Nanomanufacturing Materials and Processes

October - December 2018 4th Quarter 2018 Newsletter

Kwok Ng, NMP Director
Marie Tripp, Co-Director

DIRECTORS' MESSAGE

Dear Colleagues,

First, wish you all a Happy New Year coming with prosperity and good health! Lunar New Year was on Feb. 5th and this is Year of the Pig.

Please welcome Marie Krysak as the new TAB Chair for the Materials/ Processes side. Bob Leet had agreed to serve one more year as the ESH TAB Chair. Thank you both for "volunteering"!

TAB suggested at the last annual review to move the event to the fall in conjunction with TECHCON in Austin Texas. The NMP annual review this year will take place Wednesday Sept. 11 – Thursday Sept. 12 in the same hotel as TECHCON. Please mark it on your calendar. The change in timing from spring to fall is to review projects prior to their annual contract renewal. The TAB recommended combining with TECHCON to minimize travel for NMP TAB members. We hope to see you at both TECHCON and the Annual Review. This is the first of such attempt (review after TECHCON). If it turns out to be successful, it might set up as a model as well for other thrusts to follow.

The 2019 e-workshops are now defined; 10 in materials/processes, and 3 in ESH. The ones coming up soon are listed below in "Events".

Note that the solicitation had resulted in eight new tasks in materials/processes, and three in ESH. In addition, there is one custom task started in ESH. All tasks have fully executed contracts, and have a start date of 1/1/2019. Please sign up as liaisons on tasks of your interest, and encourage your colleagues to do the same. It is especially beneficial to get involved right at the beginning of the research. I am sure the students and professors greatly appreciate the guidance and interaction.

We had two solicitations in successive years, 1/1/2018 and 1/1/2019. Based on the planning of two solicitations every three years, there will be a longer period until the next solicitation for projects starting 1/1/2021. Thanks for the efforts you had put in the last two years.

2019 TECHCON submission has just been opened. If you have close interaction with some students, please encourage them to submit abstracts. The call will be closed on April 3rd.

Thanks for your help,

Kwok and Marie

Currently this Nanomanufacturing Materials and Processes Quarterly Newsletter is being sent to TAB members plus all liaisons, i.e., people already involved in SRC activities. If you would like to suggest names added to the mailing list to generate new interest, please let us know. For archived newsletters, please refer to the following link: https://www.src.org/program/grc/newsletter/nmp/

NEW NMP TASKS

These 8 new tasks were started on January 1, 2019 in the NMP thrust.

Task	Title	PI/University
2869.001	Thermal Engineering, Optimization and Understanding the Physics of Electron and Phonon Conduction at Solid Interfaces	Ken Goodson / Stanford
2870.001	EUV Resist Stochastics Beyond 3 Sigma	George Dendeaux / SUNY Poly
2871.001	Area-Selective Deposition of Organic Films Using Molecular Layer Deposition and Molecular Layer Etching	Steven George / Univ. of Colorado/Boulder
2872.001	Advanced Electron Microscopy of Physical, Electronic, and Thermal Effects in Cu, Co, and GST	Brian Regan / UCLA
2873.001	Area-Selective Oxidative-Molecular Layer Deposition of Polymers	Greg Parsons / NC State Univ.
2874.001	Study of Nanowires (Non-magnetic and Magnetic) in via Technology for Interconnects at mm-wave to Sub-millimeter Wave Frequencies	Rhonda Franklin (Univ. of Minnesota)
2875.001	Deposition-Based Control of Ferroelectric Hafnia for Phase Purity and Enhanced Performance	Jon Ihlefeld (Univ. of Virginia)
2881.001	Narrow High-conductivity Interconnects	Daniel Gall / RPI

NEW ESH TASKS

These 4 new tasks were started on January 1, 2019 in the ESH thrust.

Task	Title	PI/University
2818.005	Electron Reduction Technologies to Remove H2O2 or Perfluorinated Compounds from Fab Wastewaters	Paul Westerhoff (Arizona State)
2818.006	Characterization and Control of Energetic Reactions in the Downstream Sections of Deposition Tools	Jane Chang (UCLA)
2818.007	Characterization of Airborne Nanoparticulate Matter in Semiconductor Manufacturing Environments	Pierre Herckes (Arizona State)
2818.008	Novel Electrical Discharge Plasma-based Process for the Treatment of Fab Wastewater	Selma Mededovic (Clarkson Univ.)

RESEARCH REPORT HIGHLIGHTS -

Report ID	Task	Thrust	Task Title	Leader/ Univ	Headline
P095581	2658.001	NMP	Integration of Cu/Graphene Hybrid Interconnects with Damascene Process	Zhihong Chen (Purdue)	Researchers integrated graphene grown at 400 °C with patterned Cu wires, and the preliminary results show that the EM median time to

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					fail of Cu/graphene hybrid is 5X longer compared to the devices without graphene.
P095582	2658.001	NMP	Integration of Cu/Graphene Hybrid Interconnects with Damascene Process	Zhihong Chen (Purdue)	Final report on task that researchers implemented graphene growth down to 1 nm in trench structures at low temperature and performed electrical measurement for Cu/graphene hybrid in trench.
P095568	2726.001	NMP	Decoupled Process Sequences/Surface Chemistries Enabling Atomic Layer Etching of Critical Materials	Gottlieb Oehrlein (UM/College Park)	Researchers demonstrate that complex hydrofluorocarbon (HFC) precursors offer significant advantages for ALE of SiO2 with selectivity to SiGe and the etching of HfO2 selective to Si.
P095577	2794.001	NMP	Determining the Sensitivity of Metrology to Changes in Multi-Nanowire and Multi-Nanosheet FETs	Alain Diebold (SUNY POLY)	MMSE-scatterometry simulations were completed for multilayer Si/SiGe/Si/SiGe/Si/SiGe/Si sub-7nm node fins and the nanowire test structure. Sensitivity to fin CD, nanosheet thickness, and other key parameters are presented.
P095583	2795.001	NMP	Area-selective ALD of Nitrides using Inhibitors and Plasma Processes in ABC-type Cycles	Adriaan J. Mackus (Eindhoven Univ. of Tech.)	It was found that aniline can induce a nucleation delay on Ru and Co surfaces while deposition occurs normally on SiO2 and Al2O3 surfaces. 3.6 nm of TiN ALD was achieved on Al2O3 substrates while no deposition was detected on Ru substrates.

Report ID	Task	Thrust	Task Title	Leader/ Univ	Headline
P095561	2802.001	NMP	Effective Patterning of Ni for EUV Masks	Adriaan J. Mackus (Eindhoven Univ. of Tech.)	Project focused on reactive ion etch (RIE) of patterned Ni samples using Cl2/H2 plasma. Different cycles of etching were performed to examine the feature profiles.
P095590	2818.003	ESH	Mechanisms of Nitrification Inhibition by Azoles: A Framework to Promote Azole Detoxification, Biodegradation and Green Chemistry	Reyes Sierra Alvarez (Univ. of Arizona)	Report summarizes findings on: (1) Inhibitory impact of individual azole compounds on N and aerobic heterotrophic microorganisms in activated sludge. (2) Inhibitory impact of azole mixtures. (3) Attenuation of azole toxicity by particulate Cu and Fe.
P095587	2818.004	ESH	Environmental, Safety & Health Properties of “Onium” Photoacid Generators and their Photodegradation Products	Jim Field (Univ. of Arizona)	Report summarizes progress on analysis of onium molecules in the five selected model PAGs; their photodegradation kinetics and products; as well as a preliminary experiment evaluation of solid phase extraction to detect low concentrations of onium ions.

PRE-PUBLICATION PAPERS

Report ID	Task	Thrust	Task Title	Leader/ Univ	Publication Title
P095528	2818.003	ESH	Mechanisms of Nitrification Inhibition by Azoles: A Framework to Promote Azole Detoxification, Biodegradation and Green Chemistry	Reyes Sierra Alvarez (Univ. of Arizona)	Diazole and Triazole Inhibition of the Nitrification Process in Return Activated Sludge

UPCOMING EVENTS - NMP

Date	Event Summary
February 20, 2019	Area-selective ALD of Nitrides using Inhibitors and Plasma Processes in ABC-type Cycles Wednesday, Feb. 20, 2019, 1 p.m.–2 p.m. ET & 8 p.m. – 9 p.m. **via WebEx** Professor Adriaan Mackus from Eindhoven University of Technology, will speak on his research task 2795.001 in the NMP thrust.
February 27, 2019	New Precursors and Processes for the Atomic Layer Deposition of Metal and Metal Nitride Films Wednesday, Feb. 27, 2019, 1 p.m.–2 p.m. ET & 8 p.m. – 9 p.m. **via WebEx** Professor Charles Winter from Wayne State University, will speak on his research task 2800.001 in the NMP thrust.
March 20, 2019	Fabrication and Testing of Quasi-1D van der Waals Metal Interconnects Wednesday, March 20, 2019, 1 p.m.–2 p.m. ET & 8 p.m. – 9 p.m. **via WebEx** Professor Alexander Balandin from UC Riverside, will speak on his research task 2796.001 in the NMP thrust.
April 17, 2019	Crystalline Electronic and Photonic Materials without an Epitaxial Template Wednesday, April 17, 2019, 1 p.m.–2 p.m. ET & 8 p.m. – 9 p.m. **via WebEx** Professor Rehan Kapadia from the University of Southern California, will speak on his research task 2799.001 in the NMP thrust.
May 1, 2019	Sub-5 nm Patterning via Template-directed Assembly of Colloidal Nanocrystals (NCs) Wednesday, May 1, 2019, 1 p.m.–2 p.m. ET & 8 p.m. – 9 p.m. **via WebEx** Professor Cherie Kagan from the University of Pennsylvania, will speak on her research task 2797.001 in the NMP thrust.

May 22, 2019	Selective Spin-on Deposition of Polymers Wednesday, May 22, 2019, 1 p.m.–2 p.m. ET & 8 p.m. – 9 p.m. **via WebEx** Professor Christopher Bates from UCSB, will speak on his research task 2732.001 in the NMP thrust.
July 10, 2019	Effective Patterning of Ni for EUV Masks Wednesday, July 10, 2019, 1 p.m.–2 p.m. ET & 8 p.m. – 9 p.m. **via WebEx** Professor Jane Chang from the UCLA, will speak on her research task 2802.001 in the NMP thrust.
September 11 & 12, 2019	NMP Annual Review Wednesday, Sept. 11, 2019, — Thursday, Sept. 12, 2019, Renaissance Austin Hotel Trinity Room, Austin, TX Review research results for the Nanomanufacturing Materials and Processes (NMP) thrust.
November 20, 2019	Decoupled Process Sequences/Surface Chemistries Enabling Atomic Layer Etching of Critical Materials Wednesday, Nov. 20, 2019, 1 p.m.–2 p.m. ET & 8 p.m. – 9 p.m. **via WebEx** Professor Gottlieb Oehrlein from the University of Maryland, will speak on his research task 2726.001 in the NMP thrust.
December 4, 2019	Effective Patterning of Ni for EUV Masks Wednesday, Dec. 4, 2019, 1 p.m.–2 p.m. ET & 8 p.m. – 9 p.m. **via WebEx** Professor Greg Parsons from the NC State University, will speak on his research task 2729.001 in the NMP thrust.
December 18, 2019	Selective Deposition with Directed Self-assembly Wednesday, Dec. 18, 2019, 1 p.m.–2 p.m. ET & 8 p.m. – 9 p.m. **via WebEx** Professor Caroline Ross from MIT, will speak on her research task 2798.001 in the NMP thrust.

UPCOMING EVENTS – ESH

Date	Event Summary
June 5, 2019	Mechanisms of Nitrification Inhibition by Azoles: A Framework to Promote Azole Detoxification, Biodegradation and Green Chemistry Wednesday, June 5, 2019, 1 p.m.–2 p.m. ET **via WebEx** Professor Sierra Alvarez from the University of Arizona, will speak on his research task 2818.003 in the ESH thrust.
June 26, 2019	Comprehensive Characterization of Per- and Polyfluorinated Substances (PFASs) in Fab Wastewater and Their Fate and Transformation during Activated Sludge Treatment Wednesday, June 26, 2019, 1 p.m.–2 p.m. ET **via WebEx** Professor Helbling from Cornell University, will speak on his research task 2818.002 in the ESH thrust.
August 28, 2019	Environmental, Safety & Health Properties of "Onium" Photoacid Generators and their Photodegradation Products Wednesday, August 28, 2019, 1 p.m.–2 p.m. ET **via WebEx** Professor Field from the University of Arizona, will speak on his research task 2818.004 in the ESH thrust.

Note: A mid-year Review for ESH is tentatively planned for April 2019 and the Annual Review will be held in October. The location and dates are being finalized and the details will be communicated soon.