

# 2019 INTERNATIONAL IMAGE SENSOR WORKSHOP

Snowbird Resort, Utah, USA

June 24-27, 2019

## PROGRAM

### Sunday, June 23<sup>rd</sup> 2019

18:00- Registration

### Monday, June 24<sup>th</sup> 2019

08:00-08:30 Registration / Welcome

08:30-08:45 Opening

#### Session 01 Stacking and Small Pixels

Session Chairs: Yusuke Oike (Sony); Dun-Nian Yaung (TSMC)

- 08:45-09:00 The State-of-the-Art of Smartphone Imagers 1  
R01 *Ray Fontaine, TechInsights Inc., Canada*
- 09:00-09:15 A new 0.8 $\mu$ m CMOS image sensor with low RTS noise and high full well capacity 4  
R02 *Takuma Hasegawa<sup>2</sup>, Kazufumi Watanabe<sup>1</sup>, Y. Jay Jung<sup>1</sup>, Nagataka Tanaka<sup>2</sup>, Takashi Nakashikiryō<sup>2</sup>, Wu-Zang Yang<sup>3</sup>, Alan Chih-Wei Hsiung<sup>1</sup>, Zhiqiang Lin<sup>1</sup>, Sohei Manabe<sup>1</sup>, Vincent C. Venezia<sup>1</sup>, Lindsay A. Grant<sup>1</sup>*  
*<sup>1</sup>OmniVision Technologies, Santa Clara, CA, USA*  
*<sup>2</sup>OmniVision Technologies Japan, Kanagawa, Japan*  
*<sup>3</sup>OmniVision Technologies Taiwan, Hsinchu, Taiwan*
- 09:15-09:30 A Small-size Dual Pixel CMOS Image Sensor with Vertically Broad Photodiode of 0.61  $\mu$ m pitch 8  
R03 *Jungbin Yun<sup>1</sup>, Kyungho Lee<sup>1</sup>, Junghyung Pyo<sup>1</sup>, Kyungduk Lee<sup>1</sup>, Seungjoon Lee<sup>1</sup>, Masato Fujita<sup>1</sup>, Kyoung Mok Son<sup>2</sup>, Junseok Yang<sup>2</sup>, Younguk Song<sup>2</sup>, Hyejung Kim<sup>2</sup>, Younghwan Park<sup>1</sup>, Sungsoo Choi<sup>1</sup>, Eun Sub Shim<sup>1</sup>, Jeongjin Cho<sup>1</sup>, Seungjin Lee<sup>1</sup>, Seogky Yoon<sup>1</sup>, Sangil Jung<sup>2</sup>, Takashi Nagano<sup>1</sup>, Chang-Rok Moon<sup>1</sup>, and Yongin Park<sup>1</sup>*  
*<sup>1</sup>System LSI Division, Samsung Electronics Co., Ltd*  
*<sup>2</sup>Foundry Division, Samsung Electronics Co., Ltd*

09:30-09:45	World first mass productive 0.8 $\mu$ m pixel size image sensor with new optical isolation technology of to minimize optical loss for high sensitivity <i>Yunki Lee<sup>1</sup>, Jonghoon Park<sup>1</sup>, Bumsuk Kim<sup>1</sup>, Jungsaeng Kim<sup>1</sup>, Hyungeun Yoo<sup>1</sup>, Seungjoo Nah<sup>2</sup>, Donghyuk Park<sup>1</sup>, Taesung Lee<sup>1</sup>, Bomi Kim<sup>1</sup>, Dongmin Keum<sup>1</sup>, Heegeun Jeong<sup>2</sup>, Heesang Kwon<sup>1</sup>, Myoungsun Kim<sup>2</sup>, Sangil Jung<sup>2</sup>, Yitae Kim<sup>1</sup>, Changrok Moon<sup>1</sup> and Yongin Park<sup>1</sup></i> <sup>1</sup> System LSI Division, Samsung Electronics Co., Ltd <sup>2</sup> Foundry Division, Samsung Electronics Co., Ltd.	12
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10:00-10:15	0.8 $\mu$ m-pitch CMOS Image Sensor with Dual Conversion Gain Pixel for Mobile Applications <i>Dongyoung Jang, Donghyuk Park, Seungwon Cha, Heesang Kwon, Mihye Kim, Seungwook Lee, Haewon Lee, Seonok Kim, Nakyoung Lee, Jinhwa Han, Daehyung Lee, Kwanyoung Oh, Minseong Lee, Ina Yun, Hana Lee, Seokyoung Hong, Yitae Kim, Chang-Rok Moon and Yongin Park</i> <i>System LSI Division, Samsung Electronics Co., Ltd, Yongin-city, Gyeonggi-do, Korea</i>	20

**10:15-10:40 Break**

<b>Session 02</b>	<b>Noise</b> Session Chair: Bumsuk Kim (Samsung)
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10:40-10:55	Modelling Measured 1/f Noise in Quanta Image Sensors (QIS) <i>Wei Deng<sup>1</sup> (Student), Dakota Starkey<sup>1</sup> (Student), Jiaju Ma<sup>2</sup> and Eric R. Fossum<sup>1</sup></i> <sup>1</sup> Thayer School of Engineering, Dartmouth College, Hanover, NH, USA <sup>2</sup> Gigajot Technology, Inc. Pasadena, CA, USA	23
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R12	<i>Taiwan Semiconductor Manufacturing Company, Hsinchu, Taiwan</i>	
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<b>Session 03</b>	<b>Poster Presentations</b>
13:45-16:55	Session Chair: Edoardo Charbon (EPFL)

P01	Study of Multilayer FEP Characteristics Using Second Harmonic Generation Measurement <i>Sung-Kun Park, Ming Lei<sup>1</sup>, Youngwoong Do, Dong-Hyun Kim, Jae-Hyun Kim, Hyungbok Choi<sup>2</sup>, Seung-Han Lee<sup>2</sup>, Kyung-do Kim, Heon-Joon Kim, Sung-Bo Hwang, Hoon-Sang Oh, Sung-Joo Hong and Kyung-Dong Yoo<sup>3</sup></i> <i>SK hynix, Technology Development Group, Korea</i> <sup>1</sup> Femtomatrix Inc., USA <sup>2</sup> Wonik-IPS Inc., Korea <sup>3</sup> Hanyang University, Nanoscale Semiconductor Engineering, Korea	48
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- P26 Demonstration of Monolithically Integrated Pixel Sensors Based on Optical Back Biasing in 28nm node FDSOI Technology 146  
*L.Kadura<sup>1</sup>, O.Rozeau<sup>1</sup>, A.Ayres<sup>1\*</sup>, L.Grenouillet<sup>1</sup>, N.Rambal<sup>1</sup>, A.Chelnokov<sup>1</sup> and M.Vinet<sup>1</sup>*  
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\* Now with STMicroelectronics, Crolles, France
- P27 Imaging by single quantum processing: large pixels with brains or attopixels without? 150  
*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*  
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IEAP at Czech Technical University, Prague, Czech Republic  
Space Sciences Laboratory at the UC Berkeley, CA, USA
- P28 SPAD array sensitivity improvement by diffractive microlens enhancement by diffractive microlens 154  
*J. Vaillant<sup>\*</sup>, L. Masarotto<sup>\*</sup>, R. Paquet<sup>\*</sup>, V. Lecoutre<sup>\*</sup>, C. Pelle<sup>\*</sup>, N. Moussy<sup>\*</sup> and S. Jouan<sup>†</sup>*  
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<sup>†</sup> TR&D, STMicroelectronics, 850 rue Jean Monnet, F-38920 Crolles
- P29 SPAD based imaging of Cherenkov light in radiation therapy 158  
*A Pétusseau<sup>1,2</sup>, P Bruza<sup>1</sup>, S Tisa<sup>3</sup>, S Gioux<sup>2</sup>, B W Pogue<sup>1</sup>*  
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<sup>3</sup> Micro Photon Devices srl, Via Stradivari 4, 39100 Bolzano, Italy
- P30 A 2.5 $\mu$ m 9.5 Mpixel high framerate CMOS imager with hybrid output multiplexer and 58Gb/s data rate 163  
*Jeroen Rotte<sup>1</sup>, Arnaud Defernez<sup>1</sup>, Rik Visser<sup>1</sup>, Ruud van Ree<sup>1</sup>, Juul van den Heijkant<sup>1</sup>, Frank van der Weegen<sup>1</sup>, KlaasJan Damstra<sup>1</sup>, Peter Centen<sup>1</sup>, Adi Birman<sup>2</sup>, Dmitry Veinger<sup>2</sup>, Simon Louwsma<sup>3</sup>*  
<sup>1</sup> Grass Valley a Belden brand, Breda, the Netherlands  
<sup>2</sup> TowerJazz, Migdal Haemek, Israel  
<sup>3</sup> Teledyne DALSA, Enschede, the Netherlands
- P31 A CMOS Image Sensor with In-Pixel Temperature Sensors for Dark Signal Non-Uniformity Compensation 167  
*Shuang Xie<sup>1</sup>, Accel Abarca Prouza<sup>1</sup>, Albert Theuwissen<sup>1,2</sup>*  
<sup>1</sup> Electronic Instrumentation Laboratory Delft University of Technol  
<sup>2</sup> Harvest Imaging Bree, Belgium
- P32 High speed 25M global shutter image sensor with 2.5 $\mu$ m pixel 171  
*C. Ma<sup>1</sup>, Y. Guo<sup>1</sup>, Z. Li<sup>1</sup>, G. Xin<sup>1</sup>, H. Yin<sup>1</sup>, Y. Liu<sup>1</sup>, Y. Li<sup>1</sup>, Q. Zhou<sup>1</sup>, J. Bogaerts<sup>1,2</sup>, X. Wang<sup>1,2</sup>*  
<sup>1</sup> Gpixel INC, Yingkoulu 588, Changchun, China

P33 Sensor Modeling and Benchmarking — A Platform for Sensor and Computer Vision Algorithm Co-Optimization 175  
*Andrew Berkovich, Chiao Liu*  
*Facebook Reality Labs*

16:55 - **Poster Viewing**

<b>Tuesday, June 25<sup>th</sup> 2019</b>	
<b>Session 04</b>	<b>Pixels &amp; Optics</b> Session Chair: Hidekazu Takahashi (Canon)

08:30-08:45 Back Side Illuminated, Fully Depleted, Pinned Trench Photo MOS for Imaging Applications 179  
*Francois Roy<sup>1</sup>, Andrej Suler<sup>1,3</sup>, Jihane Arnaud<sup>1</sup>, Yvon Cazaux<sup>2</sup>, Laurent Montes<sup>3</sup>, Panagiota Morfouli<sup>3</sup>*

R13 <sup>1</sup>*STMicroelectronics, 850 Rue Jean Monnet, BP. 16, 38921 Colles, France*  
<sup>2</sup>*CEA Léti, 17 rue des Martyrs, 38054 Grenoble, Cedex 9, France*  
<sup>3</sup>*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 183

R14 *Jonghoon Park<sup>1</sup>, Yunki Lee<sup>1</sup>, Bomi Kim<sup>1</sup>, Junsung Park<sup>1</sup>, Eunju Yeom<sup>1</sup>, Yunji Jung<sup>1</sup>, Taehan Kim<sup>1</sup>, Hansik Yoon<sup>2</sup>, Yongho Kim<sup>2</sup>, Jinsu Park<sup>2</sup>, Bumsuk Kim<sup>1</sup>, Chang-Rok Moon<sup>1</sup>, and Yongin Park<sup>1</sup>*  
<sup>1</sup>*System LSI Division, Samsung Electronics Co., Ltd*  
<sup>2</sup>*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 187  
*Yuya Shirakawa<sup>1</sup>, Keita Yasutomi<sup>2</sup>, Keiichiro Kagawa<sup>2</sup>, Satoshi Aoyama<sup>3</sup>, and Shoji Kawahito<sup>2,3</sup>*

R15 <sup>1</sup>*Graduate School of Medical Photonics, Shizuoka University, Hamamatsu, 432-8011, Japan*  
<sup>2</sup>*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 191

R16 *Tatsuya Kunikiyo, Yotaro Goto, Fumitoshi Takahashi, Hidenori Sato, Takeshi Kamino, Koji Iizuka, Yutaka Akiyama and Tomohiro Yamashita*  
*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 195

R17 *C.Doyen<sup>1,2</sup>, S.Ricq<sup>1</sup>, P.Magnan<sup>2</sup>, O.Marcelot<sup>2</sup>, M.Barlas<sup>1</sup>, S.Place<sup>1</sup>*  
<sup>1</sup>*STMicroelectronics, 850 rue Jean Monnet, 38920 Crolles, France*  
<sup>2</sup>*ISAE-SUPAERO, Université de Toulouse, 10 Avenue Edouard Belin, 31055 Toulouse, France*



09:45-10:00 Image Artifacts in Backside Illumination CMOS Image Sensors Associated with Electrostatic Charge 199  
*Tom Frank, Tom Carducci, Bill Desjardin; ON Semiconductor, Rochester, NY, USA*  
*David Price, Rick Jerome, Jeff Gambino; ON Semiconductor, Gresham, OR, USA*  
 R18 *Rusty Winzenread; ON Semiconductor, Santa Clara, CA, USA*  
*Thad Smith; ON Semiconductor, Pocatello, ID, USA*

**10:00-10:25 Break**

<b>Session 5</b>	<b>Photon Counting</b> Session Chair: Jiaju Ma (Gigajot)
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10:25-10:45 **Invited Presentation I**  
 I1 Learning To See In The Dark  
*Vladlen Koltun, Intelligent Systems Lab at Intel, USA*

10:45-11:00 Photon-Counting Imaging with Multi-Bit Quanta Image Sensor 202  
 R19 *Jiaju Ma, Yu-Wing Chung, Abhiram Gnanasambandam, Stanley H. Chan, Saleh Masoodian*  
*Gigajot Technology Inc., Pasadena, CA 91107, USA*

11:00-11:15 Dual Layer 3D-Stacked High Dynamic Range SPAD Pixel 206  
 R20 *Tarek Al Abbas<sup>1</sup>, 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*  
<sup>1</sup> *now with Sense Photonics, Edinburgh, UK*

11:15-11:30 Iterative Image Reconstruction for Quanta Image Sensor by using Variance-based Motion Estimation 210  
 R21 *Kiyotaka Iwabuchi, Tomohiro Yamazaki and Takayuki Hamamoto*  
*Graduate School of Engineering, Tokyo University of Science*  
*6-3-1 Nijuku, Katsushika, Tokyo, 125-8585 Japan*

11:30-11:45 Crystalline Selenium-Based Stacked CMOS Image Sensor with in-Pixel Pulse-Generating Operation Suitable for Single-Photon Counting 214  
 R22 *Shigeyuki Imura, Masahide Goto*  
*NHK Science and Technology Research Laboratories, 1-10-11 Kinuta, Setagaya-ku, Tokyo 157-8510, Japan*

11:45-12:00 High Dynamic Range Imaging using Quanta Image Sensors 218  
 R23 *Abhiram Gnanasambandam<sup>1</sup>, Jiaju Ma<sup>2</sup> and Stanley H. Chan<sup>1</sup>*  
<sup>1</sup> *School of Electrical and Computer Engineering, Purdue University, West Lafayette, IN 47907*  
<sup>2</sup> *Gigajot Technology Inc., Pasadena, CA 91107, USA*

12:00- **Lunch / Social Event**

Wednesday, June 26<sup>th</sup> 2019

**Session 6**      **Range Imaging**  
Session Chair: Neale Dutton (ST Microelectronics)

08:30-08:45	A Direct TOF Sensor with In-Pixel Differential Time-to-Charge Converters for Automotive Flash LiDAR and Other 3D Applications	222
R24	<i>Yibing M. Wang<sup>1,2</sup>, Lilong Shi<sup>1</sup>, Chunji Wang<sup>1</sup>, Kwang Oh Kim<sup>1</sup>, Ilia Ovsianikov<sup>1,2</sup>, and Sungwoo Hwang<sup>2</sup></i> <sup>1</sup> Samsung Semiconductor, Inc., Pasadena, CA, USA <sup>2</sup> Samsung Advanced Institute of Technology, Suwon, Korea	
08:45-09:00	1kFPS Time-of-Flight Imaging with a 3D-stacked CMOS SPAD Sensor	226
R25	<i>Istvan Gyongy<sup>1</sup>, Sam W. Hutchings<sup>1</sup>, Max Tyler<sup>2</sup>, Susan Chan<sup>2</sup>, Feng Zhu<sup>2</sup>, Robert K. Henderson<sup>1</sup>, Jonathan Leach<sup>2</sup></i> <sup>1</sup> The University of Edinburgh, Institute for Integrated Micro and Nano Systems, Edinburgh, U.K. <sup>2</sup> Heriot-Watt University, Institute of Photonics and Quantum Sciences, Edinburgh, U.K.	
09:00-09:15	A Close-in LiDAR for Diffusive Media based on a 32 × 32 CMOS SPAD Image Sensor	230
R26	<i>Scott Lindner<sup>1,2</sup>, Chao Zhang<sup>3</sup>, Alexander Kalyanov<sup>2</sup>, Martin Wolf<sup>2</sup>, Claudio Bruschini<sup>1</sup>, Edoardo Charbon<sup>1</sup></i> <sup>1</sup> EPFL, Neuchâtel, Switzerland <sup>2</sup> University of Zurich, Zurich, Switzerland <sup>3</sup> TU Delft, Delft, The Netherlands	
09:15-09:30	Analysis of a modular SPAD-based direct time-of-flight depth sensor architecture for wide dynamic range scenes in a LiDAR system	234
R27	<i>Preethi Padmanabhan<sup>1</sup>, Chao Zhang<sup>2</sup> and Edoardo Charbon<sup>1,2</sup></i> <sup>1</sup> Advanced Quantum Architecture Laboratory (AQUA), EPFL, Neuchâtel, Switzerland <sup>2</sup> Applied Quantum Architecture Laboratory (AQUA), Delft University of Technology, The Netherlands	
09:30-09:45	A Time-Resolved Lock-in Pixel Image Sensor Using Multiple-Tapped Diode and Hybrid Cascade Charge Transfer Structure	238
R28	<i>Shoji Kawahito<sup>1,2</sup>, Keita Kondo<sup>2</sup>, Keita Yasutomi<sup>1,2</sup>, Keiichiro Kagawa<sup>1,2</sup></i> <sup>1</sup> Research Institute of Electronics, Shizuoka University, Hamamatsu, 432-8011, Japan <sup>2</sup> Graduate School of Engineering, Shizuoka University, Hamamatsu, 432-8011, Japan	
09:45-10:00	Pandion: A 400 × 100 SPAD sensor for ToF LiDAR with 5 Hz median DCR and 11 ns mean dead-time	242
R29	<i>Darek Palubiak<sup>1</sup>, Salvatore Gnechchi<sup>1</sup>, Carl Jackson<sup>1</sup>, Silei Ma<sup>2</sup>, Orit Skorka<sup>2</sup>, Radu Ispasoiu<sup>2</sup></i> <sup>1</sup> SensL Division, Intelligent Sensing Group, ON Semiconductor, Cork, Ireland <sup>2</sup> Intelligent Sensing Group, ON Semiconductor, Santa Clara, USA	
10:00-10:25	<b>Break</b>	

<b>Session 7</b>	<b>HDR</b> Session Chair: Xinyang Wang (Gpixel)
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10:25-10:40	A High Optical Performance 2.8 $\mu$ m BSI LOFIC Pixel with 120ke <sup>-</sup> FWC and 160 $\mu$ V/e <sup>-</sup> Conversion Gain <i>Ken Miyauchi<sup>†</sup>, Shunsuke Okura<sup>†</sup>, Kazuya Mori<sup>†</sup>, Isao Takayanagi<sup>†</sup>, Junichi Nakamura<sup>†</sup> and Shigetoshi Sugawa<sup>‡</sup></i>	246
R30	<sup>†</sup> <i>Brillnics Japan Inc., 6-21-12 Minami-Oi, Shinagawa-ku, Tokyo, 140-0013 Japan</i> <sup>‡</sup> <i>Graduate School of Engineering, Tohoku University, 6-6-11-811, Aza-Aoba, Aramaki, Aoba-ku, Sendai, Miyagi, 980-8579 Japan</i>	
10:40-10:55	Sub-pixel Architecture of CMOS Image Sensor Achieving over 120 dB Dynamic Range with less Motion Artifact Characteristics <i>T. Asatsuma<sup>1</sup>, Y. Sakano<sup>1</sup>, S. Iida<sup>1</sup>, M. Takami<sup>2</sup>, I. Yoshiba<sup>1</sup>, N. Ohba<sup>2</sup>, H. Mizuno<sup>1</sup>, T. Oka<sup>1</sup>, K. Yamaguchi<sup>1</sup>, A. Suzuki<sup>1</sup>, K. Suzuki<sup>1</sup>, M. Yamada<sup>1</sup>, Y. Tateshita<sup>1</sup>, and K. Ohno<sup>1</sup></i>	250
R31	<sup>1</sup> <i>Sony Semiconductor Solutions, Kanagawa, Japan</i> <sup>2</sup> <i>Sony Semiconductor Manufacturing, Kumamoto, Japan</i>	
10:55-11:10	A 1280x960 2.8 $\mu$ m HDR CIS with DCG and Split-Pixel Combined <i>Johannes Solhusvik<sup>1</sup>, Trygve Willassen<sup>1</sup>, Sindre Mikkelsen<sup>1</sup>, Mathias Wilhelmsen<sup>1</sup>, Sohei Manabe<sup>2</sup>, Duli Mao<sup>2</sup>, Zhaoyu He<sup>2</sup>, Keiji Mabuchi<sup>2</sup>, and Takuma Hasegawa<sup>3</sup></i>	254
R32	<sup>1</sup> <i>OmniVision Technologies, Oslo, Norway</i> <sup>2</sup> <i>OmniVision Technologies, Santa Clara, USA</i> <sup>3</sup> <i>OmniVision Technologies, Yokohama, Japan</i>	
11:10-11:25	A scalable 12b-16b charge-domain multi-slope column ADC for HDR imagers with 86dB DR at 1 $\mu$ s conversion time <i>Simon Louwsma<sup>1</sup>, Rinus Boot<sup>1</sup>, Paul Veldhorst<sup>1</sup>, Jeroen Beijer<sup>1</sup>, Martin Vasterink<sup>1</sup>, Daniel Groeneveld<sup>1</sup>, Jeroen Rotte<sup>2</sup>, Rik Visser<sup>2</sup>, Peter Centen<sup>2</sup></i>	258
R33	<sup>1</sup> <i>Teledyne DALSA, Enschede, The Netherlands</i> <sup>2</sup> <i>Grass Valley, Breda, The Netherlands</i>	
11:25-11:40	3.0 $\mu$ m Backside illuminated, lateral overflow, high dynamic range, LED flicker mitigation image sensor <i>Minseok Oh<sup>1</sup>, Steve Nicholes<sup>2</sup>, Maheedhar Suryadevara<sup>3</sup>, Lin Lin<sup>1</sup>, Hung-Chih Chang<sup>1</sup>, Daniel Tekleab<sup>1</sup>, Michael Guidash<sup>1</sup>, Shaheen Amanullah<sup>1</sup>, Sergey Velichko<sup>2</sup>, Manuel Innocent<sup>4</sup>, Scott Johnson<sup>2</sup></i>	262
R34	<sup>1</sup> <i>ON Semiconductor, Santa Clara, CA, USA</i> <sup>2</sup> <i>ON Semiconductor, Meridian, ID, USA,</i> <sup>3</sup> <i>ON Semiconductor, Bangalore, India</i> <sup>4</sup> <i>ON Semiconductor, Mechelen, Belgium</i>	
11:40-13:15	<b>Lunch</b>	

<b>Session 8</b>	<b>High Speed</b> Session Chair: Alex Krymski (Alexima)
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- 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 266  
R35 *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 270  
R36 *Keiichiro Kagawa<sup>1</sup>, Tomoya Kokado<sup>2</sup>, Yuto Sato<sup>3</sup>, Futa Mochizuki<sup>3</sup>, Hajime Nagahara<sup>4</sup>, Taishi Takasawa<sup>1</sup>, Keita Yasutomi<sup>1</sup>, Shoji Kawahito<sup>1</sup>*  
*<sup>1</sup>Research Institute of Electronics, Shizuoka University*  
*<sup>2</sup>Graduate School of Integrated Science and Technology, Shizuoka University*  
*<sup>3</sup>Formerly, Shizuoka University*  
*<sup>4</sup>Institute 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- 274  
R37 *T. Goji Etoh<sup>1</sup>, Nguyen Ngo<sup>1</sup>, Anh Quang Nguyen<sup>3</sup>, Yoshiyuki Matsunaga<sup>1</sup>, Taeko Ando<sup>1</sup>, Kohsei Takehara<sup>2</sup>, and Kazuhiro Shimonomura<sup>1</sup>*  
*<sup>1</sup>Ritsumeikan University*  
*<sup>2</sup>Kindai University*  
*<sup>3</sup>Hanoi University of Science and Technology*
- 14:00-14:15 Image Sensor with Panel Readout and Serialization using Multiple PLLs 278  
R38 *Alex Krymski*  
*16850 Collins Ave Suite 112-529, Sunny Isles Beach, FL*
- 14:15-14:30 16.7Mpixel 8000fps sparse binarized scientific image sensor 282  
R39 *Peng Gao, Sampsa Veijalainen, Jente Basteleus, Gaozhan Cai, Bert Luysaert, Bart Dierickx Caeleste, Hendrik Consciencestraat 1 b, 2800 Mechelen, Belgium*
- 14:30-15:00 **Break**

<b>Session 9</b>	<b>New Applications and Non-visible Imaging</b> Session Chair: Pierre Magnan (ISAE)
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- 15:00-15:20 **Invited Presentation II**  
I2 *Image Sensor Applications in Minimally Invasive Surgery*  
*Dave Shafer, Intuitive Surgical, USA*

15:20-15:35	A Sub-Electron Temporal Noise High Modulation Contrast NIR Lock-In Pixel CMOS Image Sensor for Non-Contact Physiological Measurement	286
R40	<i>Chen Cao<sup>1</sup>, Masaya Oishi<sup>1</sup>, Leyi Tan<sup>1</sup>, Keiichiro Kagawa<sup>1</sup>, Keita Yasutomi<sup>1</sup>, Satoshi Aoyama<sup>2</sup>, Nobukazu Teranishi<sup>1</sup>, Norimichi Tsumura<sup>3</sup> and Shoji Kawahito<sup>1,2</sup></i> <sup>1</sup> <i>Research Institute of Electronics, Shizuoka University, Hamamatsu, 432-8011, Japan</i> <sup>2</sup> <i>Brookman Technology Inc., Hamamatsu, 430-0936, Japan</i> <sup>3</sup> <i>Department of Information and Image Sciences, Chiba University, Chiba, 263-8522, Japan</i>	
15:35-15:50	Energy Harvesting Pixel Array with Deep Trench Isolated Diodes for Self-Powered Imaging	290
R41	<i>F. Kaklin<sup>1,2</sup>, J. M. Raynor<sup>2</sup>, R. K. Henderson<sup>1</sup></i> <sup>1</sup> <i>School of Engineering, Institute for Integrated Micro and Nano Systems, The University of Edinburgh</i> <sup>2</sup> <i>STMicroelectronics Imaging Division, Edinburgh, UK</i>	
15:50-16:05	Advanced Fundus Camera with Innovative NIR Multispectral Color Imaging System -Application Field Development of Dynamic Intelligent Systems Using High-Speed Vision-	294
R42	<i>Hirofumi Sumi<sup>1,2</sup>, Hironari Takehara<sup>2</sup>, Daiki Shirahige<sup>2</sup>, Takahiko Kondo, Kiyotaka Sasagawa<sup>2</sup>, Takashi Tokuda<sup>2</sup>, Norimasa Kishi<sup>1</sup>, Jun Ohta<sup>2</sup> and Masatoshi Ishikawa<sup>1</sup></i> <i>Graduate School of Information Science and Technology, The University of Tokyo<sup>1</sup></i> <i>Graduate School of Materials Science, Nara Institute of Science and Technology (NAIST)<sup>2</sup></i>	
16:05-16:20	Organic- and QD-based image sensors integrated on 0.13 $\mu\text{m}$ CMOS ROIC for high resolution, multispectral infrared imaging	298
R43	<i>Epimitheas Georgitzikis<sup>1,2</sup>, Pawel E. Malinowski<sup>1</sup>, Yunlong Li<sup>1</sup>, Jiwon Lee<sup>1</sup>, Andreas Süß<sup>1,5</sup>, Fortunato Frazzica<sup>1</sup>, Jorick Maes<sup>3</sup>, Sam Gielen<sup>4</sup>, Frederik Verstraeten<sup>4</sup>, Pierre Boulenc<sup>1</sup>, Ming Mao<sup>1</sup>, Stefano Guerrieri<sup>1</sup>, Wouter Maes<sup>4</sup>, Zeger Hens<sup>3</sup>, Paul Heremans<sup>1,2</sup>, and David Cheyns<sup>1</sup></i> <sup>1</sup> <i>imec, Kapeldreef 75, 3001 Leuven, Belgium</i> <sup>2</sup> <i>KU Leuven, 3001 Leuven, Belgium</i> <sup>3</sup> <i>Center for Nano- and Biophotonics (NB-Photonics), Ghent University, 9000 Ghent, Belgium</i> <sup>4</sup> <i>Hasselt University – IMO, Diepenbeek, B-3590 Belgium</i> <sup>5</sup> <i>now at OmniVision Technologies, Santa Clara, CA 95054 Belgium</i>	
16:20-16:35	A VGA Optical Filter-less CMOS Image Sensor with UV-selective and Visible Light Channels by Differential Spectral Response Pixels	302
R44	<i>Yhang Ricardo Sipauba Carvalho da Silva, Rihito Kuroda, and Shigetoshi Sugawa</i> <i>School of Engineering, Tohoku University, 6-6-11-811, Aza-Aoba, Aramaki, Aoba-ku, Sendai, Miyagi, Japan</i>	
16:35-16:50	UV Photon Counting Detectors for High-Altitude Balloon and Sounding Rocket Experiments	306
R45	<i>Shouleh Nikzad<sup>1</sup>, April D. Jewell<sup>1</sup>, John Hennessy<sup>1</sup>, Erika Hamden<sup>2</sup>, Gillian Kyne<sup>1,3</sup>, Sam Cheng<sup>1</sup>, Chris-tophe Basset<sup>1</sup>, Michael E. Hoenk<sup>1</sup>, Chris Martin<sup>3</sup>, Walter Harris<sup>2</sup>, and Todd J. Jones<sup>1</sup></i> <sup>1</sup> <i>Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109</i> <sup>2</sup> <i>University of Arizona, Tucson, AZ 85721</i> <sup>3</sup> <i>California Institute of Technology, Pasadena, CA 91125</i>	

18:30-

**Dinner / Award Session**

<b>Thursday, June 27<sup>th</sup> 2019</b>
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**Session 10****Specialty Imaging**

Session Chair: Shouleh Nikzad (JPL)

- |             |  |     |
|-------------|--|-----|
| 08:30-08:45 | <p>A Radiation Hardened CMOS Image Sensor with Almost Zero Dark Current Increase During Radiation</p> <p><i>Takashi Watanabe<sup>1</sup>, Tomoaki Takeuchi<sup>2</sup>, Osamu Ozawa<sup>3</sup>, Hirohisa Komanome<sup>3</sup>, Tomoyuki Akahori<sup>1</sup>, Kunihiro Tsuchiya<sup>2</sup></i></p>  | 310 |
| R46         | <p><sup>1</sup> Brookman Technology, Inc. 125 Daikumachi, Naka-ku, Hamamatsu, Shizuoka, 430-0936, Japan</p> <p><sup>2</sup> Japan Atomic Energy Agency, 4002 Narita, Oarai, Higashiibaraki, Ibaraki 311-1393, Japan</p> <p><sup>3</sup> Ikegami Tsushinki Co., Ltd, <sup>3</sup> -<sup>6</sup>-16 Ikegami, Ohta-ku, Tokyo, 146-8567, Japan</p>   |     |
| 08:45-09:00 | <p>Multi-spectral High-Speed Backside Illuminated TDI CCD-in-CMOS Imager</p> <p><i>Pierre Boulenc<sup>1</sup>, Steven Thijs<sup>1</sup>, David San Segundo Bello<sup>1,2</sup>, Jonas Bentell<sup>1</sup>, Vasyly Mutsnyl<sup>1</sup>, Linkun Wu<sup>1</sup>, Marco Müller<sup>3</sup>, Pilar Gonzalez<sup>1</sup>, Klaas Tack<sup>1</sup>, Celso Cavaco<sup>1</sup>, Maarten Rosmeulen<sup>1</sup>, Stefano Guerrieri<sup>1</sup> and Piet De Moor<sup>1</sup></i></p>  | 314 |
| R47         | <p><sup>1</sup> imec, Kapeldreef 75, B-3001 Leuven, Belgium</p> <p><sup>2</sup> now at Pyxalis, 170 Rue de Chatagnon, 38430 Moirans, France</p> <p><sup>3</sup> ETH Zurich, Rämistrasse 101, 8092 Zürich, Switzerland</p>  |     |
| 09:00-09:15 | <p>Partially Pinned Photodiode Performances in for Emerging Space and Nuclear Applications</p> <p><i>S. Rizzolo<sup>1</sup>, V. Goiffon<sup>1</sup>, F. Corbière<sup>1</sup>, R. Molina<sup>1</sup>, S. Rolando<sup>1</sup>, S. Girard<sup>2</sup>, P. Paillet<sup>3</sup>, P. Magnan<sup>1</sup>, A. Boukenter<sup>2</sup>, T. Allanche<sup>2</sup>, C. Muller<sup>2,3</sup>, C. Monsanglant Louvet<sup>4</sup>, H. Desjonqueres<sup>4</sup>, J-R Macé<sup>5</sup>, J. Rousson<sup>6</sup>, J-M Barbier<sup>6</sup>, J-P Baudu<sup>6</sup>, A. Saravia Flores<sup>7</sup> and S. Catherin<sup>7</sup></i></p> | 318 |
| R48         | <p><sup>1</sup> ISAE-SUPAERO, Université de Toulouse, 10 avenue E. Belin, F-31055, Toulouse, France</p> <p><sup>2</sup> Université de Lyon, Laboratoire Hubert Curien, UMR-CNRS 5516, Saint-Etienne, France</p> <p><sup>3</sup> CEA, DAM, DIF, F-91297 Arpajon Cedex, France</p> <p><sup>4</sup> IRSN, Centre de Saclay, F-91192 Gif-sur-Yvette, France</p> <p><sup>5</sup> ORANO, 1, place Jean Millier – 92400 Courbevoie - France</p> <p><sup>6</sup> OPTSYS, 7 rue Salvador Dali, F-42007 Saint Etienne, France</p>  |     |
| 09:15-09:30 | <p>Image Sensor Capable of Analog Convolution for Real-time Image Recognition System Using Crystalline Oxide Semiconductor FET</p> <p><i>Seiichi Yoneda, Yusuke Negoro, Hidetomo Kobayashi, Kosei Nei, Toshihiko Takeuchi, Masashi Oota, Takuya Kawata, Takayuki Ikeda, and Shunpei Yamazaki</i></p>   | 322 |
| R49         | <p><i>Semiconductor Energy Laboratory, Hase, Atsugi-shi, Kanagawa 243-0036, Japan</i></p>  |     |
| 09:30-09:55 | <b>Break</b>   |     |

<b>Session 11</b>	<b>Global Shutter</b>
	Session Chair: Assaf Lahav (TowerJazz)

09:55-10:10	Back Side Illuminated High Dynamic Range 4.0 $\mu$ m Voltage Domain Global Shutter Pixel with Multiple Gain Readout	326
R50	<i>K. Mori, T. Otaka, T. Isozaki, N. Yasuda, T. Akutsu, K. Miyauchi, A. Tsai<sup>1</sup>, Y. Sawai, S. Tanaka I. Takayanagi and J. Nakamura</i> <i>Brillnics Japan Inc., 6-21-12 Minami-Oi, Shinagawa-ku, Tokyo, 140-0013 Japan</i> <i><sup>†</sup> Brillnics Inc., Guangming 6th Rd., Zhubei City, Hsinchu County 302, Taiwan</i>	
10:10-10:25	A High Performance 2.5 $\mu$ m Charge Domain Global Shutter Pixel	330
R51	<i><sup>1</sup> Ikuo Mizuno, <sup>1</sup> Toshifumi Yokoyama, <sup>1</sup> Masafumi Tsutsui, <sup>1</sup> Yoshiaki Nishi, <sup>2</sup> Veinger Dmitry and <sup>2</sup> Assaf Lahav</i> <i><sup>1</sup> TowerJazz Panasonic Semiconductor Co., Ltd. 800 Higashiyama, Uozu City, Toyama, Japan 937-8585</i> <i><sup>2</sup> TowerJazz Migdal Haemeq 23105, Israel</i>	
10:25-10:40	Near Infra-Red Enhanced 2.8 $\mu$ m Global Shutter Pixel with Light Pipe Structure and High Resistivity P-type Substrate	334
R52	<i>Masafumi Tsutsui<sup>1</sup>, Toshifumi Yokoyama<sup>1</sup>, Tatsuya Hirata<sup>1</sup>, Ikuo Mizuno<sup>1</sup>, Dmitry Veinger<sup>2</sup>, Adi Birman<sup>2</sup> &amp; Assaf Lahav<sup>2</sup></i> <i><sup>1</sup> Towerjazz Panasonic Semiconductor Co. Ltd., 800 Higashiyama, Uozu City, Toyama, 937-8585, Japan</i> <i><sup>2</sup> TowerJazz, 23105 Migdal Haemek, Israel</i>	
10:40-10:55	Global Shutter Efficiency Improvement to >100dB in Advanced Global Shutter Imager with Correction Processing	338
R53	<i>Kai Shen, Scott Johnson, Radu Ispasoiu</i> <i>ON Semiconductor, USA</i>	
10:55-11:10	A BSI Global Shutter Pixel with Background Light Suppression for Multi-Frame Differential Imaging	342
R54	<i>Xiaoliang Ge, Guy Meynants, Pascale Francis, Karen Feyen, Sahitya Janardhan, Adi Xhakoni</i> <i>ams, Building 8, Borsbeeksebrug 36, 2600 Berchem, Belgium</i>	
11:10-11:15	Closing Remarks	

