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Highest Sensitivity for Small Open Area (OA%) Etch

Application Brief

Introduction

As feature size and geometries continue to shrink, a new challenge for semiconductor process manufacturers has emerged. For high aspect ratio 3D-NAND and critical dimension advanced node logic contacts, reliably detecting endpoint well below 1% open area is critical to yield and overall productivity.

The Problem

As contact width decreases with smaller process nodes, the Open Area for contact etch decreases faster, as the area dimension is proportional to the inverse square of the contact width. Additionally, the resistance of the contact increases negatively, affecting electrical performance of the transistor. Critically, end point detection (EPD) of contact etch through field oxide (silicon dioxide) needs to be performed to minimize contact resistance and ensure a good electrical contact with transistor source or drain, but without excessive over-etch that can cause shorts to the gate region or substrate damage. Further complicating contact etch is non-planar wafer topology, resulting in uneven etch and 'doughnut' or 'edge' yield patterns at final electrical test.

For 3D NAND, critical etch processes include small open area staircase etch and high aspect ratio open area for vertical channels, as well as slit etch through 100's of alternating silicon dioxide (SiO_2) and Silicon Nitride (Si_3N_4) layers. Etching through 100's of alternate layers requires high speed quantitative end point detection. High sensitivity is also critical as multi-layer step etch decreases the abundance of etch byproducts used to get a sharp step change endpoint, as the number of rows of contacts reduces as the bottom of the staircase etch is reached.

The Solution

To ensure consistent and optimized contact etch, high sensitivity in-situ molecular diagnostics is required to provide real-time measurement and quantification of the etch byproducts and enable a clearly-defined endpoint to be detected. With reducing contact open area (OA%), legacy metrology solutions like Optical Emission Spectroscopy (OES) lack the sensitivity (low signal to noise SNR ratio) to accurately detect etch end point. With OA% sensitivity demonstrated to <0.25%, Aston delivers a limit of detection up to an order of magnitude higher than OES (LOD of ~2.5%). Additionally, Aston's internally generated plasma-based ionization source allows it to work in the presence of corrosive etch gases and with or without a plasma source present in the processing chamber.

Summary

Aston is capable of accurate and actionable endpoint detection with OA% one order of magnitude (1/10th) that of legacy OES metrology solutions. The Aston solution is suitable for real-time EPD in processes with high etching throughput and performing extensive repetition of the same steps. This is accomplished with high signal to noise (SNR) ratio, thus avoiding ambiguous and complex multi-variable analysis algorithms common in OES devices.

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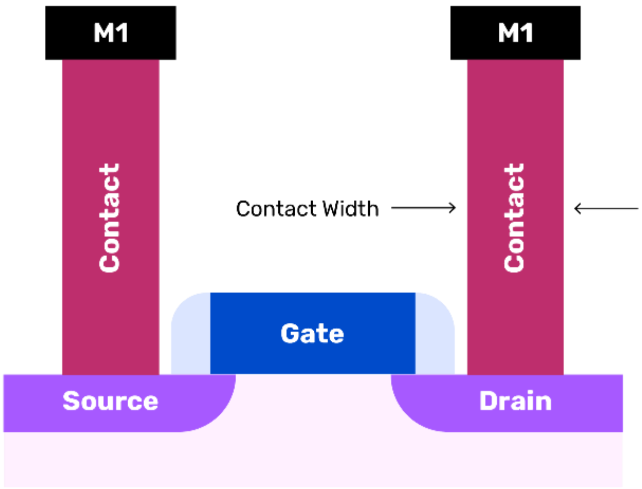
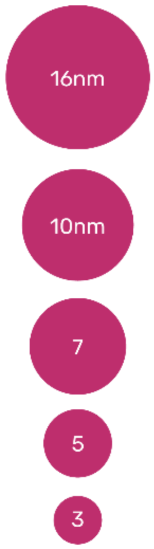
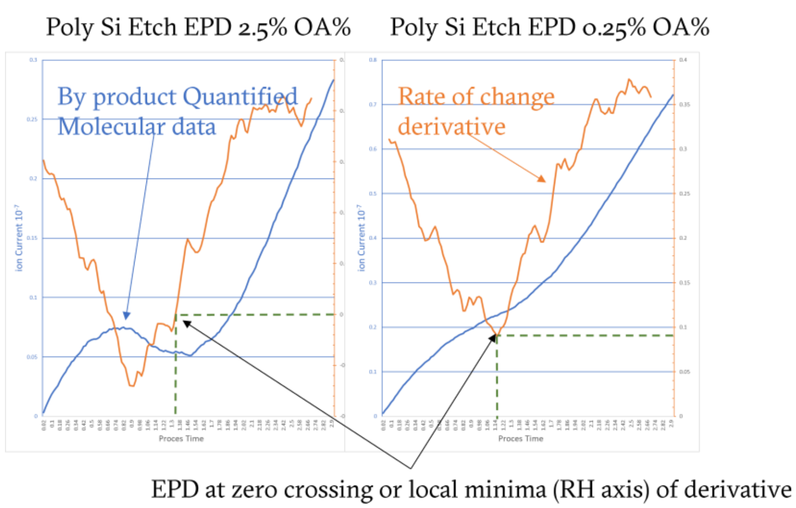


Process Node (nm)	Contact Width (nm)	Contact Open Area (nm^2)
16	24	452
10	20	314
7	16	201
5	11	95
3	10	79



Small OA% (and HAR) Etch

- Using Aston's high sensitivity (SEM) to provide actionable data to achieve end point detection in low open area etch
- Aston <0.3% OA% EPD achieve for multiple etch chemistries: x10 next best
- OES and RGA lack sensitivity to achieve low OA% EPD
- Aston solution works with or without plasma



Atonarp is advancing medical diagnostics, life sciences research, and industrial process control through next-generation digital molecular profiling. In-situ molecular profiling in advanced manufacturing means higher throughput, improved efficiency, and reduced waste. Real-time, quantitative diagnostic tests can improve outcomes and patient satisfaction at lower cost.

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