CMP nHancement
Applications Using ViPRR Carrier Technology

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Discussion agenda

- Strasbaugh Introduction
- ViPRR Carrier Technology & CMP nHacement Program
- ViPRR & CMP nHacement Applications
  - IC Manufacturing
  - Thin Film Head (TFH) Manufacturing
  - Failure Analysis (FA)
  - Research & Development

- Summary
Strasbaugh Introduction

- Founded in 1948, Strasbaugh has more than 50 years experience designing, innovating and manufacturing precision surfacing systems
- Over 15,000 polishing and grinding systems manufactured to date
- Over 45 models available today for use in diverse high-technology markets
- Headquarters in San Luis Obispo, California
- Representation throughout the world
Strasbaugh CMP Product Line

- **nTrepid (6EH)**
  - 150-300mm

- **nTegrity (6DSSP)**
  - 75-200mm

- **nHance (6EG)**
  - 150-300mm

- **nSpire (6EC)**
  - 75-200mm
ViPRR Carrier Technology and CMP nHancement Program
ViPRR Wafer Carrier

- Strasbaugh first introduced ViPRR Carrier in 1997
  - Design featured ball & socket gimbal mechanism, post in hole rotational drive, and a pneumatic retaining ring
- Since then, Strasbaugh has released a series of ViPRR carriers, including ViPRR II, III, and most recently the ViPRR IV Carrier
- ViPRR IV has been successfully implemented for a variety of wafer sizes on both Strasbaugh CMP machines as well as IPEC 372 and 472 polishers.
- The IPEC ViPRR IV and related control hardware have been named:
  “CMP nHacement” or “CMPE”
ViPRR IV Wafer Carrier

- Top Plate
- Mounting Ring
- Clamp Ring
- Drive Coupler
- Upper Spherical Bearing
- Inflatable Seal
- Manifold Plate
- Grooved variable height retaining ring
- Lower Spherical Bearing
- Wafer mounting plate
- Zone back pressure o-ring grooves
ViPRR IV Carrier Design Features

- **Projected gimbal**
  - Improves wafer to pad alignment for enhanced CTE uniformity, slurry distribution, edge exclusion, increased resistance to vibration, and flatter retaining ring wear

- **Pneumatically-controlled ViPRR retaining ring**
  - Pre-compresses polish pad ahead of the wafer, controlling pad rebound effect and improving uniformity to 3mm edge exclusion or better

- **Angular pick-up**
  - Prevents “suction cupping” at the polish pad during wafer pick-up
ViPRR IV Carrier Design Features

- **Zone back pressure**
  - Controls center to edge uniformity using two or three zones of control

- **Few moving parts**
  - For higher reliability, simplified carrier maintenance, and extended process stability

- **Grooves in the retaining ring**
  - Improves slurry distribution, reduces heat generation at polish pad

- **Proven in production**
  - Original ViPRR I carrier released in 1997
**ViPRR- Zone Back Pressure**

- Allows air back pressure to be applied selectively to circumferential zones within the carrier.
- Provides air cushion and pressure between wafer and carrier backing film in order to improve center-to-edge WIWNU.
- ViPRR’s design allows precisely controlled back pressure to be applied to the wafer through the backing film.
ViPRR- Pneumatic Retaining Ring

<table>
<thead>
<tr>
<th>Rem Within-Wafer-Non-Uniformity</th>
<th>5mmEE</th>
<th>3mmEE</th>
<th>2mmEE</th>
<th>1mmEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1</td>
<td>8.89%</td>
<td>10.62%</td>
<td>11.85%</td>
<td>12.96%</td>
</tr>
<tr>
<td>Test 2</td>
<td>6.43%</td>
<td>8.95%</td>
<td>9.76%</td>
<td>11.85%</td>
</tr>
<tr>
<td>Test 3</td>
<td>2.92%</td>
<td>4.13%</td>
<td>6.82%</td>
<td>8.65%</td>
</tr>
<tr>
<td>Test 4</td>
<td>1.96%</td>
<td>3.06%</td>
<td>4.65%</td>
<td>7.51%</td>
</tr>
</tbody>
</table>
## ViPRR / IPEC Carrier Comparison

<table>
<thead>
<tr>
<th>Strasbaugh ViPRR Carrier</th>
<th>IPEC Carrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone back pressure uniformity control and air cushioning</td>
<td>No zones for uniformity control</td>
</tr>
<tr>
<td>Pneumatically controlled retaining ring force</td>
<td>No edge exclusion technology</td>
</tr>
<tr>
<td>Low friction projected gimbaling and drive mechanisms</td>
<td>O-ring &amp; T-bar rotation cause friction in gimbal</td>
</tr>
<tr>
<td>Center of gimbal at pad/wafer interface</td>
<td>Gimbaling occurs above the pad</td>
</tr>
<tr>
<td>Simple backing film installation using alignment pins</td>
<td>No backing film alignment method</td>
</tr>
<tr>
<td>Advanced materials for reliability and durability</td>
<td>Legacy technology using legacy materials</td>
</tr>
</tbody>
</table>
CMPE for IPEC Tools using ViPRR Carrier

- ViPRR IV carrier implementation onto IPEC 372 & 472 CMP machines for Oxide and MEMS applications
ViPRR CMPE, Oxide Production Application

Fab Production Run Results with ViPRR carrier Technology (CMPE)

- Production Removal Target = 5000 A/min
- Pad life improved ~55%
- WIWNU improved ~25%
- Removal rate increased ~30%

Current Production WIWNU Target < 15%

Removal Rate, A/min

0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0

Removal WIWNU, %

0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0

Wafers #

Wfr# 10
Wfr# 40
Wfr# 41
Wfr# 55
Wfr# 111
Wfr# 161
Wfr# 213
Wfr# 227
Wfr# 236
Wfr# 313
Wfr# 369
Wfr# 425
Wfr# 493
Wfr# 549
As dimensions in thin film magnetic read/write heads become smaller, the CMP process has become critical to the manufacturing-process:

- **Lower layer CMP**
  - Smooth Al2O3 surface on AltiC substrate
  - Smooth, defect-free surface (Al2O3 & NiFe) for reader track-definition photolithography control

- **Upper layer CMP**
  - OC CMP – CMP (Al2O3 and Cu) to open up Cu studs for gold bond pads plating
TFH CMP Using ViPRR Carrier

- Lower layer surface roughness (Ra) results:
  - Pre surface Ra=3nm;
  - Post CMP Ra<0.2nm

- Upper layer Step Height (SH) results:
  - Pre SH ~5um;
  - Post SH<0.02um

- Blanket monitor ThK variation 1σ results:
  - WIW = 60nm
  - WTW = 40nm

![Graph showing removal rate and WIWNU](image-url)
FA is widely used in IC manufacturing to shorten yield learning cycles

Previous FA sample preparation methods had shortcomings:

- RIE/wet etch processes resulted in planarity/topology control loss
- Grinding (mechanical polishing) was a very slow process
  - Samples often prepared one die at a time
  - Could take up to a week to prepare a wafer for analysis
Whole wafer deconstruct (WWD) using CMP technology was developed to reduce sample preparation time, allowing much quicker response time, throughput, and lower cost.

- ViPRR added the necessary process improvements for uniformity (within wafer and die)
- Sample preparation time reduced from days to hours
- The advantage of quickly preparing wafers for FA has been recognized and has contributed much to the success of yield ramping
Silicon Haze Removal Using ViPRR & ZBP

- **Example 1 - Center fast**
  - Set Zone 1 (outer) = Low pressure
  - Set Zone 2 (inner) = High pressure

- **Example 2 - Edge fast**
  - Set Zone 1 (outer) = High pressure
  - Set Zone 2 (inner) = Low Pressure
Silicon Haze Removal Using ViPRR and ZBP

- **Example 3 - equal removal across wafer**
  - Back pressure zones 1 and 2 are optimized for uniform Silicon removal

![Graph showing Silicon haze removal](image)

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ViPRR for R&D Applications

- Cu slurry development with Strasbaugh nHance Polisher and ViPRR carrier technology

![Graph showing Cu Removal Rate vs. Polishing Down Force](image1)

![Graph showing Cu854 iCue5000 LT Performance](image2)
Summary

- Strasbaugh’s ViPRR carrier technology has been successfully implemented on Strasbaugh and IPEC CMP equipment for many polishing applications including:
  - IC production applications
  - TFH fabrication
  - Whole Wafer Deconstruct for FA
  - Si primary wafer applications
  - MEMS
  - R&D (slurry, pads, film materials, substrate, etc.)

- ViPRR carrier technology has functioned well for many wafer sizes from as small as 75mm up to 300mm
Summary

- The VIPRR IV design combines ZBP, spherical gimbal, and wafer edge profile control that has yielded state of the art WIWNU performance at an edge exclusion of less than 3mm for many applications.

- VIPRR IV’s projected gimbal design provides improved carrier stability and performance and reduces vibration in high friction processes.

- The CMPE program has extended the useable life of many IPEC 372 and 472 polishers, bringing up-to-date carrier performance to a solid platform.