngo¹, Anh Quang Nguyen³, Yoshiyuki Matsunaga¹, Taeko Ando¹, Kohsei Takehara², and Kazuhiro Shimonomura¹*  
¹Ritsumeikan University  
²Kindai University  
³Hanoi University of Science and Technology

14:00-14:15  
Image Sensor with Panel Readout and Serialization using Multiple PLLs  
*Alex Krymski*  
16850 Collins Ave Suite 112-529, Sunny Isles Beach, FL

14:15-14:30  
16.7Mpixel 8000fps sparse binarized scientific image sensor  
*Peng Gao, Sampsa Veijalainen, Jente Basteleus, Gaozhan Cai, Bert Luyssaert, Bart Dierickx*  
Caeleste, Hendrik Consciencestraat 1 b, 2800 Mechelen, Belgium

14:30-15:00  
Break

**Session 9**  
**New Applications and Non-visible Imaging**  
Session Chair: Pierre Magnan (ISAE)

15:00-15:20  
Invited Presentation II  
I2  
Image Sensor Applications in Minimally Invasive Surgery  
*Dave Shafer, Intuitive Surgical, USA*
A Sub-Electron Temporal Noise High Modulation Contrast NIR Lock-In Pixel CMOS Image Sensor for Non-Contact Physiological Measurement

Chen Cao¹, Masaya Oishi¹, Leyi Tan¹, Keiichiro Kagawa¹, Keita Yasutomi¹, Satoshi Aoyama², Nobukazu Teranishi¹, Norimichi Tsumura³ and Shoji Kawahito¹,²

¹Research Institute of Electronics, Shizuoka University, Hamamatsu, 432-8011, Japan
²Brookman Technology Inc., Hamamatsu, 430-0936, Japan
³Department of Information and Image Sciences, Chiba University, Chiba, 263-8522, Japan

Energy Harvesting Pixel Array with Deep Trench Isolated Diodes for Self-Powered Imaging

F. Kaklin¹,², J. M. Raynor², R. K. Henderson¹

¹School of Engineering, Institute for Integrated Micro and Nano Systems, The University of Edinburgh
²STMicroelectronics Imaging Division, Edinburgh, UK

Advanced Fundus Camera with Innovative NIR Multispectral Color Imaging System - Application Field Development of Dynamic Intelligent Systems Using High-Speed Vision

Hirofumi Sumi¹,², Hironari Takehara², Daiki Shirahige², Takahiko Kondo, Kiyotaka Sasagawa², Takashi Tokuda², Norimasa Kishi¹, Jun Ohta² and Masatoshi Ishikawa¹

¹Graduate School of Information Science and Technology, The University of Tokyo
²Graduate School of Materials Science, Nara Institute of Science and Technology (NAIST)

Organic- and QD-based image sensors integrated on 0.13 µm CMOS ROIC for high resolution, multispectral infrared imaging

Epimitheas Georgitzikis¹,²,³, Pawel E. Malinowski¹, Yunlong Li¹, Jiwon Lee¹, Andreas Süss¹,⁵, Fortunato Frazzica¹, Jorick Maes³, Sam Gielen⁴, Frederik Verstraeten⁴, Pierre Boulenc¹, Ming Mao¹, Stefano Guerrieri¹, Wouter Maes⁴, Zeger Hens³, Paul Heremans¹,², and David Cheyns¹

¹imec, Kapeldreef 75, 3001 Leuven, Belgium
²KU Leuven, 3001 Leuven, Belgium
³Center for Nano- and Biophotonics (NB-Photonics), Ghent University, 9000 Ghent, Belgium
⁴Hasselt University – IMO, Diepenbeek, B-3590 Belgium
⁵now at OmniVision Technologies, Santa Clara, CA 95054 Belgium

A VGA Optical Filter-less CMOS Image Sensor with UV-selective and Visible Light Channels by Differential Spectral Response Pixels

Yhang Ricardo Sipauba Carvalho da Silva, Rihito Kuroda, and Shigetoshi Sugawa

Graduate School of Engineering, Tohoku University, 6-6-11-811, Aza-Aoba, Aramaki, Aoba-ku, Sendai, Miyagi, Japan

UV Photon Counting Detectors for High-Altitude Balloon and Sounding Rocket Experiments

Shouleh Nikzad¹, April D. Jewell¹, John Hennessy¹, Erika Hamden², Gillian Kyne¹,³, Sam Cheng¹, Chris-tophe Basset¹, Michael E. Hoenk¹, Chris Martin³, Walter Harris², and Todd J. Jones¹

¹Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109
²University of Arizona, Tucson, AZ 85721
³California Institute of Technology, Pasadena, CA 91125
**Thursday, June 27th 2019**

**Session 10  Specialty Imaging**  
Session Chair: Shouleh Nikzad (JPL)

08:30-08:45  
A Radiation Hardened CMOS Image Sensor with Almost Zero Dark Current Increase During Radiation  
*Takashi Watanabe¹, Tomoaki Takeuchi², Osamu Ozawa³, Hirohisa Komanome³, Tomoyuki Akahori¹, Kunihiro Tsujiya²*  
R46  
¹Brookman Technology, Inc. 125 Daikumachi, Naka-ku, Hamamatsu, Shizuoka, 430-0936, Japan  
²Japan Atomic Energy Agency, 4002 Narita, Oarai, Higashiibaraki, Ibaraki 311-1393, Japan  
³Ikegami Tsushinki Co., Ltd, 3-6-16 Ikegami, Ohta-ku, Tokyo, 146-8567, Japan

08:45-09:00  
Multi-spectral High-Speed Backside Illuminated TDI CCD-in-CMOS Imager  
*Pierre Boulenc¹, Steven Thijs¹, David San Segundo Bello¹², Jonas Bentell², Vasyl Motsnyi¹, Linkun Wu¹, Marco Müller³, Pilar Gonzalez¹, Klaas Tack¹, Celso Cavaco¹, Maarten Rosmeulen¹*  
R47  
¹imec, Kapeldreef 75, B-3001 Leuven, Belgium  
²now at Pyxalis, 170 Rue de Chatagnon, 38430 Moirans, France  
³ETH Zurich, Rämistrasse 101, 8092 Zürich, Switzerland

09:00-09:15  
Partially Pinned Photodiode Performances in for Emerging Space and Nuclear Applications  
*S. Rizzolo¹, V. Goiffon¹, F. Corbière¹, R. Molina¹, S. Rolando¹, S. Girard¹, P. Paillét¹, P. Magnan¹, A. Boukenter², T. Allanche³, C. Muller²³, C. Monsanglant Louvet¹, H. Desjonquères⁴, J-R Macé⁵, J. Rousson⁶, J-M Barbier⁶, J-P Baudu⁶, A. Saravia Flores⁷ and S. Catherin⁷*  
R48  
¹ISAE-SUPAERO, Université de Toulouse, 10 avenue E. Belin, F-31055, Toulouse, France  
²Université de Lyon, Laboratoire Hubert Curien, UMR-CNRS 5516, Saint-Etienne, France  
³CEA, DAM, DIF, F-91297 Arpajon Cedex, France  
⁴IRSN, Centre de Saclay, F-91192 Gif-sur-Yvette, France  
⁵ORANO, 1, place Jean Millier – 92400 Courbevoie - France  
⁶OPTSYS, 7 rue Salvador Dali, F-42007 Saint Etienne, France

09:15-09:30  
Image Sensor Capable of Analog Convolution for Real-time Image Recognition System Using Crystalline Oxide Semiconductor FET  
*Seiichi Yoneda, Yusuke Negoro, Hidetomo Kobayashi, Kosei Nei, Toshihiko Takeuchi, Masashi Oota, Takuya Kawata, Takayuki Ikeda, and Shunpei Yamazaki*  
R49  
Semiconductor Energy Laboratory, Hase, Atsugi-shi, Kanagawa 243-0036, Japan

09:30-09:55  
**Break**
09:55-10:10  Back Side Illuminated High Dynamic Range 4.0μm Voltage Domain Global Shutter Pixel with Multiple Gain Readout
Brillnics Japan Inc., 6-21-12 Minami-Oi, Shinagawa-ku, Tokyo, 140-0013 Japan
† Brillnics Inc., Guangming 6th Rd., Zhubei City, Hsinchu County 302, Taiwan

10:10-10:25  A High Performance 2.5μm Charge Domain Global Shutter Pixel
Ikuo Mizuno, Toshifumi Yokoyama, Masafumi Tsutsui, Yoshiaki Nishi, Veinger Dmitry and Assaf Lahav
TowerJazz Panasonic Semiconductor Co., Ltd. 800 Higashiyama, Uozu City, Toyama, Japan 937-8585
TowerJazz Migdal Haemeq 23105, Israel

10:25-10:40  Near Infra-Red Enhanced 2.8μm Global Shutter Pixel with Light Pipe Structure and High Resistivity P-type Substrate
Masafumi Tsutsui, Toshifumi Yokoyama, Tatsuya Hirata, Ikuo Mizuno, Dmitry Veinger, Adi Birman and Assaf Lahav
TowerJazz Panasonic Semiconductor Co. Ltd., 800 Higashiyama, Uozu City, Toyama, 937-8585, Japan
TowerJazz, 23105 Migdal Haemek, Israel

10:40-10:55  Global Shutter Efficiency Improvement to >100dB in Advanced Global Shutter Imager with Correction Processing
Kai Shen, Scott Johnson, Radu Ispasoiu
ON Semiconductor, USA

10:55-11:10  A BSI Global Shutter Pixel with Background Light Suppression for Multi-Frame Differential Imaging
Xiaoliang Ge, Guy Meynants, Pascale Francis, Karen Feyen, Sahitya Janardhan, Adi Xhakoni
ams, Building 8, Borsbeeksebrug 36, 2600 Berchem, Belgium

11:10-11:15  Closing Remarks