Thursday Morning, December 12, 2024

Thin Films and Surface Modification
Room Naupaka Salon 4 - Session TF1-ThM

Thin Films - Plasma and Etching-related
Moderator: Gregory S. Herman, Argonne National Laboratory

8:40am **TF1-ThM-3 Reactive Ion Etching of InGaZnO using HFC-based Gas and Chamber Cleaning**, ***Sang Jin Lee**, J. Hong,* Sungkyunkwan University, Republic of Korea*; Y. Jeong, H. Cho, D. Jung, Y. Yeo,* Samsung Display, Republic of Korea*; D. Kim, G. Yeom,* Sungkyunkwan University, Republic of Korea

Indium gallium zinc oxide (IGZO) is one of the most important active layer semiconductor materials for next-generation semiconductor and display devices. In this study, IGZO was etched with various hydrofluorocarbon (HFC)-type gases composed of CH_xF_y and $C_3H_xF_y$ in an inductively coupled plasma (ICP) etcher and, the etch characteristics and its cleaning characteristics have been investigated. The results showed that, among HFC gases used in the experiment, IGZO was etched faster with $C_3H_xF_y$ compared to CH_xF_y and, especially, HFC gases with lower F in the gas chemistry showed the better etch characteristics in addition to a low GWP. In addition, the etch by-products including dissociated HFC gases accumulated on the chamber wall could be in-situ cleaned using a H_2/Ar plasma. X-ray photoelectron spectroscopy (XPS), quadrupole mass spectrometer (QMS), and optical emission spectroscopy (OES) were used to understand the IGZO etch mechanism and chamber cleaning mechanism.

9:00am **TF1-ThM-4 Eco-Friendly Dry-Cleaning of Silicon Dioxide Deposition Chambers using a Cylinder-Type Remote Plasma Source with NF_3/N_2 Mixtures**, ***Won Kyun Yeom**, H. Gil,* Sungkyunkwan University, Republic of Korea*; G. Yeom,* Sungkyunkwan University (SKKU), Republic of Korea

Silicon dioxide (SiO_2) chamber cleaning is critical in semiconductor manufacturing, but traditional methods using perfluorocarbon gases like NF_3 raise environmental concerns due to their high global warming potential. This study presents a novel, eco-friendly approach utilizing a cylinder-type inductively coupled plasma remote plasma source (ICP RPS) with NF_3/N_2 gas mixtures for enhanced SiO_2 removal.The addition of a small amount of N_2 to NF_3 (1:9 ratio) was found to significantly improve cleaning efficiency and uniformity. Comprehensive plasma diagnostics, including quadrupole mass spectrometry (QMS), optical emission spectroscopy (OES), and Langmuir probe measurements, revealed that N_2 addition increases electron density and temperature, leading to enhanced generation and consumption of highly reactive fluorine radicals responsible for SiO_2 etching.This innovative process offers a promising pathway to reduce NF_3 consumption in SiO_2 chamber cleaning, mitigating environmental impact while maintaining high cleaning performance. The results of this study contribute valuable insights into the optimization of plasma-based cleaning processes for the semiconductor industry.

9:20am **TF1-ThM-5 Innovative Fluorite-Based High-Entropy Oxide: A Novel Electrocatalyst for All-Vanadium Redox Flow Batteries**, ***Chen-Hao Wang,*** National Taiwan University of Science and Technology, Taiwan **INVITED**

Vanadium Redox Flow Batteries (VRFBs) are emerging as a promising solution for large-scale energy storage, offering advantages such as high capacity, long lifespan, and scalability. This study introduces a novel approach using fluorite high-entropy oxides (HEO) nanoparticles as catalytic materials for VRFBs, synthesized through a surfactant-assisted hydrothermal method followed by calcination.

The research focuses on HEO compounds, which incorporate multiple metal cations into a single-phase crystal structure, resulting in unique properties. Among the samples tested, the HEO calcined at 750°C (HEO-750) demonstrated superior electrocatalytic performance for both V^{3+}/V^{2+} and VO_2^+/VO^{2+} redox couples.

Key findings include:

1. Excellent efficiency: VRFBs using HEO-750 achieved high coulombic efficiency (CE), voltage efficiency (VE), and energy efficiency (EE) at various current densities.
2. Durability: No significant degradation was observed after 500 charge-discharge cycles.
3. Enhanced performance: The improved results are attributed to the forming of a single-phase fluorite structure during calcination, facilitating vanadium redox reactions.
4. Beneficial properties: High surface area, good wettability, and abundant oxygen vacancies improve electrochemical performance and stability.

The study concludes that HEO catalysts show great potential as next-generation electrode materials for VRFBs, potentially leading to the development of high-performance, cost-effective energy storage systems for various applications.

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