SOM – an environmentally friendly post ash/etch SW clean

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Overview

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- Summary & Wrap-up
SOM – an environmentally friendly post ash/etch SW clean
SOM – environmental friendly – post ash/etch application

Development idea:
- Transfer state-of-the-art 300mm DV-Prime® (DV-P) BEOL chemical recirculation capability into FEOL processes and therefore reduce chemical consumption per wafer of up to 95%
- Usage of Sulfuric Ozone mixture (SOM) in recirculation at elevated temperatures instead of Sulfuric Peroxide Mixture (SPM) processed to drain to remove post ash/etch polymer residues

Established concept:
- Dispense concentrated mixtures of Sulfuric acid and Ozone gas at temperatures up to 150°C with the purpose of polymer removal within an RCA cleaning sequence
- Purpose of O3 gas
  - Substitute H2O2 as an oxidizing agent in order to destroy organic components on wafer and in SOM after removal
- Purpose of 150°C SOM supply
  - Use of higher chemical reactivity at higher supply temperatures compared to wet benches
  - Match current Wetbench SPM on-wafer performance in terms of cleaning efficiency with Single Wafer (SW) cleaning tools
  - Reduce chemical dispense time in order to get reasonable process times for 8-chamber SW tools
DVP – SOM post ash/etch clean – Flow concept

O_3 supply system

SOM Tank

CHC-F (chemical supply)

Process pump

Heater

To right side PM’s

PML1

PML2

PML3

PML4

Return to CHC-F

Return to CHC-F

Return to CHC-F

Return to CHC-F
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Key challenges & applied solutions
SOM– post ash/etch clean – Key challenges for Hardware

Hardware-related challenges:

- Highly reactive liquid/gas mixtures at elevated temperatures challenge durability and reliability of HW components such as
  - Chuck
    - Chuck design which ensures no wafer breakage for less than 1 out of 100000 wafers processed at 150°C chemical supply where enhanced thermal stress is induced
    - Implement an advanced automated chuck clean functionality for FEOL applications
  - Chuck Pins
    - New pin material had to be developed which can handle high temperature with exchange interval of > 10000 wafers
  - Chamber & chamber rings
    - New chamber design and ring material developed, targeting compatibility with FEOL requirements and durability without showing any deformation due to significant thermal stress
    - Implement chamber clean functions to reach manual chamber maintenance intervals of more than 3 months
  - Process pump design and capability
    - Usage of LEVITRONIX high-temperature rotary pump which can handle liquid/gas mixtures and reliably withstand highly oxidizing chemicals such as $\text{H}_2\text{SO}_5$ and $\text{H}_2\text{S}_2\text{O}_8$ maintenance-free for more than 1 year!
SOM– post ash/etch clean – Key challenges for Process

- Process-related challenges:
  - Cleaning efficiency and particle performance when chemical is recirculated
    • Same or better on-wafer polymer removal efficiency compared to Wet benches required
    • Significantly better PC performance throughout whole bath lifetime required

  - On-wafer temperature stability and repeatability for high temperature process
    • Temperature on wafer stability of ±3°C within wafer and wafer to wafer required in order to match product and integration requirements with regard to repeatable material loss and cleaning efficiency

  - SOM chemical reusage greater than 12 hours
    • Show advantage in cost of chemicals for SOM SW process compared to SPM SW process by reaching a chemical consumption of < 100ml/ pass
    • Keep SOM chemical consumption comparable to Wetbench SPM cleans
    • Keep contamination level below specification throughout SOM bath life time
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Performance & Benefits
**SOM – CoC comparison SOM vs. SPM**

Annual chemical savings in a range of 450k$ to 1.9M$ for SW FEOL cleans

Reduction of cost of chemical when SOM is used instead of SPM from 80 to 95% possible

*Annual costs are based on 8 chamber tools, a throughput of 124 – 150 wf/hour, 90% uptime, 12 hours SOM bath life time with a FEOL post-ash production recipe*
**SOM – Within-wafer Temp. Distribution Sensarray wafer**

Within-wafer temperature uniformity of ±3°C* for ±50% boomswing

*Measurement done with KLA Temperature probe wafer*
**SOM – On-wafer temperature repeatability**

PML4 wafer-to-wafer IR temperature measurement (60s process time)

Wafer-to-wafer max Temperature within ±1°C

**Very good wafer to wafer temperature repeatability for 150°C SOM supply in terms of $T_{\text{max}}$ and $T_{\text{ave}}$**

*Measurement done with IR sensor*
SOM – ON-wafer PC performance (post ash)

With optimized post-ash recipe a particle performance of less than 20 adders at 45nm could be reached

* Precount <100@45nm on bare Si
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Summary & Wrap-up
Summary & Wrap-up

- Cost of Chemical reduction of up to 95% for SOM step in comparison to SPM possible
- Excellent defect performance and reliable cleaning efficiency for post-ash/etch applications
- Temperature stability within wafer, wafer to wafer and chamber to chamber of ±3°C reached
- 300mm DV-Prime® SOM systems are capable to handle reliable SOM mixtures up to 150°C (>90% uptime)
- Several post ash/etch systems installed at major Foundry customer for 45 – 65nm technology node
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