Atomic Layer Etching
Room 104-106 - Session ALE2-TuA

Selective ALE

Moderators: Fred Roozeboom, TNO-Holst Centre & Eindhoven University of Technology, The Netherlands, Harm Knoops, Eindhoven University of Technology

2:30pm **ALE2-TuA-5 Thermal Selective Etching on Metal Oxide and Nitride Film*, Jinhyung Park,*** Air Liquide Laboratories Korea, Republic of Korea

Highly selective etching of metal oxide, nitride and metal has been demonstrated by using metal fluoride. In addition, this etching was taking thermal dry etching without plasma assisted. Reports of thermal dry etching by using metal fluoride are very limited.1 In this work we conducted etching test between 150 and 450oC on various metal oxides, nitrides and metal substrate. Some results showed selective etching that only desired film was etched and non-desired film was not etched under same conditions. Etching rate and selective tendency was also compared. Not only flat surface, it was confirmed that metal fluoride worked for dry etching of a film in patterned wafer.

Figure 1

Figure 1. SEM image of thermal etching of ZrO2 deposited in patterned wafer

Figure 1 showed one example that etching of ZrO2 in trench by using NbF5 under different conditions. All etching results are analyzed by several methods such as ellipsometry, scanning electron microscopy (SEM), electron dispersive spectroscopy (EDS) and x-ray photoelectron spectroscopy (XPS). In this presentation, individual etching result of metal oxides (Nb2O5, Ta2O5, TiO2, ZrO2, HfO2, SiO2, Al2O3, Y2O3), metal nitrides (TiN, TaN, SiN), metal (W) and their comparison will be shown and discussed.

[1] P. C. Lemaire, G. N. Parsons, Chem. Mat. 29, 6653(2017).

2:45pm **ALE2-TuA-6 Benefits of Atomic Layer Etching for Material Selectivity*, Thorsten Lill,*** *K Kanarik, S Tan, I Berry, V Vahedi, R Gottscho,* Lam Research Corp.

For most critical etch applications such as pattern-transfer and 3D structure formation, an essential requirement is material selectivity. By material selectivity we refer to etching one material (X) preferentially to another material (Y), where the extent of selectivity is commonly denoted by the ratio X:Y for the relative amounts etched. Etching has had to be selective since the earliest years and the development of selective processes has been developed at least over the last 40 years of plasma etching. in this talk, we will discuss the strategies of selective etching and how atomic layer etching (ALE) helps. Both directional and isotropic ALE schemes will be discussed, as well as the basic underlying strategies in both. The insights will be vital for exploiting ALE in the fabrication of future devices.

3:00pm **ALE2-TuA-7 Approaching Atomic Scale Precision for Etch Technology Needs in the Semiconductor Industry*, Robert Bruce*,** *J Papalia, M Sagianis, D Montalvan, H Miyazoe, N Marchack, S Engelmann,* IBM TJ Watson Research Center **INVITED**

As we advance beyond the 7nm technology node, the semiconductor industry has implemented ever more complex architecture for logic and memory devices. For example, stacked nanosheets are a potential successor to finFETs and the number of levels continue to rise in 3D-NAND memory. To enable manufacture of new 3D devices at this unprecedented level of scale and intricacy requires atomic precision in etching and patterning, both anisotropic and isotropic, with high selectivity of etching one material over a host of other materials. Atomic layer etching (ALE) is a concept with goal to achieve this atomic scale precision by separating the etch process into controlled, self-limited reactions.

Because a large part of integrated devices are composed of insulating materials such as SiOx and SiNx, it is essential to understand their fundamental etching behavior at the atomic scale. In this talk, the interaction of SiOx and SiNx in hydrofluorocarbon-based plasmas was investigated. Due to their differences in surface modification behavior, the etching process could be tuned so that SiOx etches selectively to SiNx, and vice versa. The etch process parameters that influence material selectivity were evaluated, and it was found that hydrogen content, ion energy and substrate temperature had significant impact to the etching behavior of SiNx. The possibility of improving selectivity by separating deposition and etching in a quasi-ALE approach is also studied. These important observations provide essential guidance to a wide range of dielectric etch applications, such as self-aligned contact etching and spacer etching.

Author Index

Bold page numbers indicate presenter