Unique SmartPad™ for CMP End-point Applications

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Abstract

Efficient end-point detection (EPD) in chemical mechanical planarization (CMP) is very critical to monitor and control the process. Strasbaugh's new nVision EPD system with SmartPad technology has provided advanced operations from user-friendly software to process accuracy. Working closely with customers has enabled Strasbaugh to significantly improve the system for use in oxide, tungsten, and MRH AlTiC applications.

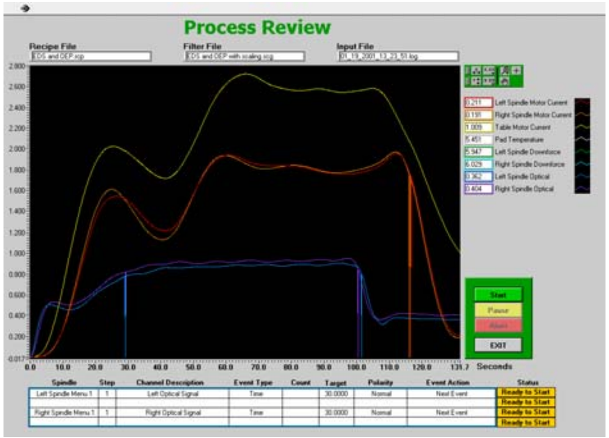
Introduction

Chemical mechanical planarization (CMP) requires and highly relies on advanced in-line monitoring and control during the process. Engineers like to call End-point detection (EPD) "precise engineering eyes" that closely monitors the wafer surface during the polishing process. When the targeted layer or feature is exposed the system can detect changes and stop the process or move forward to the next step. When combined with an optimized process including consumables and advanced wafer carrier technology, EPD can be used to achieve polish targets with consistent wafer-to-wafer results.

There are many techniques and methods the industry has researched, developed and employed in EPD for wafer fabrication processes. Most notably fraction sensing, electrical methods such as motor current and eddy current, optical signal, thermal detection and chemical spike, etc. [1-5]. Each technique utilizes its own unique solution for targeted applications. It is a comprehensive factor of sensitivity, resolution, accuracy, reliability, process consistency, CoO and friendly usage.

System Overview

Strasbaugh uses the nVision system as an EPD control. The nVision EPD system combines multiple techniques of optical reflectance, table/spindle motor current and table temperature for process control. Figure 1 illustrates the end point signals collected from one of the process applications.



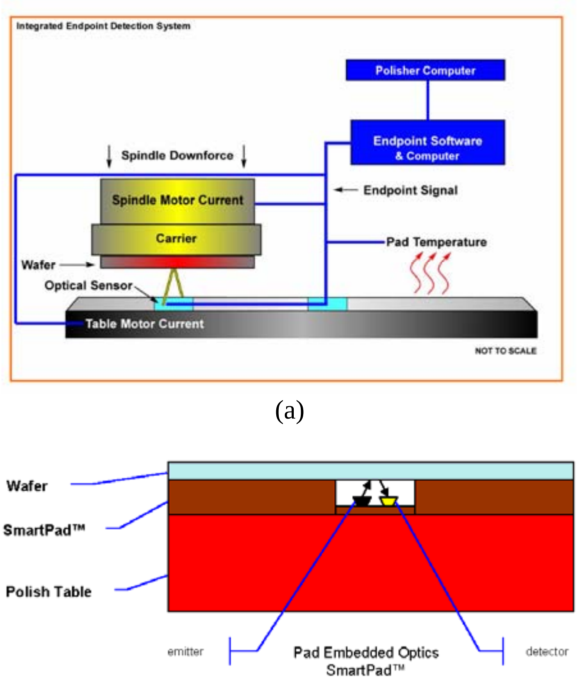
Process Review

Recipe File: EDS and DEP.rcp
Filter File: EDS and DEP with scaling.scg
Input File: 01_19_2001_13_23_51.log

Spindle	Step	Channel Description	Event Type	Count	Target	Polarity	Event Action	Status
Left Spindle Menu 1	1	Left Optical Signal	Time		30.0000	Normal	Next Event	Ready to Start
								Ready to Start
Right Spindle Menu 1	1	Right Optical Signal	Time		30.0000	Normal	Next Event	Ready to Start
								Ready to Start

Figure 1. nVision End Point signals

The optical technique relies on an optical sensor embedded completely within the polishing pad (SmartPad™), as shown in Figure 2b. During the applications the interferometry and reflectance signals from SmartPad are used to monitor film removal in real time and to pinpoint the precise moment of transition from one layer to another, respectively. With this technology, it is convenient to choose the wavelength of light that provides the optimum results for a particular film.



(a)

(b)

Figure 2. Strasbaugh nVision EPD system with the SmartPad technology (a) EPD system (b) SmartPad.

Software

Well designed new nVision EPD system software provides a user-friendly graphical use interface (GUI) with access to all features of recipe setup, signal setup, operations and data review. Figure 3 shows a few snap shots of nVision software screens.

The recipe set up is using event dictation method. Each channel can be associated with an event type and an action to be performed when that event type is seen by the EDS system.

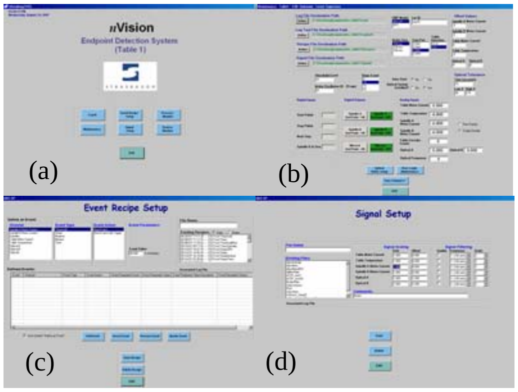
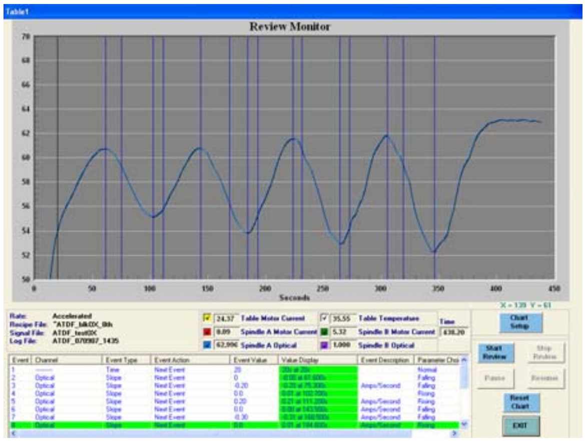


Figure 3. nVision GUI (a) Main Screen (b) Setup screen (c)Recipe setup (d) Signal setup

The Signal Setup module can modify and interpret the raw signal into a deterministic and robust signal traces. All signals collected from the process through the software can adjusted for signal drift. Noise in the raw data can be efficiently filtered out by defining scale and filter orders. Additionally, there is digital and analog input/output viewing and control.



Rate: Accelerated
Recipe File: *ATDF_blk0X_0th
Signal File: ATDF_test0X
Log File: ATDF_070907_1435

☑ 24.37 Table Motor Current
☑ 35.55 Table Temperature
🟥 0.09 Spindle A Motor Current
🟩 5.32 Spindle B Motor Current
☑ 62.996 Spindle A Optical
🟪 1.000 Spindle B Optical
Time 438.20

Event	Channel	Event Type	Event Action	Event Value	Value Display	Event Description	Parameter Cho
1	-------	Time	Next Event	20	20s at 20s		Normal
2	Optical	Slope	Next Event	0	-0.00 at 61.600s		Falling
3	Optical	Slope	Next Event	-0.20	-0.20 at 75.300s	Amps/Second	Falling
4	Optical	Slope	Next Event	0.0	0.01 at 102.700s		Rising
5	Optical	Slope	Next Event	0.20	0.21 at 111.200s	Amps/Second	Rising
6	Optical	Slope	Next Event	0.0	0.00 at 143.500s	Amps/Second	Falling
7	Optical	Slope	Next Event	-0.30	-0.31 at 160.500s	Amps/Second	Falling
8	Optical	Slope	Next Event	0.0	0.01 at 184.000s	Amps/Second	Rising

Figure 4. nVision process monitor.

The Figure 4 shows the real time data collected from processing. Signal values are displayed in numeric format as well as graphed on the chart.

Because the original signal data from each run is captured to a log file, it makes later review and analysis possible. The post run analysis of the previous wafer runs can be performed under a multitude of signal filtering and adjustment scenarios. Analyzing these stored log files decreases the number of wafers necessary to create a filter and/or recipe. Stored data can also be downloaded to an ASCII file for offline analysis.

Process Applications

Working closely with customers, the nVision system has been successfully tested with blanket oxide, blanket tungsten, pattern tungsten and MRH AlTiC applications.

Oxide Blanket Wafer

The blanket thermal oxide wafers were employed to test the system's capabilities for thin film endpointing as shown in Figure 5.

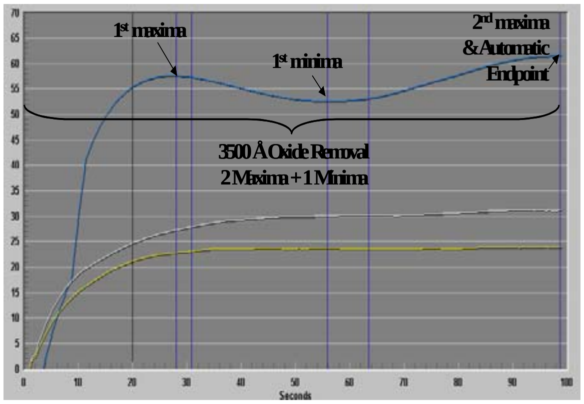


Figure 5. Blanket oxide Endpoint signals

Interferometry is used to establish the amount of film removed in real time. Using infrared diodes and thermal oxide wafers, each maxima-to-maxima relates to approximately 3300-Å removal. Within a given wavelength of light and a given thin film material, the amount of material removal per sine wave is constant. With this information and known incoming wafer thickness, an endpoint recipe can be created to target a desired endpoint thickness. Shown is an endpoint recipe targeting 3500-Å thermal oxide film removed.

Tungsten Blanket Wafer

Blanket tungsten wafers were employed to test the system's capabilities for endpointing at a transition from one film to another (Fig. 6). The optical signal shows an increase in reflectance when tungsten film transitions to the Ti/TiN adhesion layer followed by a decrease of the reflectance when Ti/TiN transitions to the underlying thermal oxide.

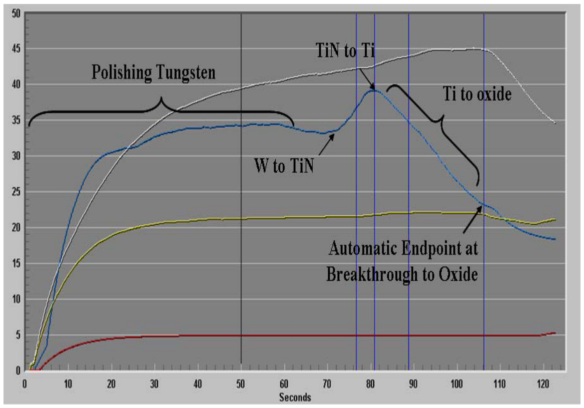


Figure 6. Blanket tungsten Endpoint signals

Tungsten Pattern Wafer

Current SEMITECH tungsten test pattern wafers were employed to test the system capabilities for endpointing with pattern wafers (Fig. 7). Planarization of the tungsten can be seen as a momentary decrease of the rising slope in the optical, pad temperature and table motor current signals. Endpoint occurs at the transition from tungsten to oxide. The adhesion layer used on the pattern wafers is much thinner than the blanket wafers tested and no increase in the optical signal is seen when the adhesion layer is polished.

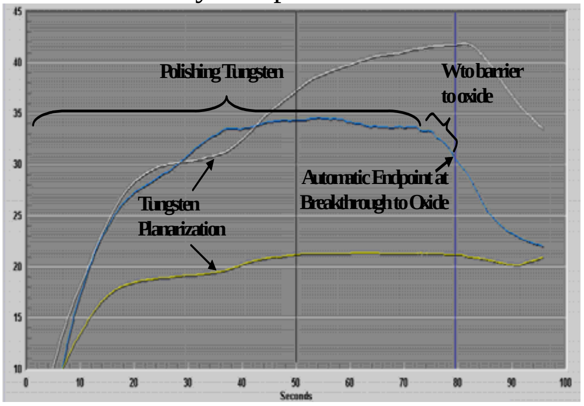


Figure 7. Tungsten test pattern Endpoint signals

Pattern MRH AlTiC wafer

nVision EPD system shows success using endpoint for MRH AlTiC applications. Several test wafers from MRH AlTiC applications were employed to further test the system capabilities for endpointing with pattern wafers. One such application is alumina thin film transition to alumina with low pattern density NiFe.

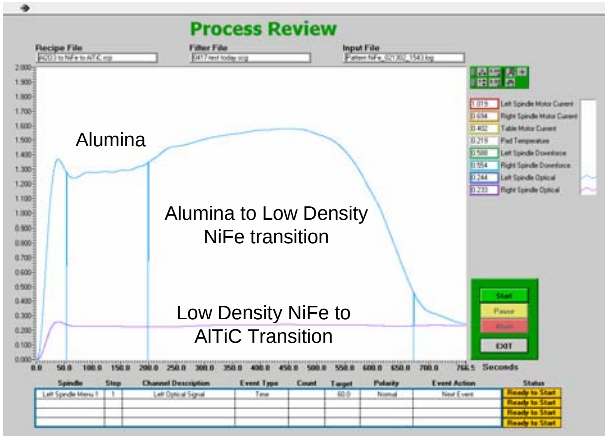


Figure 8. AiTiC lower density pattern Endpoint signals

Figure 8 shows wafer polished through to AlTiC substrate. The optical signal shows an increase in reflectance when alumina film transitions to the alumina with low pattern density NiFe followed by a decrease of the reflectance when alumina with low pattern density NiFe transitions to the underlying AlTiC substrate.

Conclusion

The Strasbaugh nVision optical endpoint system with SmartPad^{TM} technology, polish pad embedded optics, measures optical reflectance signal, table/spindle motor current and table temperature. The system provides precise control for both film transitions (i.e. tungsten to oxide) and thin film removal (i.e. real-time oxide removal control). The well designed new nVision EPD system software provides a user-friendly graphical use interface (GUI) giving a high degree of system functionality.

Reference:

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