Journey and Development history on SiC

From Metal Lift-off to Metal Etch – from Singlewafer to Batch application

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Motivation

Metal Lift-off by singlewafer process

Metal Etch by singlewafer process

Metal Etch by batch process

Summary
Motivation

2015
customer request for development of metal lift-off process on SiC-wafers (automotive application)

2016
qualification of singlewafer equipment for Metal Lift-off development of alternative process: Metal Etch

2017-2020
qualification of further equipment for Metal Etch/PR-Strip

2021
qualification of batch equipment for Metal Etch

... follow me now to the exciting journey through our development history on SiC ...
Metal Lift-off
by singlewafer process

Process development on 100/150mm SiC

Summary
Process development on 100/150mm SiC

Layer construction
• Metal stack: Ag / Ni / Ti (evaporated)
• 2 resist layers with positive resist

R&D steps
• Evaluation of AP&S Lift-off process on customer specific wafers / metal stacks / structures
• Definition of most appropriate solvent → DMSO ✓
• Evaluation of requirement of presoak station / different rinse options and its pro’s & con’s
• Generation of morphological and statistical data
• Pre-qualification of MLO process and SpinLift-off equipment in AP&S DemoCenter

Challenges
Verification that following problems not caused by AP&S Lift-off
• Black spots on Al metallization
• PR- and metal peeling
• Corrosion effects on pads Ag/Al

⇒ Optimization of Lithography steps by customer solve these problems!
⇒ no negative impact caused by AP&S Lift-off process!
Summary

✓ Qualification of a new process for metal lift-off on customer site
✓ Residual-free metal lift-off with optimized CoO
✓ several fully-automated equipmens for mass-volume production
✓ Equipment = bridge-tool for 100/150mm SiC wafers
✓ Parallel processing of various wafer thicknesses
Metal Etch
by singlewafer process

Motivation for metal etch

Process development on 150mm SiC

Tool configuration & Process flow

Process performance

Summary
Motivation for metal etch

• Rise of overall process performance due to new metallization method

• Optimization of electrical parameters on chip-level -> yield!

• Integration of 100% process control within wet process
Process development on 100/150mm SiC

Layer construction
• Metal stack: Ti / Ni / Ag (evaporated)
• etch mask by positive resist layer

R&D steps
• Evaluation of SpinMetal equipment on customer specific wafers / metal stacks / structures
• Definition of process parameters and sequence
  Ag Etch = SC1 @ RT | Ni = dHNO3 @ 35°C | Ti Etch = dHF @ RT | PR-Strip = DMSO @ 40°C
• Generation of morphological and statistical data
• Pre-qualification of Metal Etch process in AP&S DemoCenter + AP&S partner university for SEM analysis
• Pre-qualification of optical Endpoint Detection system for process control
• Pre-qualification of production sequence for Metal Etch + final PR-strip

Challenges
• Avoidance of etch defects (shadowing!)
• Defined undercut for each metal layer
• Fine-tuning for etch / PR-strip / rinse
Process performance

**Etch process**
- Full etch of metal stack Ag / Ni / Ti
- Defined undercut + non-uniformity
- No residual metal or DMSO detectable by EDX

![No metal detected](image1)
![No residual DMSO detected](image2)

**Endpoint Detection**
- Significant reduction of overetch / undercut
- Significant reduction of process times
  \[ Ag = 21.3\% \quad | \quad Ni = 4.2\% \quad | \quad Ti = 17.4\% \quad | \quad \Sigma = 16.3\% \]
- Significant reduction of chemical consumption = 18.6\%
Tool configuration & Process flow

Tool configuration

- Fully-automated double chamber system: \textcolor{red}{\textbf{SpinMetal}} + \textcolor{red}{\textbf{SpinLift-off}}
- Optical Endpoint Detection System to guarantee reproducible etch performance
- 100% process control for each etchant by concentration monitoring system
- Throughput = 10 wafer / hr

Process flow

Metal Etch on 150mm SiC / \textcolor{red}{\textbf{SpinMetal}}

PR-Strip on 150mm SiC / \textcolor{red}{\textbf{SpinLift-off}}
Summary

✓ Qualification of new process for metal etch + PR-strip on customer site
✓ High process stability by integrated Endpoint Detection System
  ✓ Exact and repeatable detection of etch stop
  ✓ Stable non-uniformity WiW + WtW
  ✓ Compensation of variation in layer thickness + etchant concentration
✓ Several fully-automated equipment's for mass-volume production
✓ Equipment = bridge-tool for 100/150mm SiC wafers
✓ Parallel processing of various wafer thicknesses
Metal Etch

*by batch process*

Process transfer singlewafer -> batch

Tool configuration & Process flow
Process transfer singlewafer -> batch

Motivation
• Significant rise of throughput for 150mm SiC wafers compared to singlewafer equipments
• Stabilization of process performance by fully-automated wet bench vs. manual wet bench (pre-production)

Estimated Challenges
• Process control in terms of parameters and quality
• Process performance on chip level by different equipment technology
Tool configuration & Process flow

Tool configuration

• Fully-automated wet bench Dry-In / Dry-Out
• Batch size = 2x 25 Wafer
• 100% process control for each etch module
• Increased bath lifetime by etchant stabilization
• Optimized hydrodynamics within process tanks
• Calculated throughput = 150 wafer / hr

Process flow

Dry-In | Ag Etch SC1 | Rinse | Ni Etch dHNO₃ | Rinse | Ti Etch dHF | Rinse | NID™ Dry | Dry-Out

Metal Etch on 150mm SiC / mass-volume production
Summary

✓ Qualification of process transfer currently on-going
✓ First etch tests show good results which match with process requirements
  ✓ no deviation of performance vs. singlewafer process
  ✓ optimized overall defectivity
  ✓ flow dynamics enable wide range of optimization on various structure layouts
✓ Equipment = bridge-tool for 100/150/(200mm) SiC wafers
✓ Parallel processing of various wafer thicknesses
Successful integration & qualification of metal lift-off and metal etch on SiC

Process development and pre-qualification in AP&S DemoCenter for quick transfer to production

Close partnership with one of the world’s leading semiconductor manufacturer

Continuous optimization for process performance and stabilization

Process transfer to different equipment technology on going
Thank you

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