## Manufacturing Science and Technology Group
## Room Oregon Ballroom 203-204 - Session MS-ThP

## Manufacturing Science and Technology Poster Session

**MS-ThP-1 Autonomous Synthesis in the MBE Using Real-Time Artificial Intelligence***, **Tiffany Kaspar**, L. Wang, J. Christudasjustus, M. Sassi, B. Helfrecht, J. Pope, A. Harilal, S. Akers, S. Spurgeon,* Pacific Northwest National Laboratory

Materials are the key components of nearly all advanced technologies, including quantum information systems, microelectronics, catalysis, and energy conversion and storage. Modern synthesis methods enable the fabrication of an ever-expanding array of novel, non-equilibrium, and/or metastable materials and composites that may possess unique and desirable functionality. Thin film deposition by molecular beam epitaxy (MBE) can produce atomically precise (or nearly so) materials with a wide range of functional electronic, magnetic, ferroelectric/multiferroic, optical, and/or ion-conducting properties. The current state of the art in precision design of functional materials is to manually explore the "growth phase space" of the deposition techniqueto optimize the film properties of interest. Limitations of time and resources often result in incomplete exploration of the growth phase space and resulting properties. Faced with this lack of complete information, materials design and synthesis decisions are made based in part on intuition and luck, slowing both materials optimization and materials discovery.This current synthesis paradigm can be disrupted by employing artificial intelligence (AI)-accelerated analysis of *in situ* and *ex situ* data streams that will enable targeted synthesis of novel materials with desired structure, chemical stability, and functional properties.Here we present a preliminary implementation of such an AI-controlled MBE.We are integrating the control of key synthesis parameters (temperatures, gas flow rates, shutters) with AI-guided computer control.Guidance will be based on near-real-time analysis of reflection high energy electron diffraction (RHEED) patterns using sparse data analytics, with low-latency feedback to the control software.As an initial demonstration, we will control the morphology and phase purity of epitaxial anatase $TiO_2$ thin films.

**MS-ThP-2 Machine Learning Based Virtual Metrology for Effective Process Control in High Product Mix Manufacturing***, **Hyung Joo Lee**, S. Choi,* Siemens EDA, Republic of Korea*; N. Greeneltch, S. Jayaram,* Siemens EDA

1. Introduction

The semiconductor foundry industry faces challenges with high product mix manufacturing, requiring increased flexibility in managing diverse customer demands. Coordinating multiple chambers and process steps with different designs and technology nodes is complex, resulting in reduced yields and increased costs.

2. CVD Process Challenges

The CVD process in semiconductor manufacturing experiences thickness variations due to device layout design and chamber condition drift. Lack of control across layouts affects transistor parameters and yield. Managing chamber-by-chamber variations is crucial for high-volume manufacturing, but current solutions hinder fab line management and throughput.

3. VM Approach and Modeling

Virtual metrology (VM) addresses the trade-off between metrology activities and cost by utilizing data from the process chamber (FDC) to predict metrology results. Design features are extracted and used for prediction across layouts and technologies, benefiting new layouts and production stages. Siemens' Calibre® software is employed for feature extraction, and ML methodologies construct the VM model. Results demonstrate the superiority of the VM model with design features and FDC.

4. APC System and Results

An APC system using the VM model for R2R control is proposed. It incorporates design features, FDC, and measurements to achieve the desired thickness target. The system triggers updates to the VM model based on prediction errors. The APC system significantly improves process capability and reduces film thickness variations. Control simulation confirms the effectiveness of the APC system in a high-mix product foundry fab setting.

5. Summary

The semiconductor foundry industry faces challenges in high product mix manufacturing. The CVD process experiences thickness variations from design features and chamber conditions, impacting yield. A VM approach, incorporating design features and FDC, improves process control. An APC system based on the VM model further enhances thickness control, demonstrating significant improvements in process capability and thickness variation reduction.

**MS-ThP-3 Experimental 3D Maintenance Work Measurement and Analysis for Maintenance Improvement and Enhancement of Productivity of Semiconductor Manufacturing Equipment***, **Takashi Numata**, Y. Ogi, K. Mitani, R. Kawamata, N. Ikeda, T. Ege,* Hitachi, Ltd., Japan*; Y. Kadomoto, R. Ishibashi, Y. Shengnan, Y. Sakka, Y. Nakamura, K. Sato,* Hitachi High-Tech Corporation, Japan

Recently, high machine availability of semiconductor manufacturing equipment has become more important, and shortage of field service engineers has become serious. Therefore, maintenance improvement which enable to increase the capacity with inexperienced field engineers and realize productivity improvement of semiconductor manufacturing equipment has been needed.

Based on these circumstances, we have proposed maintenance work measurement and analysis technologies for maintenance improvement of semiconductor manufacturing equipment. Our targets are to reduce durations of and maintenance work, and a rate of reclean (failure of maintenance) especially focusing on periodical maintenance. Maintenance work measurement and analysis have a potential to enable us to extract work differences between skilled and unskilled maintenance workers, extract complex and difficult characteristics of maintenance work, and support and/or reduce such complex and difficult maintenance work.

In this study, we developed a measurement system with 3D sensors and motion sensors, experimentally measured maintenance work of semiconductor manufacturing equipment such as parts assembly and wiping by using the developed system, and extracted indicators of personal differences among workers. We extracted various indicators including task time, working posture, amount of head motion, change of eyesight, amount of hand motion. As a result, we demonstrated representative differences of extracted indicators between an experienced maintenance worker and an inexperienced maintenance worker.

From the result, it was suggested that application of maintenance work measurement and analysis system with results of maintenance enable us to extract important factors to cause reclean, and standardize maintenance work based on skilled workers' movements and/or successful works. Then effective countermeasures for support and/or reduction of difficult task will be applied based on the results of maintenance work analysis.

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