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NMP Patterning/Front-End Processes Review eBook

May 2 & 3, 2018

NC State University

Golden LEAF Biomanufacturing Training and Education Center

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NMP Patterning/Front-End Processes Review
TAB Task Evaluation Guidelines (I/S ratings)

The evaluation of contract tasks is an extremely important function of the TAB members. The task ratings that result from the evaluation process, along with illuminating written comments, can significantly affect the decisions whether to continue a program. In addition, the ratings are used to calculate key performance metrics, for both the Researchers and the SRC, which are watched closely by the BOD, SRC OCE and staff, and the ETAB.

Please remember:

- Scores (at least) and Comments (encouraged) must be collected for record. Please provide comments for low scores ≤6. (We go over scores & comments (concerns) internally at yearly renewal.)
- Return evaluation sheets to Kwok Ng or Jacquil Toon at the end of each day

Nanomanufacturing Materials & Processes (NMP) Review Wednesday, May 2, 2018		
Time	**Title**	**Presenter**
7:30 - 8:30 am	Breakfast/Registration/Poster Set-up	
8:30 - 8:45 am	Welcome / Introduction	Kwok Ng / SRC Marie Tripp / Intel Gregory Parsons / NC State
8:45 - 9:15 am	Task 2673.001:Self-aligned DSA of Multi-color Manufacturing-relevant Patterns	Paul Nealey / Univ. of Chicago
9:15 - 9:45 am	Task 2732.001: Selective Spin-on Deposition of Polymers	Christopher Bates / UC Santa Barbara
9:45 - 10:15 am	Task 2660.001: Defect Removal Process for Area Selective ALD	Stacey Bent / Stanford
10:15 - 10:30 am	Break	
10:30 - 11:00 am	Task 2729.001: Orthogonal Dielectric/Metal Selective Area Atomic Layer Deposition	Gregory Parsons / NC State
11:00 - 11:30 am	Task 2659.001: Thermal Atomic Layer Etching of Metal Gates	Steven George / Univ. of Colorado/Boulder
11:30 - 12:00 pm	Task 2726.001: Decoupled Process Sequences/Surface Chemistries Enabling Atomic Layer Etching of Critical Materials	Gottlieb Oehrlein & Kang-Yi*/ Univ. of Maryland
12:00 - 12:15 pm	Poster ads	
12:15 - 1:30 pm	Lunch/Posters	
1:30 - 2:00 pm	Task 2658.001: Integration of Cu/Graphene Hybrid Interconnects with Damascene Process	Zhihong Chen / Purdue University
2:00 - 2:20 pm	Task 2800.001: New Precursors and Processes for the Atomic Layer Deposition of Metal and Metal Nitride Films	Charles Winter / Wayne State University
2:20 - 2:40 pm	Task 2799.001: Crystalline Electronic and Photonic Materials without an Epitaxial Template	Rehan Kapadia / Univ. of Southern California
2:40 - 3:10 pm	Break/Intro to Caucus	
3:10 - 5:25 pm	TAB Caucus (Closed Meeting -Industry Only) Posters	
5:25 - 6:25 pm	PI Feedback / Posters	

*Student

Nanomanufacturing Materials & Processes (NMP) Review Thursday, May 3, 2018		
Time	**Title**	**Presenter**
8:30 - 8:45 am	Welcome / Introduction	Kwok Ng / SRC
8:45 - 9:05 am	Task 2798.001: Selective Deposition with Directed Self-assembly	Caroline Ross / MIT
9:05 - 9:25 am	Task 2797.001: Sub-5nm Patterning Via Template-directed Assembly of Colloidal	Cherie Kagan / Univ. of Pennsylvania
9:25 - 9:45 am	Task 2795.001: Area-selective ALD of Nitrides using Inhibitors and Plasma Processes in ABC-type Cycles	Adriaan Mackus / Endhoven University of Technology
9:45 - 10:05 am	Task 2794.001: Determining the Sensitivity of Metrology to Changes in Multi-Nanowire and Multi-Nanosheet FETs	Alain Diebold / SUNY Poly Tech
10:05 - 10:20 am	Break	
10:20 - 10:40 am	Task 2801.001: Nanospectroscopic Imaging to Probe Stochastic Variations in Extreme Ultraviolet Photoresists	Eric Mattson / UT Dallas
10:40- 11:00 am	Task 2802.001: Effective Patterning of Ni and pd for EUV Masks	Jane Chang / UCLA
11:00 - 11:20 am	Task 2796.001: Fabrication and Testing of Quasi-1D van der Waals Metal Interconnects	Alexander Balandin / UC Riverside
11:20 - 12:20 pm	Break/Lunch	
12:20 - 1:35 pm	Tab Caucus (Closed Meeting - Industry Only)	

*Student

Contract Site Review Summary

Contract ID: 2016NM2658
Principal Investigator: Dr. Zhihong Chen (Purdue)
Task: 2658.001 Integration of Cu/Graphene Hybrid Interconnects with Damascene Process
Task Leader: Dr. Zhihong Chen (Purdue)
Co-TL:
Review Date: 6/27/2017
Mean Rating: 9.0, 8.2
General Comments: Strengths:
Good student presentation.

Thank you for addressing last year's feedback, please continue to do so.

Excellent results for low-temp graphene growth. Back-end compatible graphene growth is an important milestone for realizing potential industry use.
Consider submitting an invention disclosure if not done already.

Lots of industry interest in this work, keep up the excellent progress.

Questions/Comments:
Demonstrate graphene barrier property and TDDB test on ULK materials (K2.7 or 2.45).
Measure low-k damage resulting from graphene growth process.

Quantify bonding/adhesion strength between ULK, graphene and Cu.

Additional study on conductivity with respect to the diffusion barrier could add value.

Seek outside sources for higher quality Ta/TaN films to benchmark graphene performance.

Better characterize the diffusion through the Co vs thickness and understand the limits of this technique for patterned structures. Help industry understand the maximum aspect ratio trench for which this technique will work.

Develop ways to deposit Co on patterned trench structures.

Explore even lower temperature deposition, please help industry understand the limit.

Co is a key factor to lower the temperature. Reach out to industry partners to obtain more capability to deposit with additional techniques.

Importance and Satisfaction Chart

High Importance, Low Satisfaction	*High Importance, High Satisfaction*
	IBM Corporation (10, 9) Intel Corporation (9, 8) Tokyo Electron Limited (TEL) (9, 8) TSMC (9, 8) GLOBALFOUNDRIES (9, 7) Mentor, A Siemens Business (8, 9)
Low Importance, Low Satisfaction	*Low Importance, High Satisfaction*

Contract Site Review Summary

Company (I,S)	Upper Range (lowest I or S rating is 9 or greater)
IBM Corporation (10, 9)	STRENGTHS: Great student presentation. Excellent results shown this year. QUESTIONS/COMMENTS: Please consider process scheme where Co is the metal for the interconnect line, not Cu.
Company (I,S)	**Middle Range (lowest I or S rating is between 6 and 8)**
Intel Corporation (9, 8)	No Comments
Tokyo Electron Limited (TEL) (9, 8)	No Comments
TSMC (9, 8)	No Comments
GLOBALFOUNDRIES (9, 7)	QUESTIONS/COMMENTS: Start graphene barrier property and TDDB test on ULK materials (K2.7 or 2.45) - so far they have been using SiO2. Unfortunately, no low-k samples are available yet. Another input is to demonstrate bonding strength between ULK, graphene and Cu.
Mentor, A Siemens Business (8, 9)	STRENGTHS: At 15nm Cu interconnect, the 1nm graphene barrier provides at 55% reduction in resistance over a 3nm Ta barrier. BEOL compatible (<400C) PECVD graphene growth in damascene. Evaluate diffusion barrier properties of PECVD graphene, and electrical and thermal properties of Cu/graphene hybrid interconnects. Only nanocrystallina graphene can be formed at 400C Co Assisted growth at low temperature (because Co dissolves carbon well). Graphene grows on top and bottom surfaces. By etching cobalt top and bottom layers remain. 2nm thickness of graphene (with full coverage and growing at 400C and 10min). Used TDDB (Time dependent Dielectric breakdown) to test diffusion barrier effectiveness. 41s w/o graphene, and 137s with graphene. QUESTIONS/COMMENTS: Need to demonstrate 400C graphene growth in dielectric trenches using Co as sacrificial layer, especially in high aspect ratio trenches at feature sizes of interest (16nm). PECVD Graphene is much better than Cu-exfoliated graphene, need to prove with methods other than top-down SEM.

Integration of Cu/Graphene Hybrid Interconnects with Damascene Process

Task ID:	2658.001
Task Leader(s):	Chen, Zhihong (Purdue)
Goal(s):	The expected research output is a development of novel damascene Cu/graphene hybrid interconnects with enhanced electrical and thermal performance. Our proposal will address the temperature and process compatibility with BEOL, and gain critical knowledge about the graphene properties as an ultra-thin barrier to prevent Cu diffusion.
Cur. Task Funding:	GRC Core - $95,000
Cur. Funding Period:	1/1/2018 - 12/31/2018 (Year 3)
Contract Term:	1/1/2016 - 12/31/2018
Final Year:	Yes
Deliverables:	Total - 9; Received - 6; Overdue - 2; Pending - 3
Student Reports:	Total - 5; Received - 4; Overdue - 3; Pending - 1; Non-Compliant - 1
Avg I/S Rating:	9.0 / 8.2
Feedback:	

Strengths:
Good student presentation.

Thank you for addressing last year's feedback, please continue to do so.

Excellent results for low-temp graphene growth. Back-end compatible graphene growth is an important milestone for realizing potential industry use.
Consider submitting an invention disclosure if not done already.

Lots of industry interest in this work, keep up the excellent progress.

Questions/Comments:
Demonstrate graphene barrier property and TDDB test on ULK materials (K2.7 or 2.45). Measure low-k damage resulting from graphene growth process.

Quantify bonding/adhesion strength between ULK, graphene and Cu.

Additional study on conductivity with respect to the diffusion barrier could add value.

Seek outside sources for higher quality Ta/TaN films to benchmark graphene performance.

Better characterize the diffusion through the Co vs thickness and understand the limits of this technique for patterned structures. Help industry understand the maximum aspect ratio trench for which this technique will work.

Develop ways to deposit Co on patterned trench structures.

Explore even lower temperature deposition, please help industry understand the limit.

Co is a key factor to lower the temperature. Reach out to industry partners to obtain more capability to deposit with additional techniques.

Student(s): Lo, Chun-Li (Purdue)
Zhang, Shengjiao (Purdue)

Liaison(s):

Caudillo, Roman (Intel)
Chen, HaiChing (TSMC)
Grill, Alfred (IBM)
Jain, Nikhil (IBM)
Lee, Ming-Han John (TSMC)
Lee, Rinus (GLOBALFOUNDRIES)
Lin, Kevin L. (Intel)
Lin, Xuan (GLOBALFOUNDRIES)
Lin, Yu-Ming (TSMC)
Ogden, Sean P. (GLOBALFOUNDRIES)
Smith, Ryan S. (GLOBALFOUNDRIES)
Torres, Jessica (Intel)
Zhao, Jianping (TEL)

SRC Report Notes:

(1) 7.07 Task Review Summary for PDF run on 3/30/2018 by SRC_IT\altman.

(2) Report Parameters: Event = E00; Research = 2658; Task = All; Funding Type = All.

(3) Task data as of 3/30/2018.

Contract Site Review Summary

Contract ID: 2016NM2659
Principal Investigator: Professor Steven George (U. of Colorado/Boulder)
Task: 2659.001 Thermal Atomic Layer Etching of Metal Gates
Task Leader: Professor Steven George (U. of Colorado/Boulder)
Co-TL:
Review Date: 6/27/2017
Mean Rating: 8.8, 8.3
General Comments: Strengths:
The team recovered from early setbacks and seems to be onto something with the conversion/fluorination approach that may turn out to be feasible. The project approach is providing new insight and areas of further research.

Metal etch is certainly of growing interest to industry. This project is working on a relevant suite of materials.

Excellent student presentation.

Questions/Comments:
Need to translate these results onto patterned structures with multiple materials present, at relevant feature sizes.

Understand etch selectivity. Start with SiN and SiO.

Clearly define the operation conditions for the oxidation to be self-limiting.

Ti/TiN are additional materials of interest.

Importance and Satisfaction Chart

High Importance, Low Satisfaction	*High Importance, High Satisfaction*
	IBM Corporation (9, 9) Intel Corporation (9, 9) Tokyo Electron Limited (TEL) (9, 9) Mentor, A Siemens Business (9, 8) TSMC (9, 8) GLOBALFOUNDRIES (8, 7)
Low Importance, Low Satisfaction	*Low Importance, High Satisfaction*

Contract Site Review Summary

Company (I,S)	Upper Range (lowest I or S rating is 9 or greater)
IBM Corporation (9, 9)	STRENGTHS: Very good understanding developed of the challenges of the process. Very nice student presentation. Glad to see important patent/publication. QUESTIONS/COMMENTS: The removal of WO3 (and other similar metal oxides) in a self-limited way could be very interesting as surface cleanup after RIE. Ta and Ti are good targets for the future.
Intel Corporation (9, 9)	No Comments
Tokyo Electron Limited (TEL) (9, 9)	No Comments
Company (I,S)	**Middle Range (lowest I or S rating is between 6 and 8)**
Mentor, A Siemens Business (9, 8)	STRENGTHS: Goal is to perform the reverse of ALD. The challenge is to come up with chemistries when the secondary reaction etches and does not deposit. Oxidation, conversion and fluorination reactions developed to bypass the problems of the initial approach. The idea of “conversion” is to convert the top of the metal oxide to boron oxide, and then remove the boron oxide. With HF which is a self-limiting reaction. Ta, TaN, and other metals under investigation. QUESTIONS/COMMENTS: Many metals have volatile fluorides and many fluorides which were too thick.
TSMC (9, 8)	No Comments
GLOBALFOUNDRIES (8, 7)	STRENGTHS: Disappointing results in the first round of experiments, but the team recovered and seems to be onto something with the conversion/flourination approach that may turn out to be feasible. Metal etch is certainly of growing interest to us -- whether ALE-based approaches are ultimately the way to go remains to be seen. QUESTIONS/COMMENTS: Do these results translate to patterned structures at ~40nm pitch?

Thermal Atomic Layer Etching of Metal Gates

Task ID:	2659.001
Task Leader(s):	George, Steven (U. of Colorado/Boulder)
Goal(s):	Methods for thermal atomic layer etching (ALE) of metals will provide a new processing capability for the manufacturing of semiconductor devices. In particular, the thermal ALE of metal gates will find an important application in the fabrication of PMOS and NMOS gate stacks for FinFETs.
Cur. Task Funding:	GRC Core - $88,682
Cur. Funding Period:	1/1/2018 - 12/31/2018 (Year 3)
Contract Term:	1/1/2016 - 12/31/2018
Final Year:	Yes
Deliverables:	Total - 8; Received - 4; Overdue - 4; Pending - 3
Student Reports:	Total - 5; Received - 4; Overdue - 2; Pending - 1; Non-Compliant - 1
Avg I/S Rating:	8.8 / 8.3
Feedback:	Strengths: The team recovered from early setbacks and seems to be onto something with the conversion/fluorination approach that may turn out to be feasible. The project approach is providing new insight and areas of further research. Metal etch is certainly of growing interest to industry. This project is working on a relevant suite of materials. Excellent student presentation. Questions/Comments: Need to translate these results onto patterned structures with multiple materials present, at relevant feature sizes. Understand etch selectivity. Start with SiN and SiO. Clearly define the operation conditions for the oxidation to be self-limiting. Ti/TiN are additional materials of interest.

Student(s):	Johnson, Nicholas R. (U. of Colorado/Boulder)
Liaison(s):	Chen, HaiChing (TSMC) Clark, Robert D. (TEL) Engelmann, Sebastian (IBM) Joseph, Eric A. (IBM) Liebmann, Lars (GLOBALFOUNDRIES) Reid, Kimberly G. (Arm) Tapily, Kanda (TEL) Torres, Juan (Mentor (Siemens))

SRC Report Notes:

(1) 7.07 Task Review Summary for PDF run on 3/30/2018 by SRC_IT\altman.

(2) Report Parameters: Event = E00; Research = 2659; Task = All; Funding Type = All.

(3) Task data as of 3/30/2018.

Contract Site Review Summary

Contract ID: 2016NM2660
Principal Investigator: Dr. Stacey F. Bent (Stanford)
Task: 2660.001 Defect Removal Process for Area Selective ALD
Task Leader: Dr. Stacey F. Bent (Stanford)
Co-TL:
Review Date: 6/27/2017
Mean Rating: 8.8, 7.2
General Comments: Strengths:
We appreciate the group's efforts to explore multiple options to achieve selective area deposition.

We appreciate the focus on gas phase approaches that are more industry friendly.

Excellent student presentations.

Good interaction with industry liaisons.

Questions/Comments:
The current ethanol etchant didn't remove the material in the metal surface completely. Any plan to improve?

All the current results are in micron size area. Can you come up with a plan to work on more relevant feature sizes (<100nm)?

Half-way through the project and no work has been presented on non-SAM approaches. Make sure to address this part of the deliverables. Make sure to address all aspects of the project on an annual basis.

Importance and Satisfaction Chart

High Importance, Low Satisfaction	*High Importance, High Satisfaction*
	Intel Corporation (9, 9) IBM Corporation (9, 7) Mentor, A Siemens Business (9, 7) Tokyo Electron Limited (TEL) (9, 7) GLOBALFOUNDRIES (9, 6) TSMC (8, 7)
Low Importance, Low Satisfaction	***Low Importance, High Satisfaction***

Contract Site Review Summary

Company (I,S)	Upper Range (lowest I or S rating is 9 or greater)
Intel Corporation (9, 9)	No Comments
Company (I,S)	**Middle Range (lowest I or S rating is between 6 and 8)**
IBM Corporation (9, 7)	STRENGTHS: Very good student presentations. An impressive amount of work completed since last review. Good interaction with industrial liaisons. QUESTIONS/COMMENTS: There still seems to be a large gap between relevancy of these results and methods to current semiconductor processes. Many processes are 48hrs. What do the kinetics look like? Using time-to-achieve-WCA curves may be a better metric than absolute WCA to judge between processes. Significant amount of oxygen removed, enhanced Cu signal. What is the stoichiometry of oxide formed during this etch? Different than native? What is uncertainty in % P detection increasing from 200 Cycles to 300 cycles? What is the quality of the Al2O3 after your deposition process? Does it withstand standard etch processes? Do you observe any residual C from unreacted precursor? Slide 15. Ability of alcohol to act as an etchant dependant on the PKA of your alcohol? Trifluoroethanol or phenol? Shorter chain better etching, PKa? Not looked at?
Mentor, A Siemens Business (9, 7)	STRENGTHS: Extended AS-ALD to Co, W and dielectric. Tested ethanol as selective CuOx etchant OTMS SAM deposition on SiO2 to prevent corrosive HCl, but the methoxy group is less reactive than chloride group. However further improvement needed to provide adequate ALD protection (blocking). Focusing in other materials to improve process integration. There are currently challenges, but new approaches are being explored. For SAM-free methods, needs to investigate differences on various substrates. QUESTIONS/COMMENTS: Smallest feature size they have studied is 500nm, only recently they got samples to look at smaller features sizes.
Tokyo Electron Limited (TEL) (9, 7)	No Comments
GLOBALFOUNDRIES (9, 6)	QUESTIONS/COMMENTS: First, the current ethanol etchant didn't remove the material in the metal surface completely. Any plan to improve? Second, all the current results are in micron size area, any data in smaller area,like ~50 nm feature size area?
TSMC (8, 7)	No Comments

Contract Site Review Summary

Contract ID: 2016NM2673
Principal Investigator: Dr. Paul Nealey (Univ. of Chicago)
Task: 2673.001 Self-aligned DSA of Multi-color Manufacturing-relevant Patterns
Task Leader: Dr. Paul Nealey (Univ. of Chicago)
Co-TL: Professor Juan de Pablo (Univ. of Chicago)
Review Date: 6/27/2017
Mean Rating: 8.3, 8.0
General Comments: Strengths:
TEM Tomography to support modeling work is very powerful. It is illustrative in showing what is happening in the process.

Defectivity rates of self-aligned via-shrink DSA put in question adoption any time in the near future. This work is substantially expanding our understanding of DSA and how to manage defectivity rates. It could lead to a major breakthrough with potentially useful applications.

Excellent student presentations.

Excellent combination of experiment and theory.

Questions/Comments:
Need to provide progress updates on all parts of the program. Progress on tri-block copolymers (ABC blocks) was missing from this year's review. In the future, make sure to address all parts of the proposal annually.

Come up with a way to translate free energy calculations into defectivity/area numbers. We feel there is more here to learn.

Further study on brush grafting has potential to broaden the impact and scope of this work beyond DSA.

Importance and Satisfaction Chart

High Importance, Low Satisfaction	***High Importance, High Satisfaction***
	Tokyo Electron Limited (TEL) (9, 8) Intel Corporation (9, 7) IBM Corporation (8, 9) GLOBALFOUNDRIES (8, 8) Mentor, A Siemens Business (8, 8) TSMC (8, 8)
Low Importance, Low Satisfaction	***Low Importance, High Satisfaction***

Contract Site Review Summary

Company (I,S)	Middle Range (lowest I or S rating is between 6 and 8)
Tokyo Electron Limited (TEL) (9, 8)	No Comments
Intel Corporation (9, 7)	No Comments
IBM Corporation (8, 9)	STRENGTHS: Good job adjusting the scope of the project to match the needs of industry. Excellent student presentation. Nice use of tomography. The pattern placement work is important. Nice agreement between simulation and wafer data. QUESTIONS/COMMENTS: Please keep in mind that with self-aligned and fully-aligned via techniques, patterning placement and CD control of vias is becoming less important. Pillars may be more important in the future. More study on the grafting of the PS brush to make it more “preferential” would be very useful for this and other applications.
GLOBALFOUNDRIES (8, 8)	STRENGTHS: TEM Tomography to support modeling work is very powerful. New findings put commercialization of self-aligned via-shrink DSA in question any time in the near future but this work is substantially expanding our understanding of DSA and could lead to a major breakthrough with potentially useful applications
Mentor, A Siemens Business (8, 8)	STRENGTHS: Different approach to control the wetting approach to align to the underlying pattern, to compensate for misalignment. Good presentation skills of the student. 3D TEM Tomography used to understand formation within the guiding pattern. Sidewall strong PS preferentiality is critical (from the point of view of the free energy analysis of the bottom vs the walls), especially from the kinetic point of view (to have the ability to annihilate meta-stable states. QUESTIONS/COMMENTS: The cylinder is not perpendicular, can still be used for etch? TEM still needs membranes. If the walls need to be, and are designed, to be strongly PS preferential, how will this affect the ability for the cylinder to align the bottom.
TSMC (8, 8)	No Comments

Self-aligned DSA of Multi-color Manufacturing-relevant Patterns

Task ID:	2673.001
Task Leader(s):	Nealey, Paul (Univ. of Chicago) de Pablo, Juan (Univ. of Chicago)
Goal(s):	Integration of selective deposition of materials to fabricate chemical patterns for DSA, and DSA of multi-block polymers to enable self-aligned patterning for contact holes and self-aligned cut masks, and the ability to address or protect every other line in grating arrays.
Cur. Task Funding:	GRC Core - $100,000
Cur. Funding Period:	1/1/2018 - 12/31/2018 (Year 3)
Contract Term:	1/1/2016 - 12/31/2018
Final Year:	Yes
Deliverables:	Total - 5; Received - 4; Overdue - 4; Pending - 1
Student Reports:	Total - 4; Received - 3; Overdue - 2; Pending - 1; Non-Compliant - 1
Avg I/S Rating:	8.3 / 8.0
Feedback:	

Strengths:
TEM Tomography to support modeling work is very powerful. It is illustrative in showing what is happening in the process.

Defectivity rates of self-aligned via-shrink DSA put in question adoption any time in the near future. This work is substantially expanding our understanding of DSA and how to manage defectivity rates. It could lead to a major breakthrough with potentially useful applications.

Excellent student presentations.

Excellent combination of experiment and theory.

Questions/Comments:
Need to provide progress updates on all parts of the program. Progress on tri-block copolymers (ABC blocks) was missing from this year's review. In the future, make sure to address all parts of the proposal annually.

Come up with a way to translate free energy calculations into defectivity/area numbers. We feel there is more here to learn.

Further study on brush grafting has potential to broaden the impact and scope of this work beyond DSA.

Student(s):

Bezik, Cody (Univ. of Chicago)
Bowen, Alec S. (Univ. of Chicago)
Dolejsi, Moshe (Univ. of Chicago)
Li, Jiajing (Univ. of Chicago)
Zhou, Chun (Univ. of Chicago)

Liaison(s):

Cheng, Joy (TSMC)
Han, Eungnak (Intel)
Hosler, Erik (GLOBALFOUNDRIES)
Liebmann, Lars (GLOBALFOUNDRIES)
Liu, Chi-Chun (IBM)
Singh, Gurpreet (Intel)
Theofanis, Patrick L. (Intel)
Torres, Juan (Mentor (Siemens))

SRC Report Notes:

(1) 7.07 Task Review Summary for PDF run on 3/30/2018 by SRC_IT\altman.

(2) Report Parameters: Event = E00; Research = 2673; Task = All; Funding Type = All.

(3) Task data as of 3/30/2018.

Contract Site Review Summary

Contract ID: 2017NM2726
Principal Investigator: Dr. Gottlieb Oehrlein (UM/College Park)
Task: 2726.001 Decoupled Process Sequences/Surface Chemistries Enabling Atomic Layer Etching of Critical Materials
Task Leader: Dr. Gottlieb Oehrlein (UM/College Park)
Co-TL:
Review Date: 6/27/2017
Mean Rating: 8.2, 7.3
General Comments: Strengths:
Project targets important industry challenges. Plasma based approach is industry friendly.

Good focus on the fundamental etch processes.

Excellent student presentation, good job stepping in due to technical difficulties.

Questions/Comments:
Effects of H2 addition is well-known for plasma etching. Keep focus on fundamental understanding.

Will be interesting to explore the impact of H2 on SiN etching. It will be very interesting to see any differences in the role of hydrogen from H2/C4F8 and CHxFy plasma on ALE of Si, SiO2 and SiN.

CF gases are unlikely to work well for future work materials. Consider exploring other gases if the ones used thus far do not provide good results.

Explain the trends in the results in more detail.

Student or professor presenting is expected to attend in-person in the future.

Importance and Satisfaction Chart

High Importance, Low Satisfaction	*High Importance, High Satisfaction*
	GLOBALFOUNDRIES (9, 8) Mentor, A Siemens Business (9, 8) Intel Corporation (8, 8) IBM Corporation (8, 7) TSMC (8, 7) Tokyo Electron Limited (TEL) (7, 6)
Low Importance, Low Satisfaction	***Low Importance, High Satisfaction***

Contract Site Review Summary

Company (I,S)	Middle Range (lowest I or S rating is between 6 and 8)
GLOBALFOUNDRIES (9, 8)	No Comments
Mentor, A Siemens Business (9, 8)	STRENGTHS: Focused in SiO2 Shows effect of H2 additives reduce FC build up thickness H2 additive does not affect etch rate. Similar Si etching amount for each condition Future work to focus in HfO2, Hf-Silicate, and La2O3 QUESTIONS/COMMENTS: Did not send anybody in person. Flourocarbons do not etch well high-k materials, (Chlorine compounds suggested), to improve the etch rates.
Intel Corporation (8, 8)	No Comments
IBM Corporation (8, 7)	STRENGTHS: The problem statement is very relevant. The amount of work done thusfar looks promising QUESTIONS/COMMENTS: The way the results are presented, it is not clear how effective the learning is. The data is presented in too much of a raw form, and not distilled to compare and understand the learning that is being achieved.
TSMC (8, 7)	No Comments
Tokyo Electron Limited (TEL) (7, 6)	No Comments

Decoupled Process Sequences/Surface Chemistries Enabling Atomic Layer Etching of Critical Materials

Task ID:	2726.001
Task Leader(s):	Oehrlein, Gottlieb (UM/College Park)
Goal(s):	The primary project result is the knowledge base and fundamental understanding of how consecutive surface chemical modifications/low energy ion bombardment of SiO2, Si3N4, Si, SiGe, Al2O3, and HfO2, can enable atomistic precision in material etching, and impact etching selectivity, profile shape of patterns formed by ALE and surface cleanliness/damage.
Cur. Task Funding:	GRC Core - $85,000
Cur. Funding Period:	1/1/2018 - 12/31/2018 (Year 2)
Contract Term:	1/1/2017 - 12/31/2019
Final Year:	No
Deliverables:	Total - 7; Received - 3; Overdue - 1; Pending - 4
Student Reports:	Total - 5; Received - 3; Overdue - 0; Pending - 2; Non-Compliant - 2
Avg I/S Rating:	8.2 / 7.3
Feedback:	

Strengths:
Project targets important industry challenges. Plasma based approach is industry friendly.

Good focus on the fundamental etch processes.

Excellent student presentation, good job stepping in due to technical difficulties.

Questions/Comments:
Effects of H2 addition is well-known for plasma etching. Keep focus on fundamental understanding.

Will be interesting to explore the impact of H2 on SiN etching. It will be very interesting to see any differences in the role of hydrogen from H2/C4F8 and CHxFy plasma on ALE of Si, SiO2 and SiN.

CF gases are unlikely to work well for future work materials. Consider exploring other gases if the ones used thus far do not provide good results.

Explain the trends in the results in more detail.

Student or professor presenting is expected to attend in-person in the future.

Student(s): Lin, Kang-Yi (UM/College Park)

Liaison(s):
Bruce, Robert L. (IBM)
Chen, HaiChing (TSMC)
Cottle, Hongyun (TEL)
Engelmann, Sebastian (IBM)
Joseph, Eric A. (IBM)
Labelle, Catherine B. (GLOBALFOUNDRIES)
Metzler, Dominik (IBM)
Park, Chanro (GLOBALFOUNDRIES)
Tan, Joanna (Intel)

SRC Report Notes:

(1) 7.07 Task Review Summary for PDF run on 3/30/2018 by SRC_IT\altman.

(2) Report Parameters: Event = E00; Research = 2726; Task = All; Funding Type = All.

(3) Task data as of 3/30/2018.

Contract Site Review Summary

Contract ID: 2017NM2729
Principal Investigator: Dr. Gregory Parsons (NC State)
Task: 2729.001 Orthogonal Dielectric/Metal Selective Area Atomic Layer Deposition
Task Leader: Dr. Gregory Parsons (NC State)
Co-TL:
Review Date: 6/27/2017
Mean Rating: 8.8, 8.2
General Comments: Strengths:
Good consideration of the state of interfaces after processing, compared to before.

Great focus on fundamentals of interface engineering, including understanding key parameters that affect the deposition and etching selectivity.

Great results thus far in a short period. Strong start to the program, with positive initial results.

Questions/Comments:
Bring students to present next year.

Encourage continuing focus on interface engineering fundamentals, so that general methodologies for various systems can be extrapolated from the fundamental understanding.

Side-walls could be different than the top/bottom in patterned structures. As a challenge, for future work, consider all surfaces for defectivity and growth.
ALD + ALE coupled process would be slow. Consider if it is possible to speed up process time. Help industry understand fundamental limits. Keep manufacturability in the back of your mind, even for early R&D.

Importance and Satisfaction Chart

High Importance, Low Satisfaction	*High Importance, High Satisfaction*
	IBM Corporation (9, 9) GLOBALFOUNDRIES (9, 8) Mentor, A Siemens Business (9, 8) Tokyo Electron Limited (TEL) (9, 8) TSMC (9, 8) Intel Corporation (8, 8)
Low Importance, Low Satisfaction	***Low Importance, High Satisfaction***

Contract Site Review Summary

Company (I,S)	Upper Range (lowest I or S rating is 9 or greater)
IBM Corporation (9, 9)	STRENGTHS: Very nice overview of problem. Great insight developed and presented relevant to real process issues in selective ALD. Great results demonstrated. QUESTIONS/COMMENTS: Would like to see student presentation next time.

Company (I,S)	Middle Range (lowest I or S rating is between 6 and 8)
GLOBALFOUNDRIES (9, 8)	No Comments
Mentor, A Siemens Business (9, 8)	STRENGTHS: Extending understanding of how surfaces are affected in non-selected areas and how that changes time between etch clean ups, and growth rates per cycle. Will focus in intrinsic selective ALD for Metal (W,Co,Ru) and Dielectric (TiO2, HfO2, ZnO) 7nm of W deposition with about 10 deposition steps (not with etch) Removed clustered: nucleation rate increases Removed vicinal: Nucleation rate decreases. By understanding the chemistry involved, it can extend the prevention of nucleation for several more cycles, and change the behavior of the non-targeted material. QUESTIONS/COMMENTS: Need to allow students to present.
Tokyo Electron Limited (TEL) (9, 8)	No Comments
TSMC (9, 8)	No Comments
Intel Corporation (8, 8)	No Comments

Orthogonal Dielectric/Metal Selective Area Atomic Layer Deposition

Task ID:	2729.001
Task Leader(s):	Parsons, Gregory (NC State)
Goal(s):	Research will expand primary understanding of surface preparation and initial reactions needed for inherent orthogonal dielectric/metal selective-area ALD. PhD students will be prepared for further innovation in advanced materials, processes and devices.
Cur. Task Funding:	GRC Core - $86,689
Cur. Funding Period:	2/1/2018 - 1/31/2019 (Year 2)
Contract Term:	2/1/2017 - 1/31/2020
Final Year:	No
Deliverables:	Total - 7; Received - 3; Overdue - 2; Pending - 4
Student Reports:	Total - 5; Received - 2; Overdue - 0; Pending - 3; Non-Compliant - 3
Avg I/S Rating:	8.8 / 8.2
Feedback:	

Strengths:
Good consideration of the state of interfaces after processing, compared to before.

Great focus on fundamentals of interface engineering, including understanding key parameters that affect the deposition and etching selectivity.

Great results thus far in a short period. Strong start to the program, with positive initial results.

Questions/Comments:
Bring students to present next year.

Encourage continuing focus on interface engineering fundamentals, so that general methodologies for various systems can be extrapolated from the fundamental understanding.

Side-walls could be different than the top/bottom in patterned structures. As a challenge, for future work, consider all surfaces for defectivity and growth.
ALD + ALE coupled process would be slow. Consider if it is possible to speed up process time. Help industry understand fundamental limits. Keep manufacturability in the back of your mind, even for early R&D.

Student(s):

Saare, Holger (NC State)
Song, Seung Keun (NC State)
Stevens, Eric (NC State)
Xie, Wenyi (NC State)

Liaison(s):

Ahmed, Saquib (Intel)
Atanasov, Sarah (Intel)
Clark, Robert D. (TEL)
Clendenning, Scott (Intel)
De Silva, Anuja (IBM)
Yeh, Lingyen (TSMC)
You, Han (GLOBALFOUNDRIES)

SRC Report Notes:

(1) 7.07 Task Review Summary for PDF run on 3/30/2018 by SRC_IT\altman.

(2) Report Parameters: Event = E00; Research = 2729; Task = All; Funding Type = All.

(3) Task data as of 3/30/2018.

Contract Site Review Summary

Contract ID: 2017NM2732
Principal Investigator: Professor Christopher M. Bates (UC/Santa Barbara)
Task: 2732.001 Selective Spin-on Deposition of Polymers
Task Leader: Professor Christopher M. Bates (UC/Santa Barbara)
Co-TL:
Review Date: 6/27/2017
Mean Rating: 8.3, 7.8
General Comments: Strengths:
Robust characterization technique is a good way to start the project. Focusing on metrology and techniques early in the project was a good starting place.

Good starting suite of materials in which selectivity is being researched.

The systematic approach to studying this problem will serve the project well.

Questions/Comments:
Repeatable vertical phase separation as an indicator or precursor to selectivity remains to be demonstrated.

Increase interactions with industry liaisons, to develop understanding of potential industry applications and to guide the research direction.

Compare results with other SRC program results, such as self assembled monolayers (SAMs), to show benefit compared to competing techniques.

Bring students next year.

Importance and Satisfaction Chart

High Importance, Low Satisfaction	*High Importance, High Satisfaction*
	IBM Corporation (9, 8) Tokyo Electron Limited (TEL) (9, 8) Intel Corporation (8, 8) Mentor, A Siemens Business (8, 8) TSMC (8, 8) GLOBALFOUNDRIES (8, 7)
Low Importance, Low Satisfaction	*Low Importance, High Satisfaction*

Contract Site Review Summary

Company (I,S)	Middle Range (lowest I or S rating is between 6 and 8)
IBM Corporation (9, 8)	STRENGTHS: This is extremely relevant and practical work that has a lot of potential applications and opportunity for understanding. It's clear that there is a very good team behind this work. Results thusfar are good considering the early nature. QUESTIONS/COMMENTS: Strongly encourage reaching out to industrial liaisons to ensure that you study systems and surfaces of interest.
Tokyo Electron Limited (TEL) (9, 8)	No Comments
Intel Corporation (8, 8)	No Comments
Mentor, A Siemens Business (8, 8)	STRENGTHS: Need to understand when, why and how polymers adsorb to certain surfaces. Materials: Polymer blends Processing: Casting solvent, film thickness, annealing temperature Characterization: SIMS, ATR-IR, AFM How materials deposit on Cu, TiN, SiN, SiO2 surfaces Thermal annealing seems to be not necessary (which simplifies processing) Leverages facilities (not waiting for students to be trained in metrology tools). Does not use it as an excuse for not showing progress. QUESTIONS/COMMENTS: Please let students present (gets a pass because it is the first time presenting) Need to prove selectivity due to surface affinity and not difference in solubility and air interface.
TSMC (8, 8)	No Comments
GLOBALFOUNDRIES (8, 7)	STRENGTHS: Robust characterization technique is a good start to the project by. Repeatable vertical phase separation as an indicator or precursor to selectivity remains to be demonstrated.

Determining the Sensitivity of Metrology to Changes in Multi-Nanowire and Multi-Nanosheet FETs

Task ID:	2794.001
Task Leader(s):	Diebold, Alain (SUNY POLY)
Goal(s):	Advances are required for metrology to control future transistor processes. This project would provide an assessment of capability of scatterometry (optical critical dimension), critical dimension small angle X-ray scattering (CDSAXS), and reciprocal space mapping X-ray diffraction (RSM-XRD) for measuring changes in dimension and shape of gate-all-around transistor structures.
Cur. Task Funding:	GRC Core - $90,000 SUNY POLY Collaborative - $33,000
Cur. Funding Period:	1/1/2018 - 12/31/2018 (Year 1)
Contract Term:	1/1/2018 - 12/31/2020
Final Year:	No
Deliverables:	Total - 6; Received - 0; Overdue - 0; Pending - 6
Student Reports:	Total - 4; Received - 0; Overdue - 1; Pending - 3; Non-Compliant - 3
Avg I/S Rating:	N/A
Feedback:	N/A
Student(s):	Korde, Madhulika S. (SUNY POLY)
Liaison(s):	Jensen, Jacob M. (Intel) Kuhn, Markus (Intel) Muthinti, Gangadhara Raja (IBM) Vaid, Alok (GLOBALFOUNDRIES)

SRC Report Notes:

(1) 7.07 Task Review Summary for PDF run on 3/30/2018 by SRC_IT\altman.

(2) Report Parameters: Event = E00; Research = 2794; Task = All; Funding Type = All.

(3) Task data as of 3/30/2018.

Area-selective ALD of Nitrides using Inhibitors and Plasma Processes in ABC-type Cycles

Task ID:	2795.001
Task Leader(s):	Mackus, Adriaan J. (Eindhoven Univ. of Tech.)
Goal(s):	This task will extend the set of available area-selective ALD processes to nitrides. New strategies for area-selective ALD will be developed relying on the use of inhibitor molecules and plasma processes in ABC-type ALD cycles. Insight will be obtained into what controls the selectivity of nitride ALD processes.
Cur. Task Funding:	GRC Core - $87,606
Cur. Funding Period:	1/1/2018 - 12/31/2018 (Year 1)
Contract Term:	1/1/2018 - 12/31/2019
Final Year:	No
Deliverables:	Total - 6; Received - 0; Overdue - 0; Pending - 6
Student Reports:	Total - 3; Received - 0; Overdue - 1; Pending - 2; Non-Compliant - 2
Avg I/S Rating:	N/A
Feedback:	N/A
Student(s):	Merkx, Marc (Eindhoven Univ. of Tech.)
Liaison(s):	Clendenning, Scott (Intel) De Silva, Anuja (IBM) Tsai, Wilman (TSMC)

SRC Report Notes:

(1) 7.07 Task Review Summary for PDF run on 3/30/2018 by SRC_IT\altman.

(2) Report Parameters: Event = E00; Research = 2795; Task = All; Funding Type = All.

(3) Task data as of 3/30/2018.

Fabrication and Testing of Quasi-1D van der Waals Metal Interconnects

Task ID:	2796.001
Task Leader(s):	Balandin, Alexander (UC/Riverside) Bartels, Ludwig (UC/Riverside)
Goal(s):	A demonstration of novel prototype interconnects providing an ultimate atomic thickness limit of the cross-section. The technology utilizes one-dimensional van der Waals metals, which can be grown into individual single crystalline atomic threads with extraordinary current-carrying capability due to absence of electron scattering from rough interfaces and grain boundaries.
Cur. Task Funding:	GRC Core - $88,000 UC/Riverside Collaborative - $20,348
Cur. Funding Period:	1/1/2018 - 12/31/2018 (Year 1)
Contract Term:	1/1/2018 - 12/31/2020
Final Year:	No
Deliverables:	Total - 9; Received - 0; Overdue - 0; Pending - 9
Student Reports:	Total - 4; Received - 1; Overdue - 0; Pending - 3; Non-Compliant - 3
Avg I/S Rating:	N/A
Feedback:	N/A
Student(s):	Geremew, Adane K. (UC/Riverside)
Liaison(s):	Lin, Kevin L. (Intel) Naylor, Carl H. (Intel)

SRC Report Notes:

(1) 7.07 Task Review Summary for PDF run on 3/30/2018 by SRC_IT\altman.

(2) Report Parameters: Event = E00; Research = 2796; Task = All; Funding Type = All.

(3) Task data as of 3/30/2018.

Sub-5 nm Patterning via Template-directed Assembly of Colloidal Nanocrystals (NCs)

Task ID:	2797.001
Task Leader(s):	Kagan, Cherie (Univ. of Pennsylvania)
Goal(s):	To define design rules for the directed self-assembly of colloidal nanocrystals (NCs) to achieve sub−5nm patterned features to meet the needs of future semiconductor device manufacturing.
Cur. Task Funding:	GRC Core - $90,000 Univ. of Pennsylvania Collaborative - $37,516
Cur. Funding Period:	1/1/2018 - 12/31/2018 (Year 1)
Contract Term:	1/1/2018 - 12/31/2020
Final Year:	No
Deliverables:	Total - 9; Received - 0; Overdue - 0; Pending - 9
Student Reports:	Total - 4; Received - 0; Overdue - 1; Pending - 3; Non-Compliant - 3
Avg I/S Rating:	N/A
Feedback:	N/A
Student(s):	
Liaison(s):	Krysak, Marie (Intel) Singh, Gurpreet (Intel)

SRC Report Notes:

(1) 7.07 Task Review Summary for PDF run on 3/30/2018 by SRC_IT\altman.

(2) Report Parameters: Event = E00; Research = 2797; Task = All; Funding Type = All.

(3) Task data as of 3/30/2018.

Selective Deposition with Directed Self-assembly

Task ID:	2798.001
Task Leader(s):	Ross, Caroline (MIT)
Goal(s):	This project will deliver a set of etchless processes that enables metal and dielectric features of a few nm dimensions to be formed in specific locations on a block copolymer template, whose long-range order can be determined by directed self assembly.
Cur. Task Funding:	GRC Core - $90,000 MIT Collaborative - $24,790
Cur. Funding Period:	1/1/2018 - 12/31/2018 (Year 1)
Contract Term:	1/1/2018 - 12/31/2020
Final Year:	No
Deliverables:	Total - 9; Received - 0; Overdue - 0; Pending - 9
Student Reports:	Total - 4; Received - 0; Overdue - 1; Pending - 3; Non-Compliant - 3
Avg I/S Rating:	N/A
Feedback:	N/A
Student(s):	
Liaison(s):	De Silva, Anuja (IBM) Han, Eungnak (Intel) Hourani, Rami (Intel) Singh, Gurpreet (Intel)

SRC Report Notes:

(1) 7.07 Task Review Summary for PDF run on 3/30/2018 by SRC_IT\altman.

(2) Report Parameters: Event = E00; Research = 2798; Task = All; Funding Type = All.

(3) Task data as of 3/30/2018.

Crystalline Electronic and Photonic Materials without an Epitaxial Template

Task ID:	2799.001
Task Leader(s):	Kapadia, Rehan R. (Univ Southern California)
Goal(s):	We will demonstrate the growth of single crystalline III-V materials (e.g. InP, InAs, GaP, GaAs) on amorphous substrates (e.g. SiO2 or Si3N4) using TF-VLS growth, followed by MOCVD growth to create latticed matched heterostructures for electronic and photonic devices.
Cur. Task Funding:	GRC Core - $88,000 Univ Southern California Collaborative - $23,855
Cur. Funding Period:	1/1/2018 - 12/31/2018 (Year 1)
Contract Term:	1/1/2018 - 12/31/2020
Final Year:	No
Deliverables:	Total - 8; Received - 0; Overdue - 0; Pending - 8
Student Reports:	Total - 4; Received - 0; Overdue - 1; Pending - 3; Non-Compliant - 3
Avg I/S Rating:	N/A
Feedback:	N/A
Student(s):	
Liaison(s):	Torres, Jessica (Intel)

SRC Report Notes:

(1) 7.07 Task Review Summary for PDF run on 3/30/2018 by SRC_IT\altman.

(2) Report Parameters: Event = E00; Research = 2799; Task = All; Funding Type = All.

(3) Task data as of 3/30/2018.

New Precursors and Processes for the Atomic Layer Deposition of Metal and Metal Nitride Films

Task ID:	2800.001
Task Leader(s):	Winter, Charles H. (Wayne State)
Goal(s):	Successful execution of this research project would afford new ALD precursors for TiN, TaN, Ni, Co, Fe, Cr, Rh, Ir and other metals that combine high volatility, high thermal stability, and high reactivity toward a reducing reagent, and low temperature ALD growth processes for high purity nitride and metal films.
Cur. Task Funding:	GRC Core - $88,000 Wayne State Collaborative - $10,544
Cur. Funding Period:	1/1/2018 - 12/31/2018 (Year 1)
Contract Term:	1/1/2018 - 12/31/2020
Final Year:	No
Deliverables:	Total - 9; Received - 0; Overdue - 0; Pending - 9
Student Reports:	Total - 4; Received - 0; Overdue - 1; Pending - 3; Non-Compliant - 3
Avg I/S Rating:	N/A
Feedback:	N/A
Student(s):	
Liaison(s):	Clendenning, Scott (Intel) De Silva, Anuja (IBM) Mokhtarzadeh, Charles C. (Intel) Tsai, Wilman (TSMC)

SRC Report Notes:

(1) 7.07 Task Review Summary for PDF run on 3/30/2018 by SRC_IT\altman.

(2) Report Parameters: Event = E00; Research = 2800; Task = All; Funding Type = All.

(3) Task data as of 3/30/2018.

Nanospectroscopic Imaging to Probe Stochastic Variations in Extreme Ultraviolet Photoresists

Task ID:	2801.001
Task Leader(s):	Mattson, Eric C. (UT/Dallas) Chabal, Yves J. (UT/Dallas)
Goal(s):	Nanospectroscopic imaging using an atomic force microscopy-infrared (AFM-IR) type probe coupled to a synchrotron source will provide unprecedented insight into the degree of stochastic variation in model chemically amplified resists and their role in development failure, with methodology that can be extended to emerging inorganic resists.
Cur. Task Funding:	Intel Custom - $85,000 UT/Dallas Collaborative - $50,000
Cur. Funding Period:	1/1/2018 - 12/31/2018 (Year 1)
Contract Term:	1/1/2018 - 12/31/2019
Final Year:	No
Deliverables:	Total - 8; Received - 0; Overdue - 0; Pending - 8
Student Reports:	Total - 3; Received - 0; Overdue - 1; Pending - 2; Non-Compliant - 2
Avg I/S Rating:	N/A
Feedback:	N/A
Student(s):	
Liaison(s):	Blackwell, James (Intel) Tripp, Marie (Intel)

SRC Report Notes:

(1) 7.07 Task Review Summary for PDF run on 3/30/2018 by SRC_IT\altman.

(2) Report Parameters: Event = E00; Research = 2801; Task = All; Funding Type = All.

(3) Task data as of 3/30/2018.

Effective Patterning of Ni for EUV Masks

Task ID:	2802.001
Task Leader(s):	Chang, Jane (UCLA)
Goal(s):	To develop an atomic layer etching process for Ni, followed by the implementation of a hybrid RIE and ALE process to address both the throughput concern as well as the atomic precision in achieving a high anisotropic etch profile.
Cur. Task Funding:	Intel Custom - $75,000 UCLA Collaborative - $5,000
Cur. Funding Period:	1/1/2018 - 12/31/2018 (Year 1)
Contract Term:	1/1/2018 - 12/31/2019
Final Year:	No
Deliverables:	Total - 10; Received - 0; Overdue - 0; Pending - 10
Student Reports:	Total - 3; Received - 0; Overdue - 1; Pending - 2; Non-Compliant - 2
Avg I/S Rating:	N/A
Feedback:	N/A
Student(s):	Chen, Ernest L. (UCLA)
Liaison(s):	Choi, Chang-Ju (Intel) Liang, Ted (Intel) Marchack, Nathan (IBM) Tronic, Tristan A. (Intel)

SRC Report Notes:

(1) 7.07 Task Review Summary for PDF run on 3/30/2018 by SRC_IT\altman.

(2) Report Parameters: Event = E00; Research = 2802; Task = All; Funding Type = All.

(3) Task data as of 3/30/2018.

Defect Removal Process for Area Selective ALD

Task ID:	2660.001
Task Leader(s):	Bent, Stacey F. (Stanford)
Goal(s):	Development of a self-correcting process for area selective atomic layer deposition (AS-ALD) that overcomes the challenges faced by current AS-ALD processes. The final target is a vapor phase process requiring no blocking layer that is highly selective, versatile, and manufacture-worthy.
Cur. Task Funding:	GRC Core - $25,000
Cur. Funding Period:	4/1/2018 - 12/31/2018 (Year 2)
Contract Term:	1/1/2016 - 12/31/2018
Final Year:	No
Deliverables:	Total - 9; Received - 6; Overdue - 4; Pending - 3
Student Reports:	Total - 5; Received - 4; Overdue - 3; Pending - 1; Non-Compliant - 1
Avg I/S Rating:	8.8 / 7.2
Feedback:	

Strengths:
We appreciate the group's efforts to explore multiple options to achieve selective area deposition.

We appreciate the focus on gas phase approaches that are more industry friendly.

Excellent student presentations.

Good interaction with industry liaisons.

Questions/Comments:
The current ethanol etchant didn't remove the material in the metal surface completely. Any plan to improve?

All the current results are in micron size area. Can you come up with a plan to work on more relevant feature sizes (<100nm)?

Half-way through the project and no work has been presented on non-SAM approaches. Make sure to address this part of the deliverables. Make sure to address all aspects of the project on an annual basis.

Student(s):
Bobb-Semple, Dara (Stanford)
Closser, Richard G. (Stanford)
Liu, Tzu-Ling (Stanford)

Liaison(s):
Chen, HaiChing (TSMC)
Cheng, Joy (TSMC)
Clark, Robert D. (TEL)
Clendenning, Scott (Intel)
Hourani, Rami (Intel)
Lee, Ming-Han John (TSMC)
Reid, Kimberly G. (Arm)
Tapily, Kanda (TEL)
Torres, Juan (Mentor (Siemens))
Wojtecki, Rudy J. (IBM)
You, Han (GLOBALFOUNDRIES)

SRC Report Notes:

(1) 7.07 Task Review Summary for PDF run on 3/30/2018 by SRC_IT\altman.

(2) Report Parameters: Event = E00; Research = 2660; Task = All; Funding Type = All.

(3) Task data as of 3/30/2018.

Selective Spin-on Deposition of Polymers

Task ID:	2732.001
Task Leader(s):	Bates, Christopher M. (UC/Santa Barbara)
Goal(s):	This task will establish the feasibility of selective spin-on polymer deposition onto metals and dielectrics. Specific knowledge regarding material-surface interactions, coverage, uniformity, and selectivity will be identified for various polymer and substrate combinations.
Cur. Task Funding:	GRC Core - $150,000
Cur. Funding Period:	2/1/2018 - 1/31/2019 (Year 2)
Contract Term:	2/1/2017 - 1/31/2020
Final Year:	No
Deliverables:	Total - 7; Received - 3; Overdue - 1; Pending - 4
Student Reports:	Total - 5; Received - 2; Overdue - 0; Pending - 3; Non-Compliant - 3
Avg I/S Rating:	8.3 / 7.8
Feedback:	

Strengths:
Robust characterization technique is a good way to start the project. Focusing on metrology and techniques early in the project was a good starting place.

Good starting suite of materials in which selectivity is being researched.

The systematic approach to studying this problem will serve the project well.

Questions/Comments:
Repeatable vertical phase separation as an indicator or precursor to selectivity remains to be demonstrated.

Increase interactions with industry liaisons, to develop understanding of potential industry applications and to guide the research direction.

Compare results with other SRC program results, such as self assembled monolayers (SAMs), to show benefit compared to competing techniques.

Bring students next year.

Student(s):
Abrams, Austin S. (UC/Santa Barbara)
Zhang, Yuanyi (UC/Santa Barbara)

Liaison(s):
Burns, Ryan L. (TEL)
Cheng, Joy (TSMC)
De Silva, Anuja (IBM)
Felix, Nelson M. (IBM)
Han, Eungnak (Intel)
Liu, Chi-Chun (IBM)
Somervell, Mark H. (TEL)
Yeh, Lingyen (TSMC)

SRC Report Notes:

(1) 7.07 Task Review Summary for PDF run on 3/30/2018 by SRC_IT\altman.

(2) Report Parameters: Event = E00; Research = 2732; Task = All; Funding Type = All.

(3) Task data as of 3/30/2018.