IC CMP and GMR Head CMP are Not the Same – Custom Solutions are Required

CMP User’s Group, Sept. 15 2010
Introduction

• CMP equipment designed for mainstream IC manufacturing does not adequately support the needs of Hard Disk Drive makers

• CMP equipment suppliers must address the unique requirements of the HDD industry in order to be successful

• Custom solutions produce better results:
  – Improved process performance
  – Higher throughput
  – Lower cost of ownership
  – Higher yields
Contents

- Strasbaugh Overview
- CMP Applications, Similarities and Differences
- GMR Head CMP Challenges
- Custom Solutions that Work
• Founded in 1948
  – Strasbaugh has over 60 years of leadership in design and manufacturing of systems for precision surface preparation including CMP, polishing, and grinding

• With over 15,000 polishing and grinding systems sold
  – Strasbaugh is recognized around the world as a leader in precision polishing and grinding technology

• Many design & development partnerships
  – developed with world leading Semiconductor, LED, Optics, and Photonics companies, plus various substrate manufacturers

• Strasbaugh became a public company in 2007
  – currently trading on the OTC bulletin board under the symbol STRB.OB

• Headquarters are in San Luis Obispo, California
  – with a world-wide sales and support network

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### CMP and Polishing Systems

<table>
<thead>
<tr>
<th>Product</th>
<th>Wafer Sizes</th>
<th>Automation</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>STB P300</td>
<td>150-300mm</td>
<td>Full</td>
<td>3 Table, 2 Spindle, DIDO/DIWO</td>
</tr>
<tr>
<td>Hance</td>
<td>200-300mm</td>
<td>Semi</td>
<td>1 Table, 1 Spindle, DIWO</td>
</tr>
<tr>
<td>Spire</td>
<td>75-200mm</td>
<td>Semi</td>
<td>1 Table, 1 Spindle, DIWO</td>
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<tr>
<td>Tegrity</td>
<td>100-200mm</td>
<td>Full</td>
<td>2 Table, 2 Spindle, DIWO</td>
</tr>
<tr>
<td>Finity</td>
<td>100-200mm</td>
<td>Full</td>
<td>2 or 3 Table, 2 or 3 Spindle, Wax-mount Polisher</td>
</tr>
</tbody>
</table>

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### Grinding Systems

<table>
<thead>
<tr>
<th>Product</th>
<th>Wafer Sizes</th>
<th>Automation</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>nTellect</td>
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<td>Full</td>
<td>4 Cassette, 2 Work Chuck, 2 Grind Spindle, Infeed Rotary Surface Grinder</td>
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<tr>
<td>nGenuity</td>
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<td>Full or Manual</td>
<td>2 Cassette, 1 Work Chuck, 1 Grind Spindle, Infeed Rotary Surface Grinder</td>
</tr>
<tr>
<td>nCompass</td>
<td>100-200 mm</td>
<td>Full</td>
<td>Precision Edge Profiler</td>
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</table>

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Driving Future Growth

Strasbaugh continues to help drive technology forward

– by investing heavily in new products and leading edge technologies for strategic, high growth industries

These industries include:

– Semiconductor CMP
– LED
– TSV
– MEMS
– GMR Head CMP
– Silicon Prime Wafer
– Compound semiconductor
– Wafer reclaim
– Failure Analysis
– Precision Optics
CMP Applications
CMP Applications

• **CMP is critical to a broad range of applications including:**
  – GMR and MR Head
  – Semiconductor IC
  – Through Silicon Via (TSV) or 3D IC
  – MEMS
  – LED

• **Common concerns:**
  – Planarity
  – Uniformity
  – Dishing and erosion
  – Edge exclusion
  – Removal rate
  – Defectivity

• **One solution does not fit all**
Gigantic Magnetoeresistive Head

Detailed structure of a GMR head assembly. The arm/slider/head structure at the top is actually only about ¼" (6.3 mm) long.

Cross sectional view showing multilayered design and required CMP steps. A typical such “sensor stack” is about 40 nm thick. A typical wafer will have a capacity of about 20,000 such heads.

Original image © IBM Corporation from www.pcguide.com

Image from www.electroiq.com
Microelectromechanical Systems (MEMS)

The resonant ring at the heart of the Silicon Sensing Systems gyro is shown here as an SEM image.

Silicon Sensing Systems, a joint venture between Sumitomo and British Aerospace (BAE), has brought to market an electromagnetically driven and sensed MEMS gyro. A permanent magnet sits above the MEMS device. Current passing through the conducting legs creates a force that resonates the ring. This Coriolis-induced ring motion is detected by induced voltages as the legs cut the magnetic field.
**Through Silicon Via (TSV)**

**Via-first integration** forms the TSVs in the wafer fab during frontend processing, and the vias are generally smaller, ranging from 1-10µm dia. and 10-60µm in depth.

**Via-last integration** takes place in assembly and packaging after wafer processing is completed and typically creates fewer, larger vias, 20-50µm in dia. and 50-400µm deep.

The market forces driving 3D IC development include consumer demand for greater functionality in smaller devices, enhanced performance in advanced computing systems and, ultimately, lower cost. Thinned chips connected by TSVs can reduce the height and width of the packaged chip stack relative to current wire bonding technologies.
Light Emitting Diodes (LEDs)

The typical substrates used in LED manufacturing, i.e. Silicon Carbide or Sapphire, are usually chosen for their insensitivity to increased operating temperatures (dissipation coefficient), resistance to most chemicals and radiation, power output, and high field strength. Some LEDs are being made using monocrystalline silicon as the substrate.
<table>
<thead>
<tr>
<th>Application</th>
<th>Pattern Density</th>
<th>Structures</th>
<th>Film Types</th>
<th>Typical Removal</th>
<th>Planarization Challenges</th>
<th>Special Challenges</th>
</tr>
</thead>
</table>
| IC CMP      | Very dense      | • 65 nm down to 22 nm and smaller  
• Metal devices  
• Cu, W plugs | • ILD  
• STI  
• Cu  
• Al  
• W  
• TiN  
• TaN | ~ 4000 Å (or 0.4 microns) | • 10 or more metal layers  
• 6% - 8% WIWNU (three sigma)  
• Multitude of various small structures  
• WIW dishing <100 Å | • Defectivity  
• CoO  
• Throughput  
• Dishing/Erosion  
• End Point  
• Low downforces |
| GMR Head    | Moderately dense  
• Density increasing every year | • Large, up to 80µm - 100µm  
• Constant size reduction effort  
• Copper coils | • AlTiC (substrate)  
• Al₂O₃  
• NiFe  
• Cu  
• Tantalum  
• Ruthenium | • up to 35µm of Al₂O₃ overcoat  
• ~ 6µ or less for NiFe  
• 5Kµm - 10Kµm for other film types | • WIW dishing <40 Å (std deviation)  
• Combination of dissimilar material hardnesses of various structures and devices.  
• Substrate bow/warp | • TTV of the AlTiC substrates  
• Results sensitive to pad surface  
• Wafer flats  
• Final thickness control  
• Pre CMP film NU  
• Corrosion |
| MEMS        | Often not dense  
• Numerous structure types  
• Small wafers but large features and structures | • Silicon  
• Oxides  
• Nitrides  
• Titanium  
• Copper  
• Polysilicon | Could be extreme up to several tens of microns. | | | • Wide variety of features, patterns  
• Need excellent planarization  
• Very low down forces are important |
| TSV         | 2µm x 2µm (via first) to 30µm x 100µm or more (via last) up to 400µm | This process exposes narrow but deep trenches for multichip interconnects | Usually silicon but also could involve Al, Cu, Nitrides | 20µm – 50µm (or more) of silicon | | • Thin wafer mounted on glass substrate  
• Combination of grinding & polishing  
• Process CoO  
• Mechanical stress |
| LED         | N/A             | N/A        | Substrate is SiC, Si, or Sapphire | Hundreds of microns | Post-grind polishing balances stress, and facilitates improved brightness | • Thinning process  
• Bow, warp  
• Handling |
Challenges in GMR Head CMP

- Total thickness variation (TTV) of AlTiC substrates
  - TTV can vary from 0µm to 5µm wafer to wafer
  - Substrates can be bowed, warped, concave or convex
- CMP results are sensitive to pad surface
- Wafer flats
- Final thickness control
- Pre-CMP film non-uniformity
- Corrosion of exposed metal on the head device
- Most IC CMP advancements take place at 300mm while the bulk of GMR Head manufacturing is being done on 150 to 200mm wafers
Our latest generation CMP system, the STB P300 has been designed to meet the unique needs of GMR Head CMP.

ViPRR™ Wafer Carrier and Multi-Zone Back Pressure Control
- Available for 125mm, 150mm, 200mm and 300mm wafers
- Better uniformity control & reduced edge exclusion

Low downforce process capability
- Minimizes dishing and erosion

Precision™ Pad Conditioner
- Maintains ideal pad roughness to control uniformity and minimize dishing and erosion

Optical Endpoint
- Prevents over and under polish

Post CMP Cleaning
- Improves defectivity and minimizes corrosion of exposed metal on the head device

Wafer surface grinding prior to CMP for overcoat removal
STB P300-DS™

A Better Choice in CMP
STB P300™ CMP System

Introduction

• Built for flexible process and high volume production
• 15 to 50% smaller footprint than other 300mm high volume production CMP systems
• Independent spindle movement allows flexible process flows through the tool
• Auto Force Calibration™ reduces setup time and the number of test wafers required
• 2 spindle, 3 table design further reduces setup time

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• Industry-proven, integrated cleaning and state-of-the-art defectivity control
• 125, 150, 200, and 300mm wafer size capable – approximate conversion time: 16 hours
• CMP system and cleaner can operate independently from one another
Independent Spindle Motion

- Spindles move independently from one another, enabling flexible process flows through the tool
- The P300 performs serial and parallel processing for one, two, or three table polishing processes
- Allows polish times to vary for each wafer – providing a level of process optimization and flexibility available only with the P300
Process Technologies & Features
150mm Blanket Alumina Process Results (STB P300)

- **Wafers:**
  - 150mm AlTiC substrate with blanket alumina

- **CMP System:** STB P300

- **Carrier:** ViPRR I, Button Style

- **Consumables:**
  - IC1000/Suba IV, K Groove
  - Cabot, MH 210

<table>
<thead>
<tr>
<th>Wafer</th>
<th>WIWNU(%) (61 point contour)</th>
<th>Rate (A/min)</th>
<th>WIWNU(%) (55 point diameter, 5mmEE)</th>
<th>Rate (A/min)</th>
</tr>
</thead>
<tbody>
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<td>1</td>
<td>2.8</td>
<td>10142</td>
<td>2.4</td>
<td>10072</td>
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<td>9867</td>
<td>2.3</td>
<td>9762</td>
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<td>3</td>
<td>2.7</td>
<td>10106</td>
<td>2.3</td>
<td>9988</td>
</tr>
<tr>
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<td>3.8</td>
<td>10153</td>
<td>4.0</td>
<td>10167</td>
</tr>
<tr>
<td>Avg.</td>
<td>3.1</td>
<td>10105</td>
<td>3.0</td>
<td>10050</td>
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</tbody>
</table>

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150mm Blanket Alumina Process Results (nTegrity 6DS-SP)

Average Results:
Removal Rate = 5399 (A/min)
WIWNU (%) = 4.4%
WTW = 0.98%

150mm Alumina Wafers
5mm Edge Exclusion
23 Wafer Run

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ViPRR Carriers

- “ViPRR” = Variable Input Pressure Retaining Ring
- Utilizes solid backing plate with insert film rather than membrane
- Combines with Multi-Zone Back Pressure to optimize uniformity results
- Results in better exclusion at the wafer flat (5mm edge exclusion)
- Proven in production for a wide range of applications since 1997
  - GMR Head, MEMS, TSV, STI, W, TEOS, SOI

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ViPRR Carrier Features

• Angular pick-up prevents “suction-cupping” at the polish pad
• ViPRR retaining ring precompresses the polish pad near the wafer, reducing the possibility of a thick-edge polish
  – Grooved and Non-grooved
  – Designed for flat retaining ring wear for longer ring life
• Few moving parts
  – Improves reliability, minimizes carrier maintenance, and extends process stability
  – Re-assembly is made easy by engraved alignment marks
• Corrosion resistant materials
  – Titanium, SS, Advanced Polymers
• Variety of gimbal choices
  – Choose the gimbal that optimizes process results and provides a large vibration-free window
Improved Uniformity with Zone Back Pressure

Reduced Diameter ViPRR II Carrier - Tungsten Wafer
Standard. vs. Zone Back Pressure Comparison
Diameter Scan (5mm Edge Exclusion)

WITH ZONE BACK PRESSURE
Outer Edge Zone Back Pressure
WIWNU = 2.9 %

WITHOUT ZONE BP
Standard Back Pressure
WIWNU = 11.9 %

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P300 is designed to accurately provide a wide range of polish forces (25 to 750 lbs.)

Low force range calibration data from Strasbaugh P300 CMP Tool

Force is accurate to within 1% down to 10 lbs.

<table>
<thead>
<tr>
<th>Cmd Force (lb)</th>
<th>Actual Force (lb)</th>
<th>Display Force (lb)</th>
<th>Target Error (%)</th>
<th>Display Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>10.1</td>
<td>10</td>
<td>1.0</td>
<td>-1.0</td>
</tr>
<tr>
<td>15</td>
<td>14.9</td>
<td>15.04</td>
<td>-0.7</td>
<td>0.9</td>
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<tr>
<td>20</td>
<td>19.9</td>
<td>19.9</td>
<td>-0.5</td>
<td>0.0</td>
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<td>25</td>
<td>24.9</td>
<td>25.1</td>
<td>-0.4</td>
<td>0.8</td>
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<td>30</td>
<td>29.9</td>
<td>30.05</td>
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<td>0.5</td>
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<td>34.7</td>
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<td>-0.6</td>
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<td>60</td>
<td>59.7</td>
<td>60.1</td>
<td>-0.5</td>
<td>0.7</td>
</tr>
<tr>
<td>70</td>
<td>69.8</td>
<td>70.1</td>
<td>-0.3</td>
<td>0.4</td>
</tr>
</tbody>
</table>
Precision™ Pad Conditioning

- Programmable control of sweep segment dwell time, force, and rotational speed
- Dwell time and downforce are input to control 23 conditioning zones
- Zones can be used to create a specific pad profile
- Conditioning arms for each of the primary polish tables
- Insitu and/or exsitu pad conditioning
- Low profile head maximizes throughput
- Closed loop downforce control holds tighter tolerance enabling ultra low-downforce conditioning

Down force range:
0.5 to 20 lbs.
• Precision Pad Conditioner calibration data shows an average variance of only 0.3% between the target and actual downforce.

<table>
<thead>
<tr>
<th>Target (lb)</th>
<th>Actual (lb)</th>
<th>Display (lb)</th>
<th>Target Error (%)</th>
<th>Display Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3.02</td>
<td>3.03</td>
<td>0.67</td>
<td>0.33</td>
</tr>
<tr>
<td>5</td>
<td>5.01</td>
<td>5.02</td>
<td>0.2</td>
<td>0.2</td>
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<tr>
<td>10</td>
<td>10.05</td>
<td>10.02</td>
<td>0.5</td>
<td>-0.2</td>
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<tr>
<td>15</td>
<td>15</td>
<td>15.01</td>
<td>0.53</td>
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<td>20</td>
<td>20.04</td>
<td>20.03</td>
<td>0.2</td>
<td>-0.05</td>
</tr>
</tbody>
</table>
Cleaning System Overview

- The P300 offers a fully-integrated, industry-proven, post CMP cleaning system
- Wafer size convertible for 150, 200 and 300mm
- Two modular horizontal brush modules with the following features:
  - Active chuck wafer rotation drive system (edge-contact only)
  - Double-side brush scrub
  - Multiple chemistry clean capability (2nd chemical optional)
- Megasonic Module (optional)
- A spin rinse dry (SRD) station
  - Safe edge contact wafer holding
  - DI-water and backside rinse
  - Non-turbulent high volume ULPA airflow system for efficient vapor evacuation
nVision II™
Optical & Motor Current Endpoint Detection

Featuring SMARTpad® Technology
nVision II™
Optical and Motor Current Endpoint

• nVision II is one of the most advanced in-situ endpoint systems available
• nVision II combines multiple endpoint methods in a single system
• The system uses changes in table motor current, spindle motor current, pad temperature, and optical signals to control the CMP process
• Optical endpoint is enabled by Strasbaugh’s patented SmartPad technology – a light source and optical sensor embedded in a polish pad
• nVision II provides
  – Improved process control
  – Increased productivity
  – Reduced costs
  – Higher wafer yields
SmartPad® Technology

• **SmartPad features a wireless IR light source and sensor embedded in the polish pad**
  – Highly reliable
  – Provides better signal integrity
  – Compatible with standard polish pads
  – Maintains consistent pad performance

• **A urethane epoxy is used to embed the sensor:**
  – Adheres well
  – Seals against liquid
  – Maintains pad compressibility

• **TPU cap material**
  – Wears evenly
  – Matches pad properties
  – Does not increase defects
  – Has a good index of refraction and good optical qualities
Advanced filtering and display formatting
Offset, gain, filter order, frequency
Easy filter management
Application: Al2O3 → AlTiC

80RPM Table
4 psi Force
4 psi Ring
4.3 um Alumina
250nm removal
AlTiC Transition
Application: Al2O3 → AlTiC with Cu
Application: Al2O3 → NiFe → AlTiC

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Wafer Grinding Prior to CMP

Bulk Removal of Overcoat Material
Some GMR Head applications have a very thick overcoat layer that needs to be planarized.

In the following example, we used the Strasbaugh nTellect (7AF) wafer grinder to remove up to 35µm of alumina overcoat to expose copper studs.

A 2 minute CMP step was used to remove the grind marks on the exposed copper studs.

- (polish times vary depending on grind mark depth)
## Overcoat Grinding Summary

<table>
<thead>
<tr>
<th>Run #</th>
<th>Grind Wheel</th>
<th>Initial THK (µm)</th>
<th>Target Removal (µm)</th>
<th>Target THK (µm)</th>
<th>Final THK (µm)</th>
<th>Target Error (µm)</th>
<th>Max Down Force (lbs)</th>
<th>Max Grind Time (sec)</th>
<th>Removal Amount (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>800 grit Resin</td>
<td>1295.0</td>
<td>32</td>
<td>1263.0</td>
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<td>0.4</td>
<td>6</td>
<td>88</td>
<td>32.6</td>
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<td>32</td>
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<td>1200 grit KR Resin</td>
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<td>5</td>
<td>79</td>
<td>34.6</td>
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</table>
Grind Wheel Marks on Copper Studs

Figure 1: 800 grit Wheel Grind Marks
Figure 2: 1200 grit Wheel Grind Marks

- The 1200 grit grind wheel caused fewer grind marks
Results of Grinding Process

- **Dramatically shortened CMP process times ➔ higher throughput**
  - CMP without grinding = 35 to 70 minutes to remove 35µm
  - Post-grind CMP = 2 minutes to remove 1 to 2µm

- **Improved final thickness and uniformity ➔ improved yield**
  - TTV can be as much as 5µm
  - Grinding the alumina prior to CMP can reduce the TTV to less than 1µm
  - Long polish times tend to degrade uniformity

- **Reduced CMP consumables usage ➔ lower Cost of Ownership**
  - Achieve 10 to 20 times the pad life
  - Significant savings in slurry, pad conditioning disk wear, retaining rings, etc.

- **Reduces the bottleneck of overcoat polishing ➔ improved production efficiency**
  - Decreases overall CMP capacity requirements
  - Frees up CMP for more critical layers
Conclusion
Conclusion

• Although there are similarities among IC, GMR Head and other CMP applications, a custom solution is required to optimize process performance

• Strasbaugh’s polishing and grinding equipment, including our most recent P300 CMP system, is production proven for GMR Head manufacturing

• We have an inventive mindset and are very willing to customize our equipment to achieve the best results
Thank You

• For more information, please contact us

• General Inquiries:
  – www.strasbaugh.com
  – info.@strasbaugh.com
  – 800.541.6424

• Sarah Okada:
  – sokada@strasbaugh.com