

SYMPOSIUM ON ULTRA CLEAN PROCESSING OF SEMICONDUCTOR SURFACES 2021

PROGRAM

all presentations: online
(Time: UTC+2h)

Tuesday 13 April 2021

WELCOME AND OPENING

08:20 – 08:40

08:20 - 08:40

1.1 - Welcome and opening address

Paul Mertens

imec, Belgium

SESSION 1 - FEOL: ETCHING OF GROUP IV SEMICONDUCTORS

08:40 – 09:20

Chair:

Kurt Wostyn

imec

Co-Chair:

Takahashi Hiroaki

SCREEN

08:40 - 09:00

1.1 - Reaction Kinetics of Poly-Si Etching in TMAH Solution (student presentation)

Park, Taegun, Lim, Sangwoo

Yonsei University, Republic of Korea

09:00 – 09:20

1.2 - Surface Chemistry and Nanoscale Wet Etching of Group IV Semiconductors in Acidic H₂O₂ Solutions

van Dorp, Dennis

imec, Belgium

SESSION 2 - FEOL: ETCH DIELECTRIC FILMS & REMOVAL OF MASKING FILMS

09:20 – 10:40

Chair:

Martin Knotter

NXP Semiconductors

Co-Chair:

Nasser Belmiloud

SCREEN

09:20 – 09:40

2.1 Highly Selective Etching between Different Oxide Films by Vapor Phase Cleaning

Nishihara, Kazuki; Inaba, Masaki; Takahashi, Hiroaki

SCREEN Semiconductor Solutions Co., Ltd., Japan

09:40 – 10:00

2.2 - Kinetic Study on the Si₃N₄ Etching in Superheated Water (student presentation)

Son, Changjin; Lim, Sangwoo

Yonsei University, Republic of Korea

10:00 – 10:20

2.3 - Silicon Corrosion during Selective Silicon Nitride Etch with Hot Diluted Hydrofluoric Acid

Garnier, Philippe (1); Massin, Thomas (1); Chatelet, Corentin (1); Oghdayan, Emmanuel (1); Lauerhaas, Jeffrey (2); Morote, Carlos (2); Butterbaugh, Jeffery (2)

1. STMicroelectronics, France; 2. TEL Manufacturing and Engineering of America, Inc, USA

10:20 – 10:40

2.4 - High Performance, Eco-Friendly SPM Cleaning Technology Using Integrated Bench-Single Wafer Cleaning System

Henry, Sally Ann (1); Chen, Fuping (1); Wang, David (1); Zhang, Xiaoyan (1); Wang, Wenjun (1); Ren, Shuchao (1); Jia, Shena (1); Wang, Jun (1); Wang, Jane (1); Wang, Xi (1); Tang, Baoguo (1); Lee, Jason (1); Kim, YY (1); Chae, KK (1); Lee, SH (1); Lee, Bruce (1); Lei, Haibo (2); Zhang, Yu (2); Zhang, Tao (2); Huang, Jun (2); Li, Fang (2); Wang, Chunwei (2); Li, Hong (2); Yang, Yi (2)

1: ACM Research (Shanghai), Inc, United States of America; 2: Shanghai Huali Microelectronics corporation

10:40 – 11:00

BREAK

SESSION 3 - CONTAMINATION AND CONTAMINATION CONTROL

11:00 – 13:10

Chair:

Gyuhyun Kim

SK HYNIX

Co-Chair:

Guy Vereecke

imec

11:00 – 11:20

3.1 - Direct Analysis of Ultra Trace Metallic Particles in NH₃ and HCl Gases by GED-ICP-MS

Kawabata, Katsu; Nishiguchi, Kohei; Ichinose, Tatsu
IAS Inc., Japan

11:20 – 11:40

3.2 - Investigation of Contaminants in Single Wafer Wet Cleaning Using Isopropyl Alcohol (student presentation)

Oh, Seungjun (1); Lee, Sunyoung (2); Kim, Heehwan (3);
IAS Inc., Japan

11:40 – 12:00

3.3 - Cl-Containing Microplastics from the Environment

Knotter, D. Martin; Sharma, Pradeep; Goumans, Leon
NXP Semiconductors

12:00 – 12:20

3.4 - Experimental Wafer Carrier Contamination Analysis and Monitoring in Fully Automated 300 mm Power Production Lines

Zängle, Clara (1); Pfeffer, Markus (1); Franze, Peter (2); Schneider, Germar (2); Bauer, Anton (1)
1: Fraunhofer Institute of integrated Systems and Device Technology; 2: Infineon Technologies Dresden GmbH & Co. KG

12:20 – 12:40

3.5 - Characterization and Removal of Metallic Contamination in Process Chemicals Using Single Particle Inductively Coupled Plasma Mass Spectrometry (SP-ICP-MS)

Sampath, Siddarth; Maharjan, Kusum; Ozzello, Anthony; Bhabhe, Ashutosh
Entegris, United States of America

12:40 – 13:10

3.6 - Surface Cleaning Challenges for Organic Light Emitting Diodes (invited speaker)

Chris Giebink
Pennsylvania State University, United States of America

13:10 – 13:30

BREAK

**SESSION 4 - FEOL: SURFACE CHEMISTRY AND ETCHING OF
III-V COMPOUND SEMICONDUCTOR**

13:30 – 15:00

Chair: *Dennis Van Dorp* *imec*
Co-Chair: *Harold Philipsen* *imec*

- 13:30 – 13:50** **4.1 - Analysis of Surface Reaction for Group III-V Compound Semiconductors in Functional Water**
Nishio, Kenya (1); Oinoue, Takashi (1); Saito, Suguru (1); Hagimoto, Yoshiya (1); Ogawa, Yuuichi (2); Ida, Junichi (2); Iwamoto, Hayato (1)
1: Sony Semiconductor Solutions Corporation, Japan; 2: Kurita Water Industries Ltd.
- 13:50 – 14:10** **4.2 - Effect of Surface Oxidation on the Material Loss of InGaAs in Acidic Solutions (student presentation)**
Na, Jihoon; Lim, Sangwoo
Yonsei University, Republic of Korea
- 14:10 – 14:30** **4.3 - Characterization of Wet Chemical Atomic Layer Etching of InGaAs**
Tomoki, Hirano; Kenya, Nishio; Takashi, Fukatani; Suguru, Saito; Yoshiya, Hagimoto; Hayato, Iwamoto
Sony Semiconductor Solutions, Japan
- 14:30 – 15:00** **4.4 - GaN MOS Structures with Low Interface Trap Density (invited speaker)**
Ronming Chu
Pennsylvania State University, United States of America

15:00 – 15:40 **BREAK**

SESSION 5 - FEOL: SURFACE PREPARATION OF GROUP IV SEMICONDUCTORS **15:40 – 16:20**

Chair: *Jim Snow* **SCREEN**
Co-Chair: *Akshey Seghal* **INTEL**

- 15:40 – 16:00** **5.1 - Towards Si-Cap-Free SiGe Passivation: Impact of Surface Preparation on Low-Pressure Oxidation of SiGe**
Wostyn, Kurt; Arimura, Hiroaki; Kimura, Yosuke; Hikavy, Andriy; Rondas, Dirk; Conard, Thierry; Ragnarsson, Lars-Ake; Horiguchi, Naoto
imec, Belgium
- 16:00 – 16:20** **5.2 - Wet Chemical Cleaning of Organosilane Monolayers**
Hinckley, Adam; Muscat, Anthony
University of Arizona, United States of America

Chair: *Kuntack Lee* **SAMSUNG**
Co-Chair: *Sangwoo Lim* **Yonsei University, Korea**

- 08:00 – 08:20** **6.1 - Effect of Hydrophobicity and Surface Potential of Siliconon SiO₂ Etching in Nanometer-Sized Narrow Spaces**
Ueda, Dai (1); Hanawa, Yousuke (1); Kitagawa, Hiroaki (1); Fujiwara, Naozumi (2); Otsuji, Masayuki (2); Takahashi, Hiroaki (2); Fukami, Kazuhiro (3)
1: SCREEN Holdings Co., Ltd., Japan;
- 08:20 – 08:40** **6.2 - Formulation and Evaluation of Diluted Sulfuric-Peroxide-HF (DSP+) Mixtures for Cleaning High-Aspect Ratio Contacts in 3D NAND (student presentation)**
An, Kook-Hyun; Kim, Hyun-Tae; Kim, Tae-Gon; Park, Jin-Goo
Hanyang University, Korea, Republic of (South Korea)
- 08:40 – 09:00** **6.3 - PDMS Micro-Channels Application for the Study of Dynamic Wetting of Nanoetched Silicon Surfaces Based on Acoustic Characterization Method (student presentation)**
Salhab, Abbas (1,2); Carlier, Julien (1); Campistrion, Pierre (1); Neyens, Marc (2); Toubal, Malika (1); Nongaillard, Bertrand (1); Thomy, Vincent (3)
1: Univ. Polytechnique Hauts-de-France, CNRS, Univ. Lille, ISEN, Centrale Lille, UMR 8520 - IEMN - Institut d'Électronique de Microélectronique et de Nanotechnologie, DOAE - Département d'Opto-Acousto-Électronique, F-59313 Valenciennes, France; 2: STMicroelectronics, 850 rue Monnet, F-38926 Crolles, France; 3: Institute of Electronics, Microelectronics and Nanotechnology, Univ. Lille, UMR 8520 - IEMN, F-59000 Lille, France
- 09:00 – 09:20** **6.4 - Characterization of Wetting of Deep Silica Nanoholes by Aqueous Solutions Using ATR-FTIR**
Vereecke, Guy (1); Dochain, Denis (2); De Coster, Hanne (3); Conlan, Shona (4); Nurekeyeva, Kunsulu (3); Nsimba, Anthony (4);
1: imec, Belgium; 2: UCLouvain, Belgium; 3: KULeuven, Belgium; 4: TU Dublin, Ireland
- 09:20 – 09:40** **6.5 - New Test Structure Development for Pattern Collapse Evaluations**
Xu, XiuMei
imec, Belgium
- 09:40 – 10:00** **6.6 - Breakthrough of Sublimation Drying by Liquid Phase Deposition**
Sasaki, Yuta (1); Hanawa, Yosuke (1); Otsuji, Masayuki (2); Fujiwara, Naozumi (2); Kato, Masahiko (2); Yamaguchi, Yu (2); Takahashi, Hiroaki (2)
1: SCREEN Holdings Co., Ltd., Japan; 2: SCREEN Semiconductor Solutions Co., Ltd., Japan

Chair: *Tae-Gon Kim* *HanYang University*
Co-Chair: *Antoine Pacco* *imec*

- 10:00 – 10:20** **7.1 - Study on Uniform Deposition on 300 mm Silicon Wafer with sub-100 nm Sized Particles for Cleaning Application (student presentation)**
 Lee, Seungjae (1); Hong, Seokjun (1); Oh, Haerim (3); Chae, Seung-ki (4); Kim, Taesung (1,2)
 1: School of Mechanical Engineering, Sungkyunkwan University, Korea; 2: SKKU Advanced Institute of Nanotechnology, Sungkyunkwan University, Korea;
 3: Engineering Lab, SEMES, Korea; 4: Research & Business Foundation, Sungkyunkwan University, Korea
- 10:20 – 10:40** **7.2 - Ultrafine Particle Removal in the Wafer Cleaning Process Using High Concentration DIO₃-DHF Mixture (student presentation)**
 Han, Hyeon Joon; Lee, Hunhee; Kim, Charles; Kim, Yongmok
 1: SCREEN Holdings Co., Ltd., Japan;
- 10:40 – 11:00** **7.3 - Particle Removal in Ultrasonic Water Flow Cleaning Role of Cavitation Bubbles as Cleaning Agents**
 Ando, Keita (1); Sugawara, Mao (1); Sakota, Riria (1); Ishibashi, Tomoatsulshibashi (2); Matsuo, Hisanori (2); Watanabe, Katsuhide (2)
 1: Keio University, Japan; 2: Ebara Corporation, Japan
- 11:00 – 11:20** **7.4 - Scalable Particle Removal for sub-5 nm Nodes**
 Yoshida, Yukifumi (1); Akiyama, Katsuya (1); Zhang, Song (1); Ueda, Dai (2); Inaba, Masaki (1); Takahashi, Hiroaki (1)
 1: SCREEN Semiconductor Solutions Co., Ltd.; 2: SCREEN Holdings Co., Ltd.
- 11:20-11:40** **7.5 - The Effect of Thermal Aging on Nanoparticle Removal (student presentation)**
 Kim, Yeoho (1); Jin, Seung-Wan (1); Kim, Hyun-Tae (2); Kim, Tae-Gon (3); Won, Kyu-Hwang (4); Park, Jin-Goo (1,2)
 1: Department of Materials Science and Chemical Engineering, Hanyang University, Ansan, 15588, Republic of Korea; 2: Department of Bio-Nano Technology, Hanyang University, Ansan, 15588, Republic of Korea; 3: Department of Smart Convergence Engineering, Hanyang University, Ansan, 15588, Republic of Korea; 4: Samsung Electronics Co., Ltd, Hwaseong, 18448, Republic of Korea

11:40 – 12:00

BREAK

Chair: Marc Meuris imec
Co-Chair: Paul Mertens imec

Each poster author is allocated 3 minutes to advertise his/her poster using max 3 slides.

P01 - Simulation of Rayleigh Bubble Growth near a No-Slip Rigid Wall (student presentation)

Tanaka, Tomoya; Ando, Keita
Keio University, Japan

**P02 - Interaction between Free-Surface Oscillation and Bubble Translation in a Megasonic Cleaning Bath
(WITHDRAWN)**

Katano, Yu; Ando, Keita
Keio University, Japan

P03 - Removal of SOC Hard Mask for Patterning of Work Function Metal by Thermally Activated Ozone Gas

S. Iwahata, M. Inaba, F. Sebaai and E. Altamirano Sanchez
Screen Semiconductor Solutions Co Ltd, Japan

P04 - Removal of Post Etch Residue on BEOL Low-K with Nanolift

Y. Akanishi, Q. T. Le and Efrain Altamirano Sanchez
Screen Semiconductor Solutions Co Ltd, Japan

P05 - Selective Ru or Co Etch for 3nm Applications

HSU, Chien-Pin Sherman; Chen, Polly Yi-Ting
Avantor, Taiwan

P06 - Remote Plasma Etching of Backend Semiconductor Materials for Reliable Packaging

Evertsen, Rogier; Beckers, Nicolle; Wang, Shaoying; Van der Stam, Richard
ASM PT, The Netherlands

P07 - Wafer Container Monitoring concerning Airborne Molecular Contaminations along a 300 mm Power Semiconductor Production Flow)

Franze, Peter (1); Schneider, Germar (1); Kaskel, Stefan (2)
1: Infineon Technologies Dresden GmbH & Co. KG, Germany; 2: Chair of Inorganic Chemistry I, Technical University of Dresden, Germany

P08 - Si1-XGeX Selective Etchant for Gate-All-Around Transistors

Harada, Ken (1); Suzuki, Tatsunobu (2); Kusano, Tomohiro (1); Takeshita, Kan (1); Oniki, Yusuke (3);
Altamirano-Sánchez, Efrain (3); Struyf, Herbert (3); Holsteyns, Frank (3)
1: Mitsubishi Chemical Corporation, Japan; 2: Mitsubishi Chemical Corporation, Japan; 3: imec, Belgium

P09 - Challenges and Solutions of Replacement Metal Gate Patterning to Enable Gate-All-Around Device Scaling

Oniki, Yusuke (1); Ragnarsson, Lars-Åke (1); Iino, Hideaki (2); Cott, Daire (1); Chan, Boon Teik (1); Sebaai, Farid (1); Hopf, Toby (1); Dekkers, Harold (1); Dentoni Litta, Eugenio (1); Altamirano-Sánchez, Efrain (1); Holsteyns, Frank (1); Horiguchi, Naoto (1)
1: imec, Belgium; 2: Kurita, Japan

Chair: *Ara Philipossian* *University of Arizona, Tucson*
Co-Chair: *Martin Knotter* *NXP Semiconductors*

14:20 – 14:40

8.1 - Visualization of Acoustic Waves and Cavitation in Ultrasonic Water Flow

Usui, Hidehisa (1); Ishibashi, Tomoatsu (2); Matsuo, Hisanori (2); Watanabe, Katsuhide (2); Ando, Keita (1)

1: Keio University, Japan; 2: Ebara Corporation, Japan

14:40 – 15:00

8.2 - Effect of Surfactant in Gas Dissolved Cleaning Solutions on Acoustic Bubble Dynamics

Han, SoYoung (1); Yerriboina, Nagendra Prasad (1); Kim, Dong Gyu (1); Sahoo, Bichitra Nanda (1); Kang, Bong Kyun (3); Klipp, Andreas (4); Lim, Geon Ja (3); Kim, Tae Gon (2); Park, Jin Goo (1)

1: Department of Materials Science and Chemical Engineering, Hanyang University, Ansan, 15588, Republic of Korea; 2: Department of Smart Convergence Engineering, Hanyang University ERICA, Ansan 15588, Republic of Korea; 3: BASF Company Ltd., Suwon 16419, Republic of Korea; 4: BASF SE, Ludwigshafen, 67056, Germany

15:00 – 15:20

8.3 - Estimation of the Generation Rate of $h\cdot$ Radicals in a Megasonic Field Using an Electrochemical Technique

Han, Zhenxing (2); Raghavan, Srini (1); Beck, Mark (3)

1: University of Arizona, Materials Science and Engineering; 2: University of Arizona, Chemical and Environmental Engineering; 3: Product Systems, Inc.

SESSION 9 - BEOL: INTERCONNECTS AND PACKAGING

10:50 – 12:50

Chair: *Andreas Klipp* **BASF**
Co-Chair: *Gyuhyung Kim* **SK HYNIX**

- 10:30 – 10:50** **9.1 - Copper Catalysis Effect Investigation for TiW Etch Process on Patterned Wafers**
 Venegoni, Ivan; Votta, Annamaria; Bellandi, Enrico; Pipia, Francesco; Alessandri, Mauro
 STMicroelectronics, Italy
- 10:50 – 11:10** **9.2 - Selective nickel platinum removal without titanium nitride metal gate corrosion**
 Garnier Philippe, Audoin, Marine (1); Pizzetti, Christian (1); Loup, Virginie (2); Gabette, Laurence (2); Morote, Carlos (3); Dekraker, David (3); Schwab, Brent (3)
 1: Technic, France; 2: CEA - Leti, France; 3: TEL Manufacturing and Engineering of America, USA
- 11:10 – 11:30** **9.3 - Roughness and uniformity control during wet etching of molybdenum**
 Pacco, Antoine (1); Akanishi, Yuya (2); Le, QuocToan (1)
 1: imec, Belgium; 2: SCREEN, Semiconductor Solutions.
- 11:30 – 11:50** **9.4 - Effect of Surface Chemistry on Ruthenium Wet Etching**
 LE, Quoc Toan; KESTERS, Els; DOMS, Mathias; ALTAMIRANO SANCHEZ, Efrain
 imec, Belgium

11:50 – 12:10 **BREAK**

SESSION 10 - POST-CMP CLEANING

12:10 – 15:10

Chair: *Lieve Teugels* **imec**
Co-Chair: *Francesco Pipia* **STM**

- 12:10 – 12:30** **10.1 - Effect of Viscosity on Ceria Abrasive Removal in the Buffing CMP Process (student presentation)**
 Kim, Juhwan (1); Hong, Seokjun (1); Bae, Chulwoo (2); Wada, Yutaka (3); Hiyama, Hirokuni (3); Hamada, Satomi (3); Kim, Taesung (1,2)
 1: Department of Mechanical Engineering, Sungkyunkwan University, Korea, Republic of (South Korea);
 2: Department of SKKU Advanced Institute of Nano Technology, Sungkyunkwan University, Korea, Republic of (South Korea); 3: Ebara Corp (Japan)
- 12:30 – 12:50** **10.2 - Nodule Deformation of PVA Roller Brushes on a Rotating Plate: Optimum Cleaning for Nanosized Particles due to Liquid Absorption and Desorption of Sponge Deformation**
 Miyaki, Tsubasa (1); Mizushima, Yuki (1); Hamada, Satomi (2); Koshino, Ryota (2); Fukunaga, Akira (2); Sanada, Toshiyuki (1)
 1: Shizuoka University, Japan; 2: Ebara Corporation, Japan

- 12:50 – 13:10** **10.3 – Mechanism of PVA Brush Loading with Ceria Particles during Post-CMP Cleaning Process (student presentation)**
 Sahir, Samrina (1); Cho, Hwi-Won (1); Yerriboina, Nagendra Prasad (1); Kim, Tae-Gon (2); Wada, Yutaka (3); Hamada, Satomi (3); Hiyama, Hirokuni (3); Park, Jin-Goo (1) 1:
 1: Department of Materials Science and Chemical Engineering, Hanyang University, Ansan, 15588, Korea; 2: Department of Smart Convergence Engineering, Hanyang University, Ansan, Republic of Korea, 15588.; 3: EBARA Corporation, Fujisawa, Kanagawa, Japan
- 13:10 – 13:30** **10.4 - Effect of Dissolved Oxygen on Removal of Benzotriazole from Co during a Post-Co CMP Cleaning (student presentation)**
 Ryu, Heon-Yul (1); Sahoo, Bichitra Nanda (1); Yerriboina, Nagendra Prasad (1); Kim, Tae-Gon (1); Hamada, Satomi (2); Park, Jin-Goo (1)
 1: Hanyang University, Korea, Republic of (South Korea); 2: EBARA Corporation, Japan
- 13:30 – 14:30** **BREAK (PC MEETING)**
- 14:30 – 14:50** **10.5 - Tribological Characterization of Anionic Supramolecular Assemblies in Post-STI-CMP Cleaning Solution Using a Novel Post-CMP PVA Brush Scrubber**
 Philipossian, Ara (1); Sampurno, Yasa (1); Theng, Sian (1); Sudargho, Fransisca (1); Wortman-Otto, Katherine (2); Graverson, Carolyn (2); Keleher, Jason (2)
 1: Araca, Inc., USA; 2: Lewis University, USA
- 14:50 – 15:10** **10.6 - Contact vs. Non-Contact Cleaning: Correlating interfacial reaction mechanisms to processing methodologies for enhanced FEOL/BEOL post-CMP cleaning (invited speaker)**
 Katherine M. Wortman-Otto, Abigail N. Linhart, Allie M. Mikos, Kiana A. Cahue, and Jason J. Keleher
 Lewis University, Department of Chemistry, Romeoville IL

SESSION 11 - CLOSURE

- 15:20 – 16:00** **Concluding remarks & best student papers: awards**
 P. Mertens & K. Wostyn