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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

Strasbaugh Background

- **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

CMP and Polishing Systems

STB P300	*n*Tegrity	*n*Hance	*n*Spire	*n*Finity
				

Product	Wafer Sizes	Automation	Descriptions
STB P300	150-300mm	Full	3 Table, 2 Spindle, DIDO/DIWO
***n*Hance**	200-300 mm	Semi	1 Table, 1 Spindle, DIWO
***n*Spire**	75-200 mm	Semi	1 Table, 1 Spindle, DIWO
***n*Tegrity**	100-200 mm	Full	2 Table, 2 Spindle, DIWO
***n*Finity**	100-200 mm	Full	2 or 3 Table, 2 or 3 Spindle, Wax-mount Polisher

Grinding Systems

*n*Tellect	*n*Genuity	*n*Compass
		

Product	Wafer Sizes	Automation	Descriptions
***n*Tellect**	100-200 mm	Full	4 Cassette, 2 Work Chuck, 2 Grind Spindle, Infeed Rotary Surface Grinder
***n*Genuity**	75-200 mm	Full or Manual	2 Cassette, 1 Work Chuck, 1 Grind Spindle, Infeed Rotary Surface Grinder
***n*Compass**	100-200 mm	Full	Precision Edge Profiler

Driving Future Growth

Strasbaugh continues to help drive technology forward

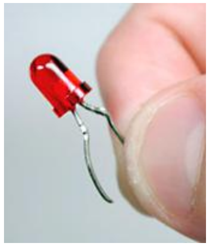
– by investing heavily in new products and leading edge technologies for strategic, high growth industries

Samsung

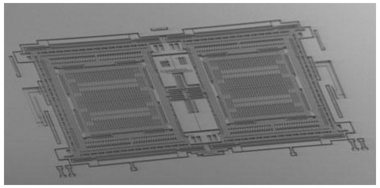
ATT

NASA

ACR AquaLink



Solid State Electronics



Bosch inertial sensor

These industries include:

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

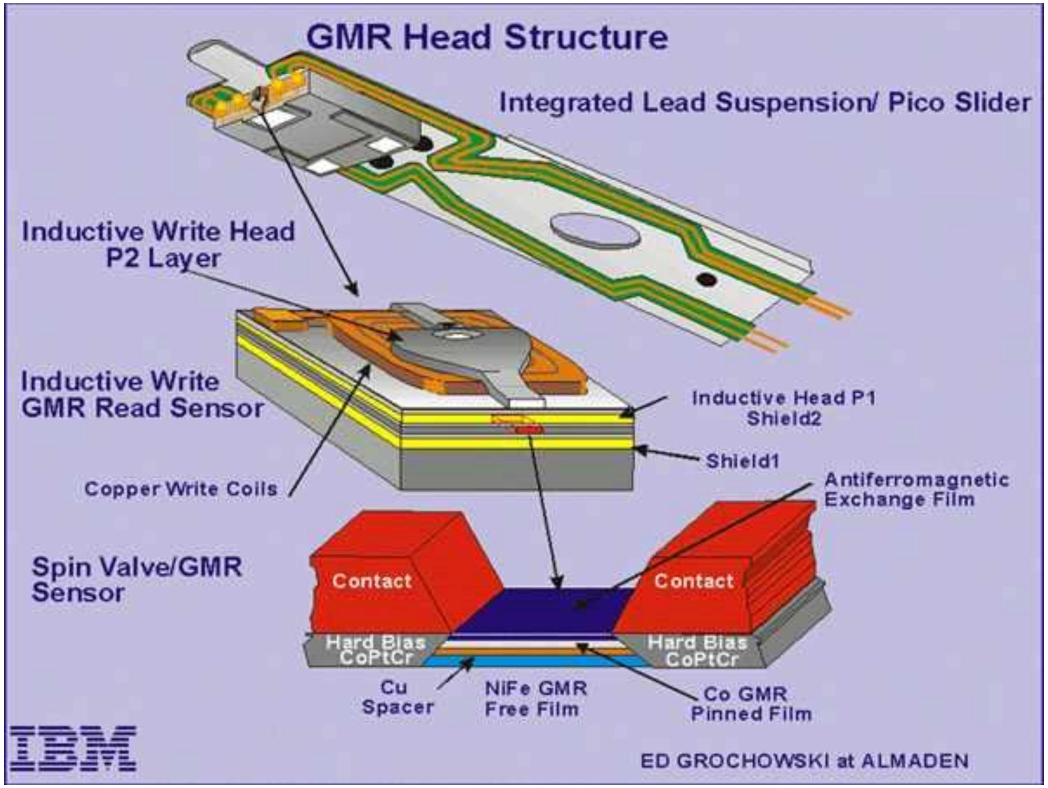
CMP Applications

Similarities and Differences

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 Magnetoresistive 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.

Original image © ***IBM Corporation***
from www.pcguide.com

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.

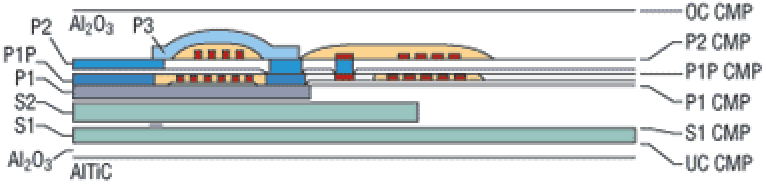


Image from www.electroiq.com

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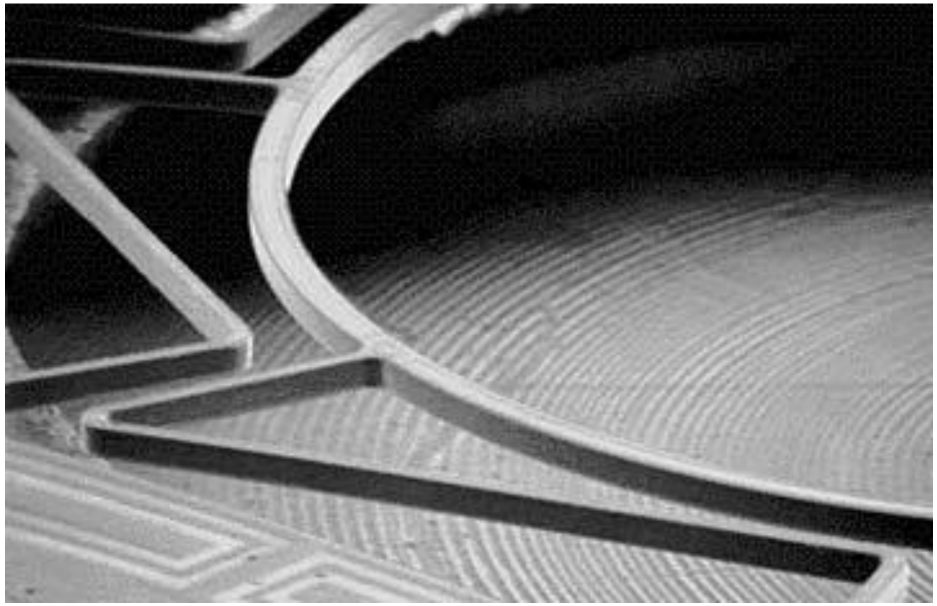
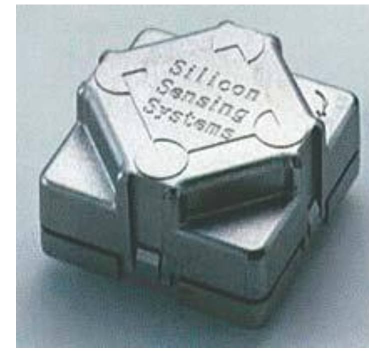
Microelectricomechanical Systems (MEMS)



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.



www.sensormag.com

www.segway.com

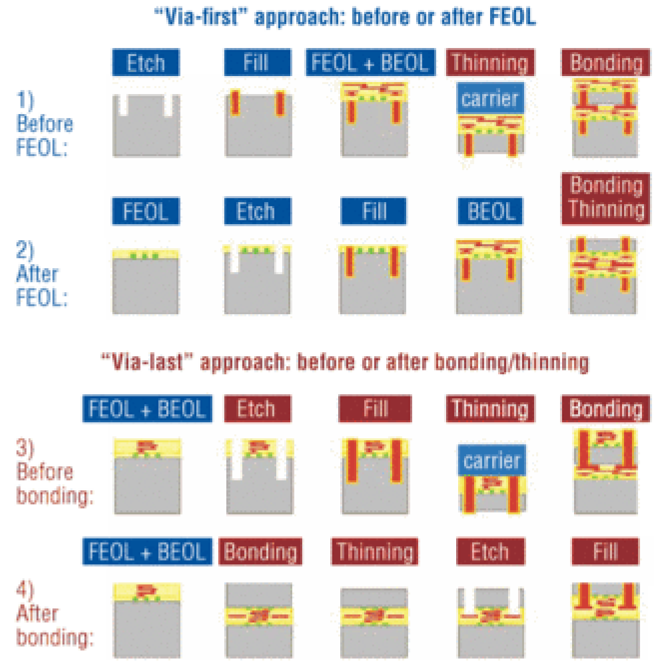
Through Silicon Via (TSV)

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.

TSV integration approaches

		"Via-first"		"Via-last"	
		Before CMOS	Betw. CMOS and BEOL	Before bonding	After bonding
Thinning *before bonding*	Etched material	Si	Oxide and Si	(Metal) Oxide and Si	(Oxide) and Si
	Preferred mask	PR or Ox	PR	PR	PR
	Typical via CD (µm)	2-5	5-20	20-50	5-50
	Typical via depth (µm)	30-50	40-150	50-400	30-150
	Stop layer	None	None	None	Yes
	Bevel/edge protection	Yes	Some	No	No
Thinning *after bonding*	Etched material	Si	Oxide and Si	Oxide and Si	Oxide and Si (and bond layer)
	Preferred mask	PR or Ox	PR	PR	PR
	Typical via CD (µm)	1-5	1-5	3-5	3-5
	Typical via depth (µm)	5-25	5-25	5-25	5-25
	Stop layer	None	None	None	Yes
	Bevel/edge protection	Yes	Some	No	No



All images from www.electroiq.com

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.

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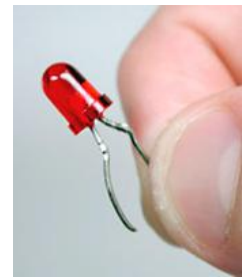
Light Emitting Diodes (LEDs)

www.statusreports.atp.nist.gov

The Real Color Display, a moving sign which is capable of displaying the full range of colors, made possible by the use of blue LEDs.



www. pge.com

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 monocrystaline silicon as the substrate.

Cree's LED chips are used by Siemen's A.G. for back lighting for this dashboard.

www.statusreports.atp.nist.gov

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CMP Applications: Similarities and Differences

Application	Pattern Density	Structures	Film Types	Typical Removal	Planarization Challenges	Special Challenges
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) •Al_2O_3 •NiFe •Cu •Tantalum •Ruthenium	•up to 35µm of Al_2O_3 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.	•Large structures •Thick films •Large open spaces •Small wafers; sometimes one large device per wafer	•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	Expose all of the trenches in order to facilitate chip-to-chip mulitlayer interconnections	•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**

Strasbaugh's Custom Solution

- **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**

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STB P300-DS™

A Better Choice in CMP

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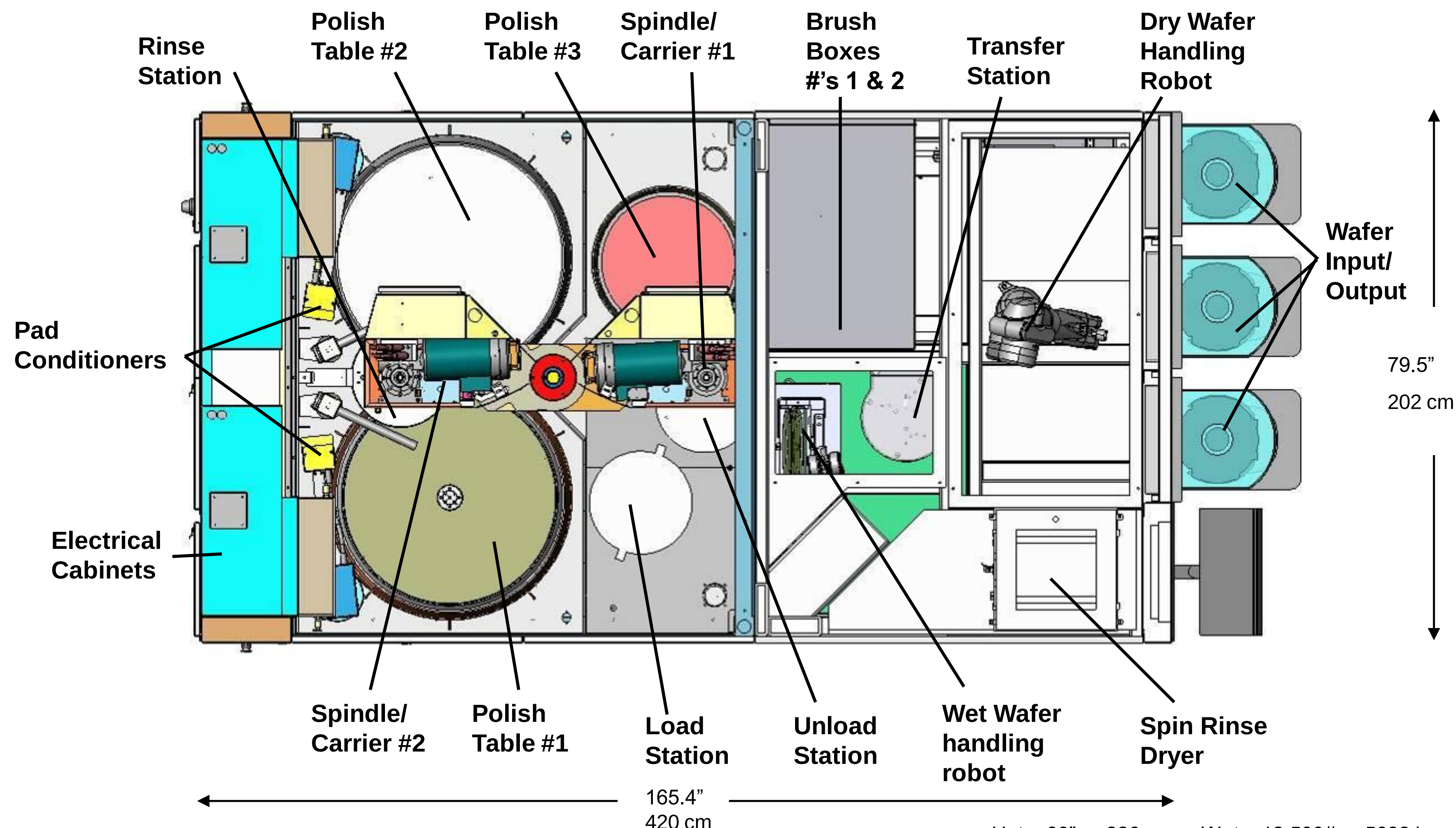
STB P300™ CMP System Introduction

- **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**

STB P300 Introduction Cont.

- **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**

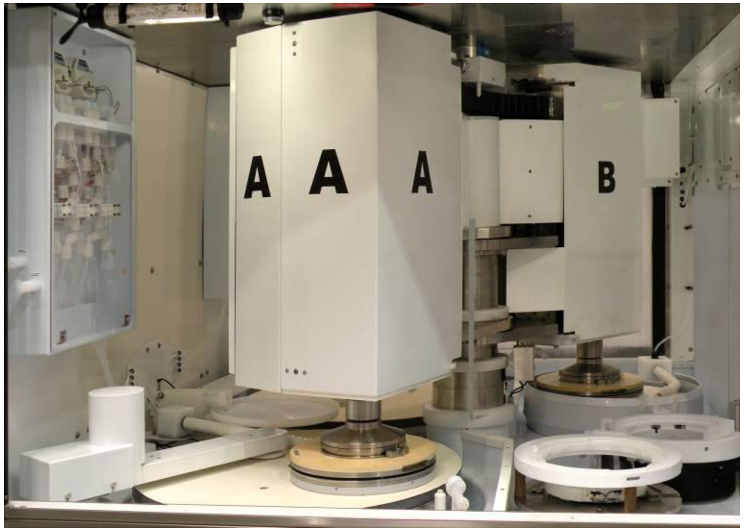
STB P300 Overhead View



Hgt = 89" or 226 cm   Wgt = 12,500# or 5682 kg

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**



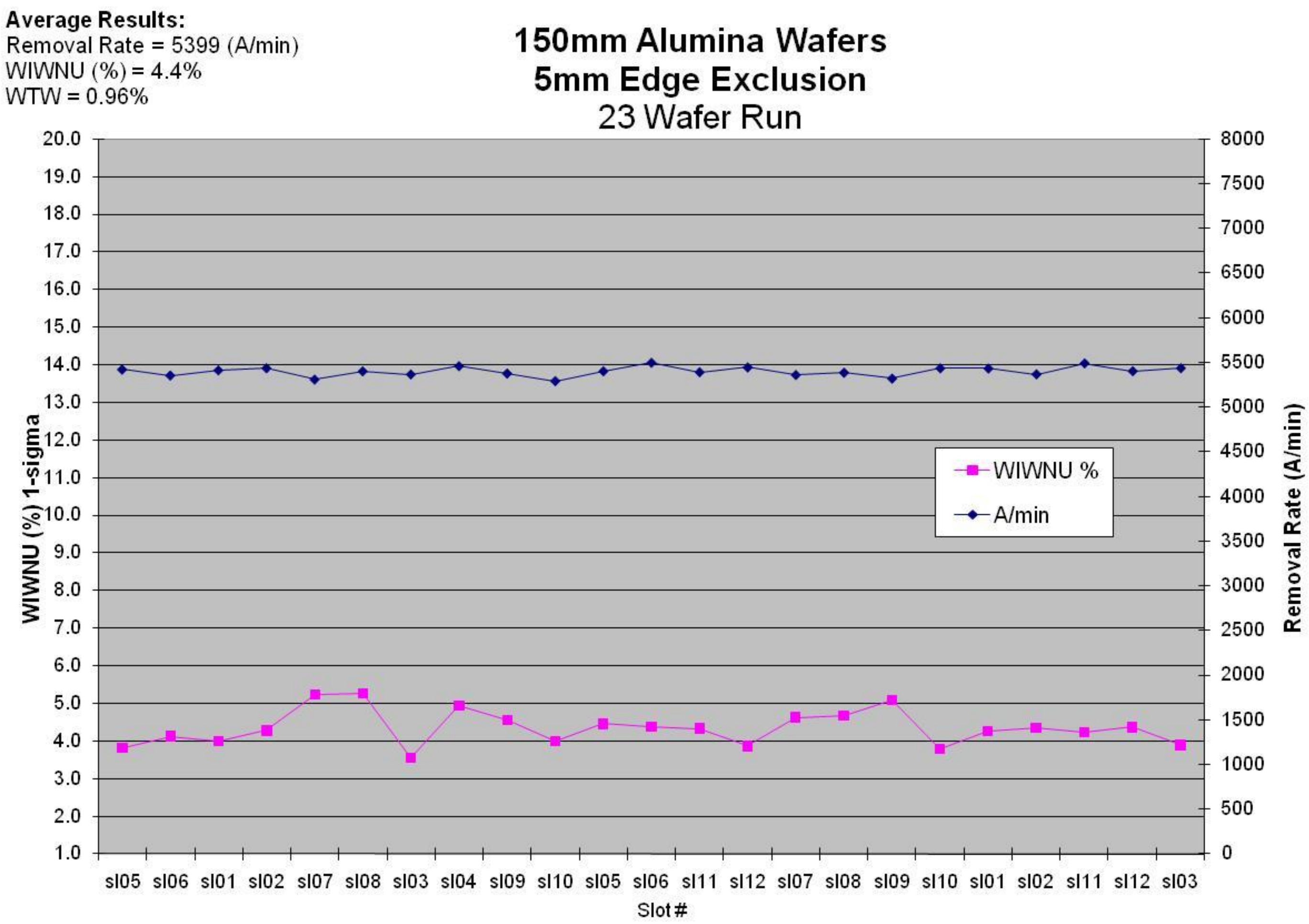
Process Technologies & Features

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

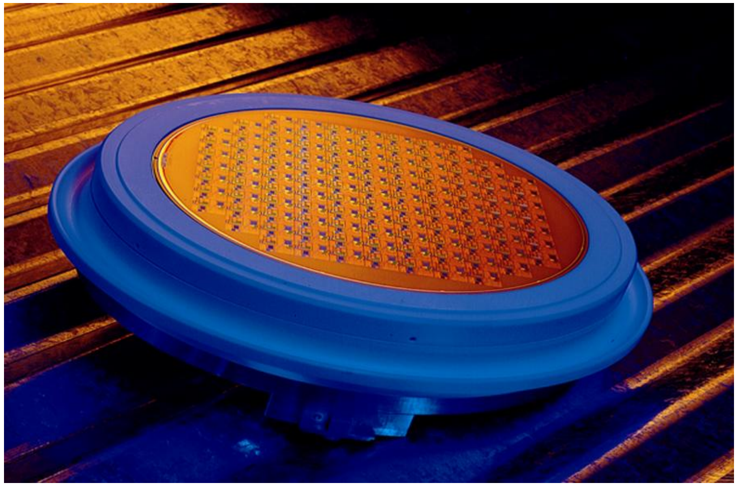
Wafer	WIWNU(%) (61 point contour)	Rate (A/min)	WIWNU(%) (55 point diameter, 5mmEE)	Rate (A/min)
1	2.8	10142	2.4	10072
2	2.7	9867	2.3	9762
3	2.7	10106	2.3	9988
4	3.7	10259	4.1	10259
5	3.8	10153	4.0	10167
Avg.	**3.1**	**10105**	**3.0**	**10050**

150mm Blanket Alumina Process Results (*n***Tegrity** 6DS-SP)



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

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Improved Uniformity with Zone Back Pressure

Uniform Polishing

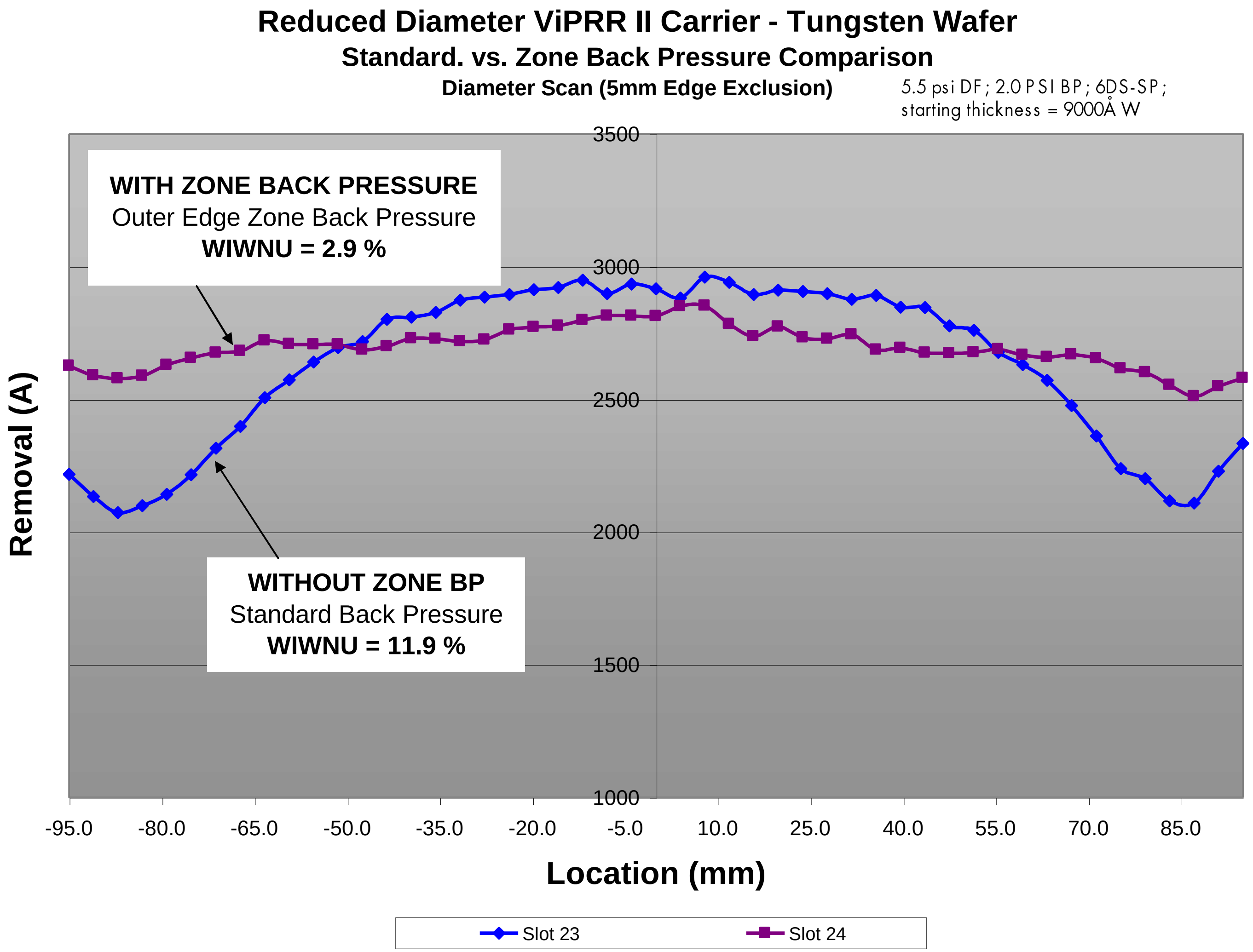
2.8% 1 sigma

Center Fast Polishing

Positive Back Pressure

Center Slow Polishing

Negative Back Pressure



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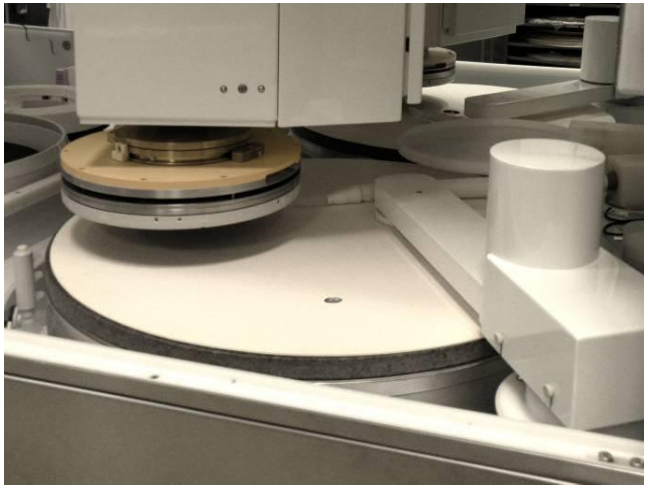
Low Downforce Control

- **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 10lbs**

	Low Range	Calibration				
Cmd Force	**Actual Force**	**Display Force**		**Target Error**		**Display Error**
(lb)	(lb)	(lb)		(%)		(%)
10	10.1	10		1.0		-1.0
15	14.9	15.04		-0.7		0.9
20	19.9	19.9		-0.5		0.0
25	24.9	25.1		-0.4		0.8
30	29.9	30.05		-0.3		0.5
35	34.7	35		-0.9		0.9
40	39.8	39.9		-0.5		0.3
50	49.7	49.9		-0.6		0.4
60	59.7	60.1		-0.5		0.7
70	69.8	70.1		-0.3		0.4

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 Force Control-Example

- **Precision Pad Conditioner calibration data shows an average variance of only 0.3% between the target and actual downforce**

Target	Actual	Display		Target Error		Display Error
(lb)	(lb)	(lb)		(%)		(%)
3	3.02	3.03		0.67		0.33
5	5.01	5.02		0.2		0.2
10	10.05	10.02		0.5		-0.2
15	15	15.01		0.53		-0.46
20	20.04	20.03		0.2		-0.05

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

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*n*Vision II™

Optical & Motor Current Endpoint Detection

Featuring SMARTpad® Technology

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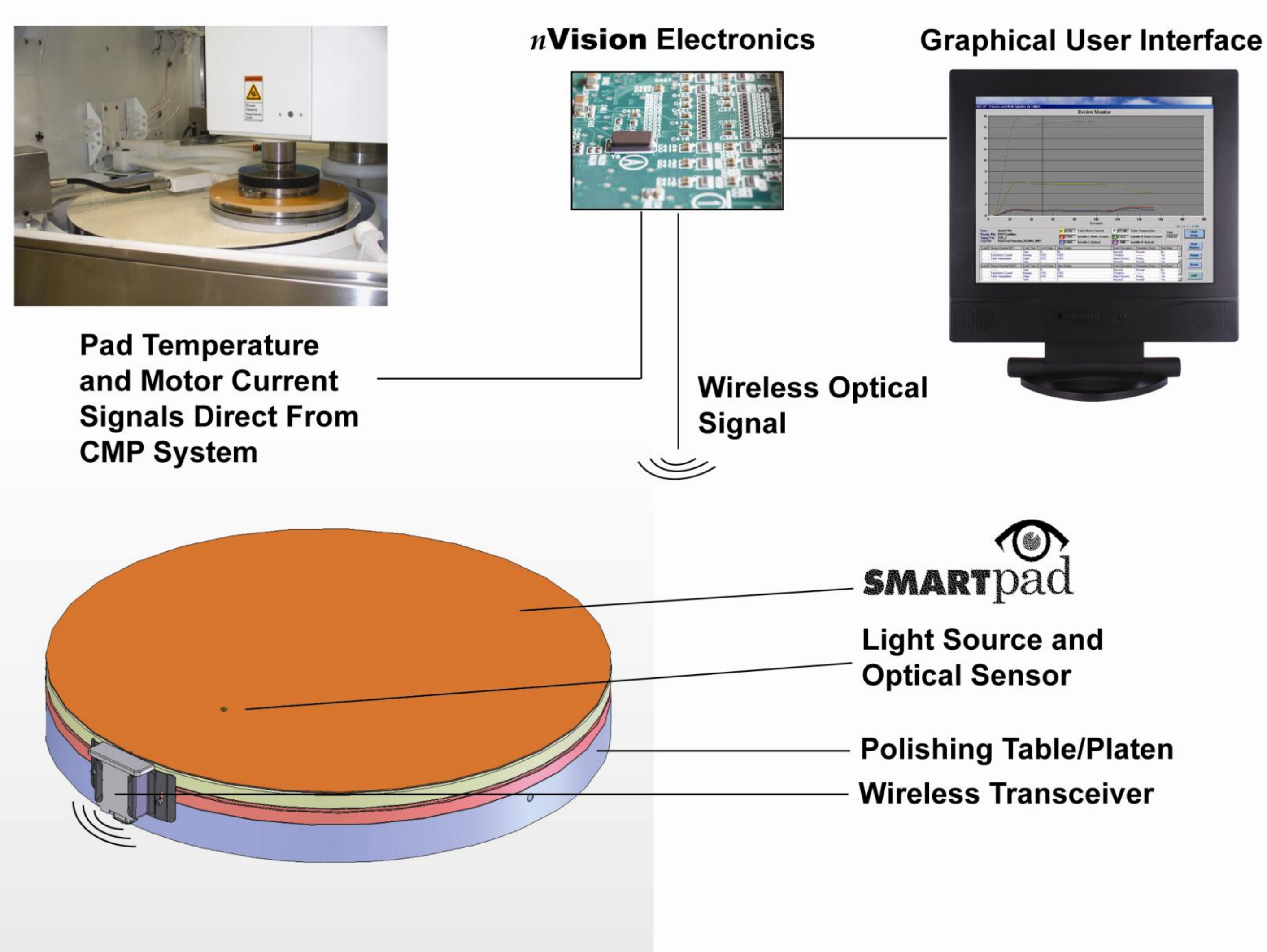
*n*Vision II™ Optical and Motor Current Endpoint

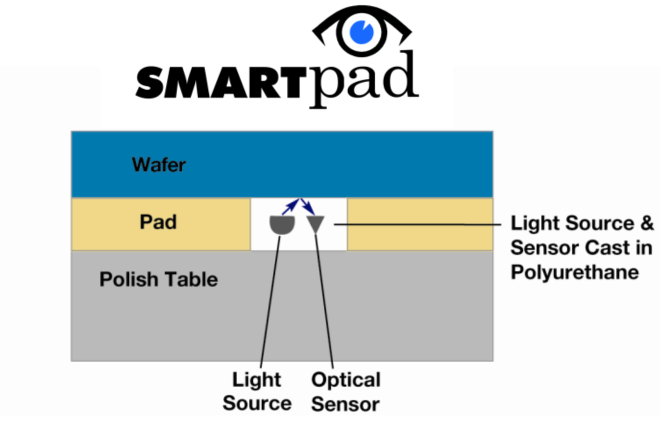
- **nVision II is one of the most advanced in-situ endpoint systems available**
- **nVision II combines multiple endpoint methods in a single system**
- **The system uses changes in table motor current, spindle motor current, pad temperature, and optical signals to control the CMP process**
- **Optical 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

*n*Vision II System Diagram



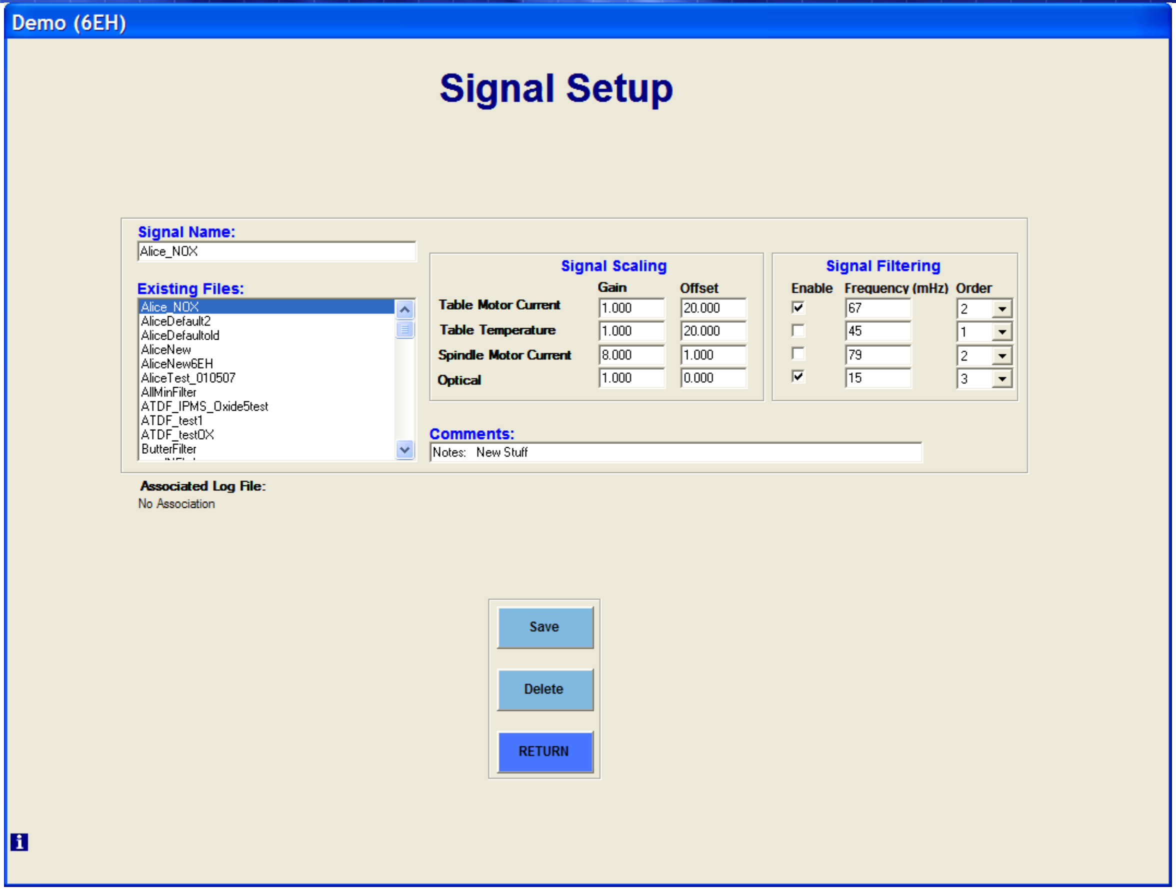
SmartPad® Technology

- **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

*n*Vision II Signal Setup



- **Advanced filtering and display formatting**
- **Offset, gain, filter order, frequency**
- **Easy filter management**

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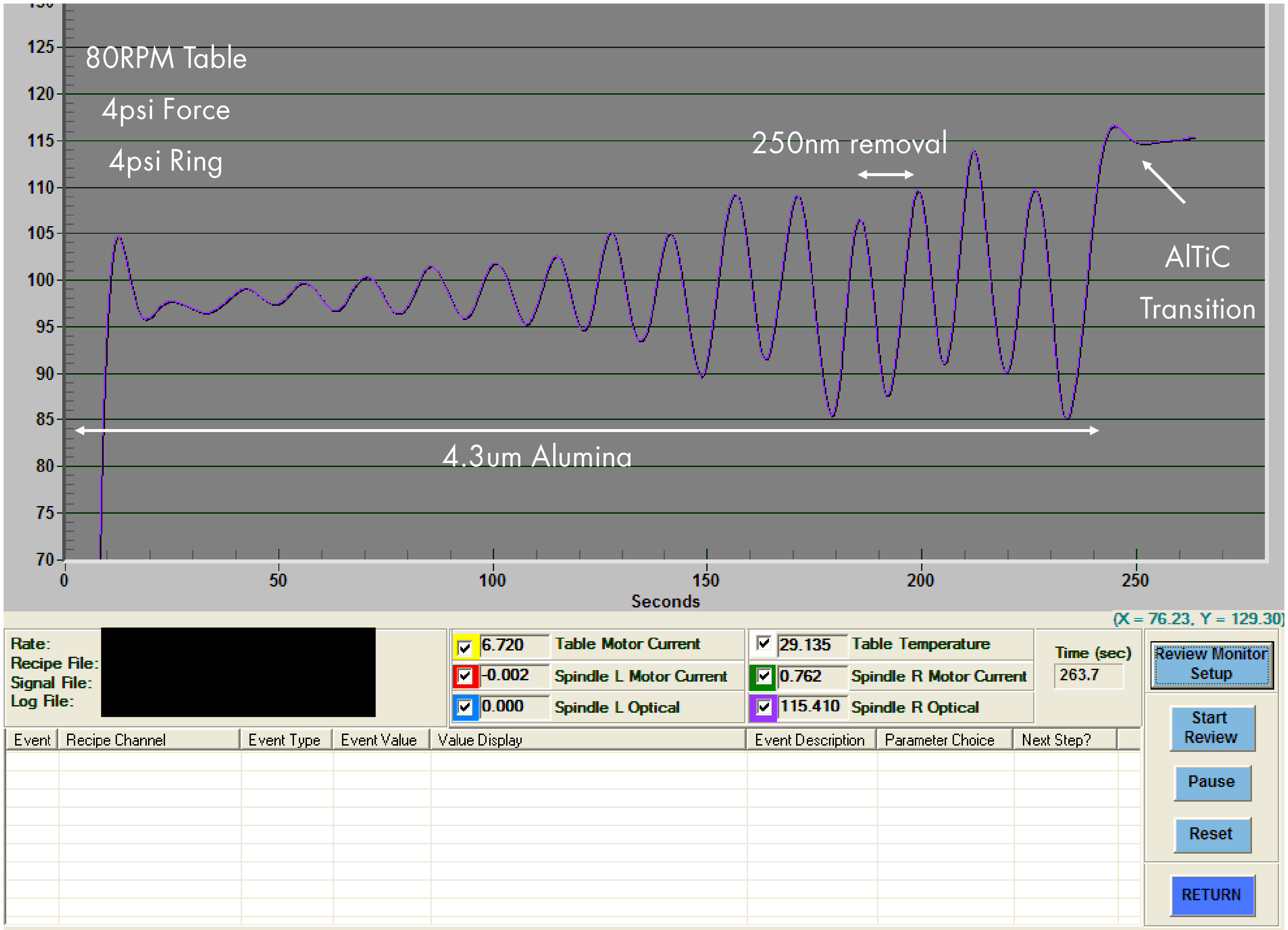
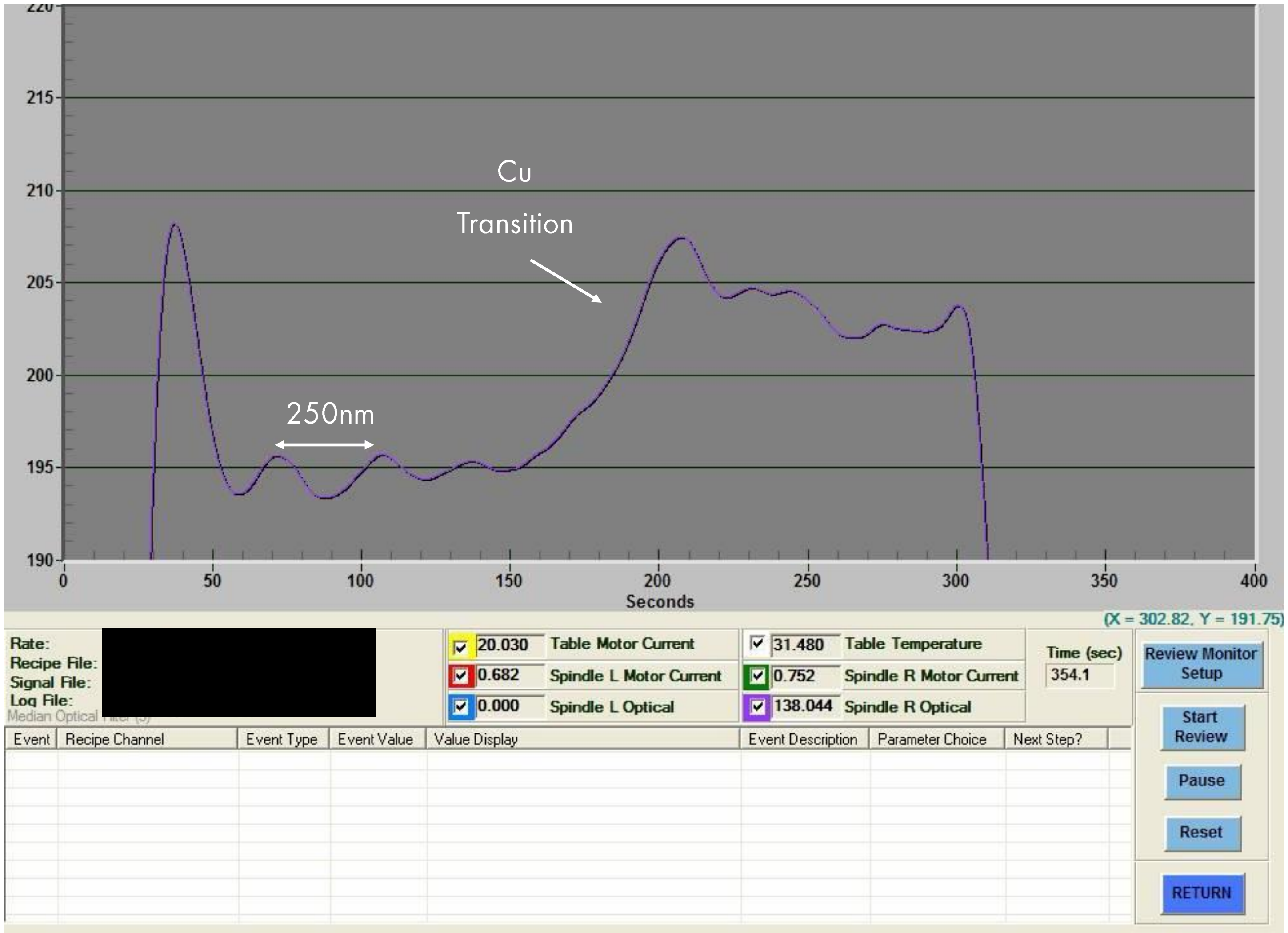
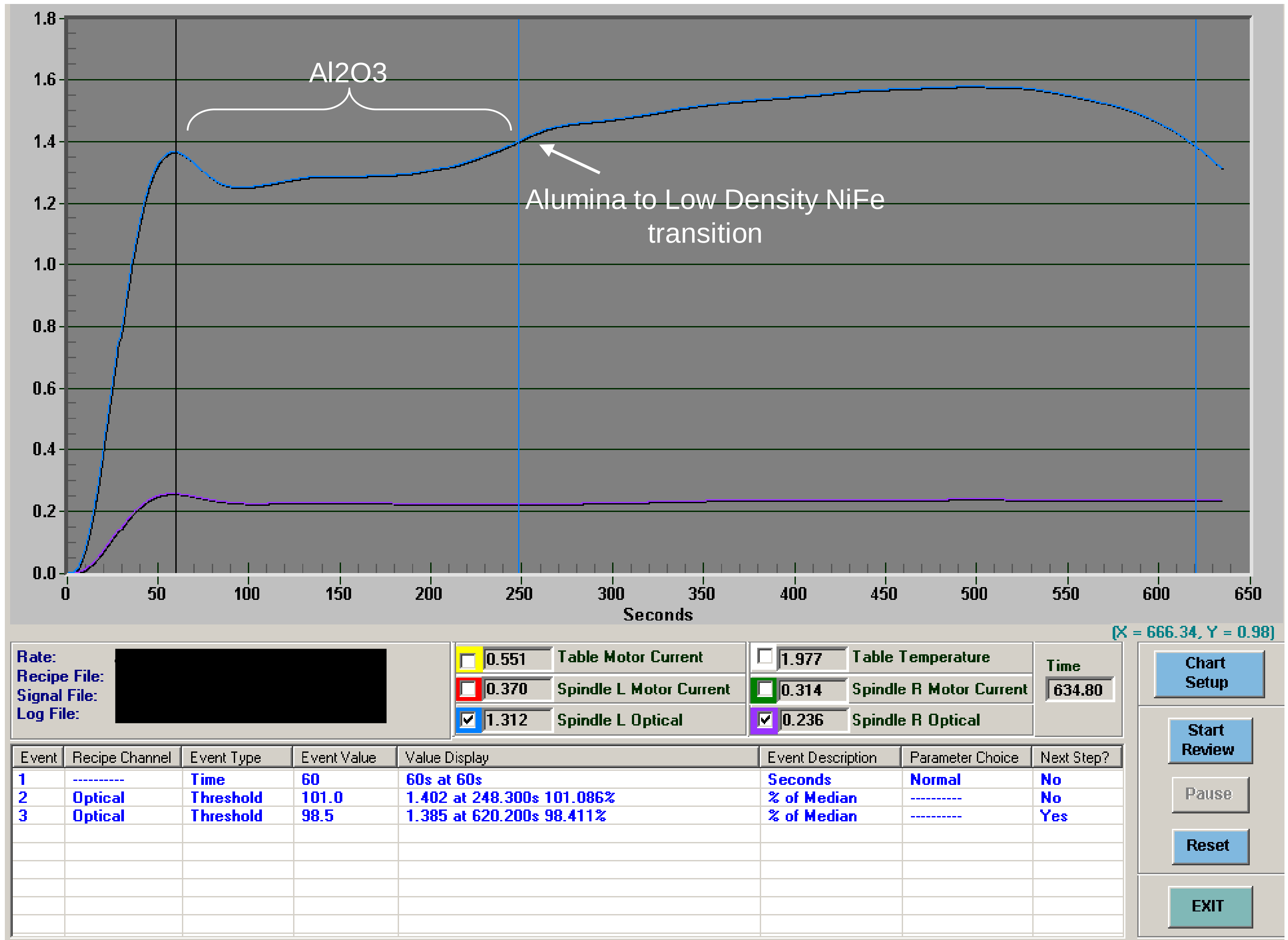
Application: Al2O3 → AlTiC



Application: Al2O3 → AlTiC with Cu



Application: Al2O3 → NiFe → AlTiC



Wafer Grinding Prior to CMP

Bulk Removal of Overcoat Material

Wafer Grinding Prior to CMP

- **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

Run #	Grind Wheel	*Initial THK* (µm)	*Target Removal* (µm)	*Target THK* (µm)	*Final THK* (µm)	*Target Error* (µm)	*7AF Fine Grind Data* *Max Down Force* (lbs)	*Max Grind Time* (sec)	*Removal Amount* (µm)
1	800 grit Resin	1295.0	32	1263.0	**1262.6**	0.4	6	88	32.6
2		1290.3	32	1258.3	**1260.2**	-1.9	7	84	31.4
3		1293.8	30	1263.8	**1265.0**	-1.2	5	68	28.9
4		1292.2	20	1272.2	**1274.3**	-2.1	6	52	17.9
5		1273.0	20	1253.0	**1256.0**	-3.0	5	102	19.5
6	1200 grit *KR* Resin	1294.1	35	1259.1	**1259.5**	-0.4	5	105	34.7
7		1288.5	35	1253.5	**1253.0**	0.5	6	111	35.6
8		1291.0	35	1256.0	**1255.6**	0.4	6	97	34.9
9		1293.6	35	1258.6	**1259.5**	-0.9	5	79	34.6

Grind Wheel Marks on Copper Studs

Figure 1: 800 grit Wheel Grind Marks

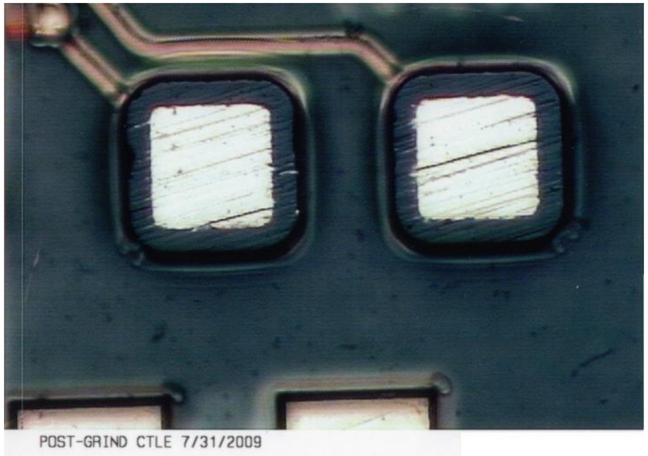
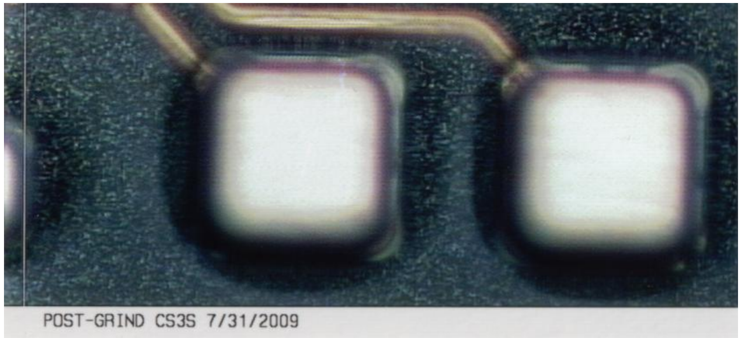


Figure 2: 1200 grit Wheel Grind Marks



- 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

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- 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**

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