Supervision of Plasma-Etch-Processes at different Tool Types

Volker Tegeder

Infineon Technologies SC300
Supervision of Plasma Etch Processes at different Tool Types

- European Project: APC300
- Sensor Integration
  - different chamber types
  - B-field variations
- Linking logistical Data
  - spy for logistical data
  - innovative tool/sensor interface
- Application Examples of SEERS in Production
  - automatic Fault Detection
  - tool start-up / Tool release
  - chamber conditioning
  - influence of preprocesses
European Project: APC300
Supervision of Plasma Etch Process by SEERS

Assessment Site of Hercules/APC System
Infineon Technologies SC300 (Dresden)

Participants
AMD Saxony
ASI (Berlin)
Infineon Technologies (Regensburg)
ST Microelectronics (Rousset, France)

Start: 1st February 2000
Duration: 18 Month

European SEA IST-Project: APC300
Control System Set Up

Evaluation Site: Infineon Technologies SC300

- Dr. Volker Tegeder
- AEC/APC-Symposium XII 24.-28.9.00

Plasma Process Control

- HERCULES/APC (Plasma-Parameter)
- APC NET (Tool-Parameter)
- Data base
- Test-Data
- Correlation between yield and plasma
- CoO, OEE

Evaluation site

- focus on
  - process control
  - economical benefit
- 100% supervision on monitored etch processes
- up to 12 chambers
- approx. full POR
- link to logistical data
- different processes
  - poly / metal / oxide
- different chamber types
  - capacitive / ICP

Participants

- different applications at single tools
- mutual exchange of results
Sensor Integration
SEERS Measurement Principle

Measurement of plasma-electron-density and collision rate

- **Top Power**
- **Chamber**
- **Bottom Power**
- **Passive Sensor Head**
- **RF current**
- **HERCULES**
  - Fast ADC
  - 500 MHz
  - 1GS/s
  - 50 Ω input
- **Chamber**
- **Peak voltage**

**Electron density** $n$ and **Collision Rate** $v$:

- **SEERS Measurement Principle**
- **HERCULES**
- **Fast ADC**
- **500 MHz**
- **1GS/s**
- **50 Ω input**

**Graphs**:
- **Etch Time [s]**
- **Collision Rate [$10^6 s^{-1}$]**
- **Time**

**Institute**
- **Infineon Technologies**
- **SC300**

**Authors**
- **Dr. Volker Tegeder**

**Conference**
- **AEC/APC-Symposium XII 24.-28.9.00**
Adaptation to different chamber types

**DPS**
- peak voltage
- inductively coupled
- capacitive ≠ inductive coupled freqency

**LAM 300**
- peak voltage
- inductively coupled
- special software interface

**eMxP+**
- peak voltage
- rotating B-field
- optical access for OES
Synchronization to rotating B-Field

B-field impacts plasma => varying SEERS signal => synchronization necessary

B-field and trigger signal

eMXP300: B-field Signal

Varying magnetic field

B-field sensor at chamber wall
Linking Sensor Data to logistical Data
Linking Sensor Data to logistical Data

Logistical data the missing link?!?

Product #, lot #, recipe...important for any sensor:

Data Analysis
  correlation to in-line/electrical data
  economical benefit

Fault detection
  depending on product
  depending on recipe

Link I : Spy for logistical Data

Link II : Innovative tool sensor interface
SPY for logistical Data

Linking sensor data to logistical data

ABAKUS SECSII SPY
- full passive system
- configurable message filter
- communication to sensor via SECSII
- ethernet based
  (patent pending)
Innovative Tool / Sensor Interface

Example: SEERS

LAM Plug and Play Interface

- universal sensor data interface
- independent network ethernet based 10 Mbit
- access to logistical data
- merging tool and sensor data => the virtual tool
Application Examples of SEERS in Production
Automatic Fault Detection

Different fault detection methods possible. First: average value of ν, n

SEERS sensitive to
- pressure
- magnetic field
- RF- power
- chemistry
- chamber condition
- pre-processes
- etched substrate
- arcing

Average curve from 80 individual M1 runs.

SEERS Fingerprint
Automatic Fault Detection

Arcing Traces in Chamber ⇒ Exchange of E-Chuck and Ion Shield

Fault detected by lot-average of $\nu$
Tool start up / Tool release

Checking Chamber Condition with SEERS

Define
Determine
Perform Tests for

- reference recipe
- process fingerprint
- HW change
- tool hook up
Tool start up / Tool release

Recipe
Step 1
25mtoorr / 215W / 30G /
50 sccm O2

Step 2
25mtoorr / 215W
0 G / 50sccm O2
Chamber Conditioning
(after idle chamber)

Normalized warm up curve

First wafer effect
- same chamber
- approx. 1h idle
- different gasses
- $P_{G/D}$ proportion 1:2
- $t_{G/D}$ proportion 1:2.2
- $p_{G/D}$ proportion 1:2.5

similar warm up curve with strongly different recipes
=> thermic effect expected

Comparison with different recipes
Chamber Conditioning
(after wet clean)

Lesson learned: minimal collision rate correlates with particle count

Usual procedure with resist and poly wafers

Conditioning procedure I
- resist wafers
- poly wafers
- particle test
- etch-rate test

acceptable particle level after > 50 wafers
=> long and costly procedure
Chamber Conditioning (after wet clean)

Collision Rate rises as poly is etched
- still not perfect conditioning

Improved conditioning with patterned oxide wafers

Conditioning procedure II
- oxide wafer for low collision rate
- patterned wafers
- constant collision rate
- particle test
Chamber Conditioning
(after wet clean)

Conditioning procedure III
- resist wafers
- oxide wafers (unpatterned)
- particle test

Collision rate evolution after the third wet clean

Only 10 wafers for conditioning compared to prior 50!

Optimized procedure with resist and oxide wafers

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Influence of Pre-Processes

Process mix at one chamber

Collision rate with different pre-processes

GC MO Process
- stable level for $\nu$ at $10^6 s^{-1}$
- P3 pre-process highest impact
Influence of Pre-Processes

P3: strongly polymerizing process
P1: strongly etching of polymers

Process mix impact on product

- Multi-Process-Chamber
- Preprocess indicated
- P3 has highest impact
- P1 compensates P3 impact
Influence of Pre-Processes

Data Mining: Decision Tree
- based on statistics
- suitable for high data volume
- detects correlation

Target for decision tree: Plasma Collision Rate $\nu$

$\Rightarrow$ Correlation: Collision Rate / GC BIAS for special Lots with high collision rate

Decision Tree for Electrical Data
Influence of Pre-Processes

Strong correlation between collision rate and GC bias ($R^2 > 0.92$) for indicated lots with high collision rate

Plot of collision rate and GC bias
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