CMP Enhancement Applications Using ViPRR Carrier Technology

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Abstract

Chemical Mechanical Planarization (CMP) technology are highly demanded on wafer removal WIWNU (Within Wafer Non-uniformity). Carrier technology is one of the key components to control process results within the targeted edge exclusion. Strasbaugh ViPRR carrier technology provides the solid and robust performance with a high reliability.

This article will highlight the ViPRR carrier technology and applications successfully used in the industry.

Introduction

Chemical Mechanical Planarization (CMP) technology has been employed extensively in the IC, MEMS, MR head, and LED industries. New technology nodes are placing ever higher performance demands on the CMP process.

In general, a CMP process is happened on a rotary table with morn than 30 variables dynamically effecting to each other. The main categories are polisher, wafer carrier, consumables, process parameters and controlling, and incoming wafers materials and characterization.

Here, one of the key components in any CMP system is the wafer carrier. The design, proper material selections, set up and maintenance of the wafer carrier itself makes a big single contribution to the overall CMP process performance.

During the process the table linear velocity, polishing pad compressibility, slurry distribution, process conditionings, and even incoming wafers are not identical from wafer die to die. Control and provide a reliable CMP process with demanded targets is always a challenge. Among those targets material removal rate, within wafer non-uniformity (WIWNU), within die non-uniformity (WIDNU) along with reduced wafer edge exclusion (EE) are usually the first few specs the process struggles on.

Strasbaugh ViPRR carriers are the family of wafer carriers that also consists of fixed gimbal carrier, carrier X as well as carrier VX. The ViPRR carrier has been introduced and used in production since 1997. A tremendous research and development effects have provided the evidence that the product delivers what the customer truly needs and can adapt to the customer's challenges. This paper will highlight the updated ViPRR carrier technology that successfully used in the production line.

ViPRR Carrier

ViPRR carrier stands for Variable input Pneumatic Retaining Ring carrier. Over the past 9 years, the carrier has been keeping updated and improved in terms of better performance, material choice, and reliability to meet the end-users satisfactions. The Figure 1 shows the schematic of ViPRR carrier. It has incorporated the following features into its design.

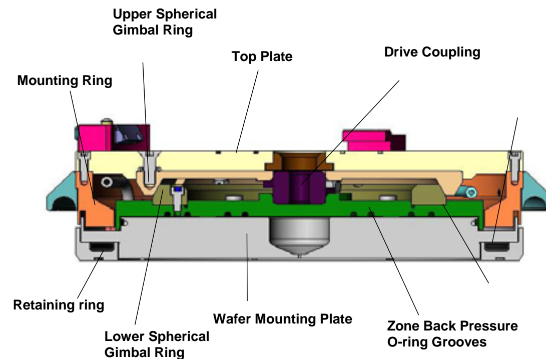

Figure 1. Strasbaugh ViPRR IV carrier used for CMP applications

1) Projected gimbaling**-** projecting the gimbal point to the pad/wafer interface provides improved wafer to pad alignment for better center to edge uniformity, slurry distribution, edge exclusion, and flatter retaining ring wear.

2) Low friction rotational drive mechanism

3) Pneumatic retaining ring**-** pre-compresses the polish pad ahead of the wafer, controlling pad rebound effect and improving uniformity to 3mm or better.

4) Angular pick-up**-** prevents the wafer from sticking to the polish pad during pick-up after polish.

5) Few moving parts**-** for simple maintenance and high reliability.

7) Material choice with longer life time, light weight, thermal resistance

A tremendous study, research and reliability tests have been done for the best carrier material selection for better process results, reliability, longer life time, lighter weight, as well as easy maintenance. A few test results are shown in Figures 2 and 3 below.

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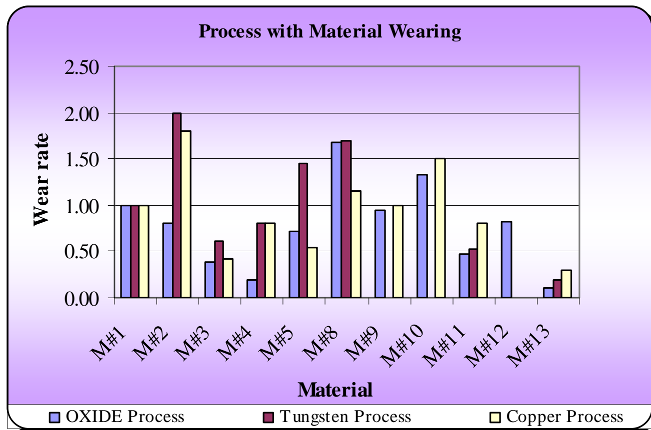

Figure 2. Retaining Ring Material Wearing Test Results

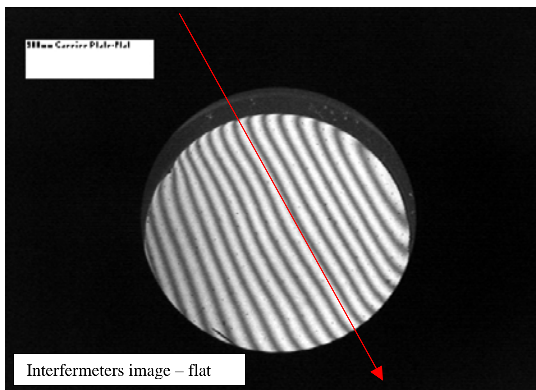

Figure 3. Carrier surface flatness by interferometers images.

Process Controlling Through ViPRR Carrier

With all the through design features, ViPRR carrier provides a gentle and smooth performance during CMP process. It is flexible and adjustable with the polishing film. The carrier allows the polishing pressure applying to the wafer through the carrier backing-film. Adjustable backpressure (BP) or zoned backpressure (ZBP), which allows air back pressure to be applied selectively to the circumferential zones within the carrier, adds up an extra air cousin and pressure between wafer and carrier backing-film in order to modify and improve center-to-edge WIWNU. Figure 4 demonstrates the back pressure optimization in general.

Pneumatically controlled wafer retaining ring is critical for compensate poor uniformity from compressed pad at wafer edge, slurry distribution and incoming wafer that inherited edge poor uniformity from the previous process. WIWNU and CMP process yields will be improved significantly just by optimizing the ring pressure and backpressure using ViPRR carrier. From Figure 5 it can be seen that WIWNU improved from 10.62% to 3.06% with only change backpressure and ring pressure and leave all other process parameters are the same.

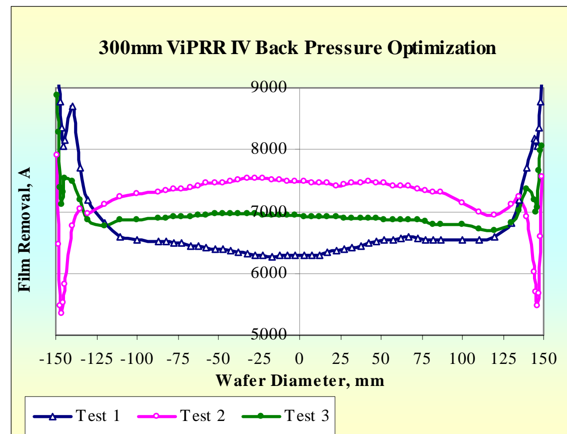

Figure 4. ViPRR carrier back pressure optimization

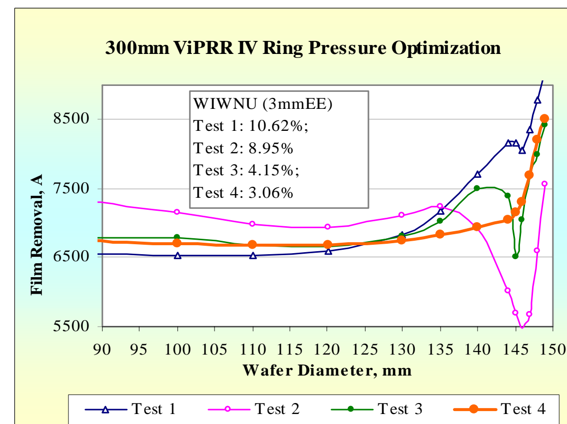

Figure 5. ViPRR carrier ring pressure optimization

ViPRR Carrier Applications

Strasbaugh CMP tool with ViPRR carrier technology is wildly used in semiconductor productions applications such as Oxide, STI, Tunstong, Cu, MEMS, MRH, WWD and R&D fields. The following are a few examples with ViPRR technology.

Enhancement ViPRR Carrier Applications

VIPRR IV carrier represents the latest design in the VIPRR carrier line and was the carrier of choice for implementation onto one of existed CMP equipment in the market. By upgrading and improving the carrier technology used on legacy CMP machines, the useful life of these tools may be extended to meet current and next generation process demands. The Figure 6 shows to implement ViPRR carrier technology on IPEC 372 & 472 for Oxide and MEMS applications.

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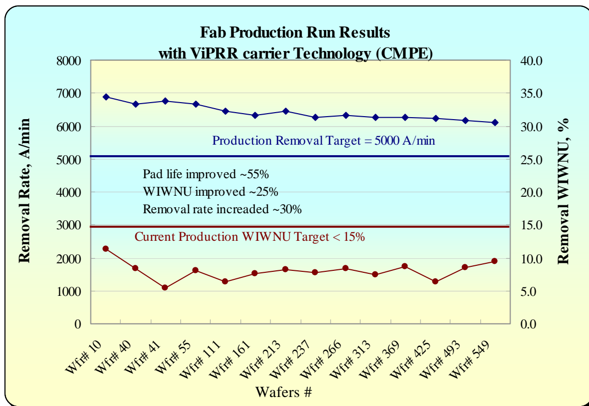
The production results have been shown to extend the useful life of older equipment, meet the latest requirements, resulting in improved production efficiency and lower production costs. Figure 7 shows that both removal rate and WIWNU are improved by using ViPRR carrier (Figure 7). Furthermore, the pad life was increased as much as twice longer.

Figure 6. ViPRR Carrier Over Clean Station



The Figure 7. Five hundred oxide wafers production run at the customer site using Enhancement ViPRR carrier technology

MRH Applications

CMP on thin- film head (TFH) wafer has become more critical to overall manufacturing-process performance. The TFH consists of an inductive electromagnetic coil write, a giant magneto resistive reader (GMR), and a slider body with an air-bearing surface, which files over the magnetic disk to perform the read and write functions.

The CMP is an approved method to enables the building of subsequent layers on flat and smooth surface. Figure 8 illustrates the disk drive where CMP required. Figure 9 is the results generated from customer site using ViPRR carrier technology.

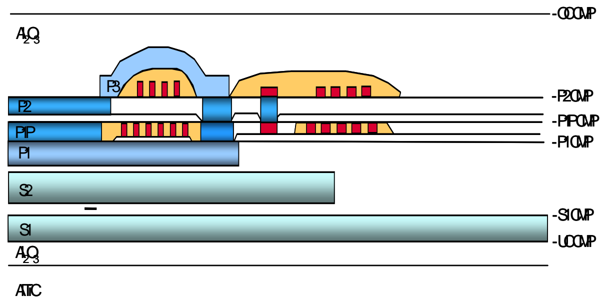


Figure 8. CMP requirement in MRH process

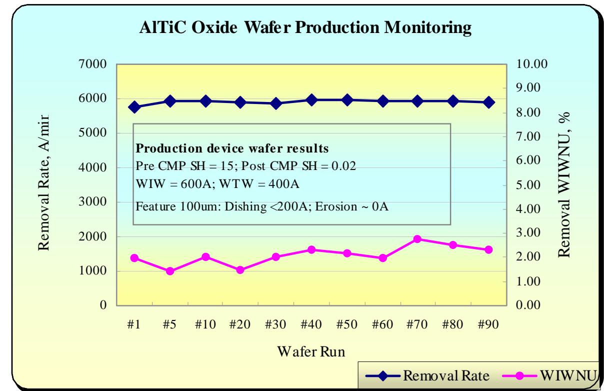


Figure 9. AlTiC MRH Production results

WWD Applications for Physical Failure Analysis

A key method for yield learning is physical failure analysis (PFA). Defects and structures of interest are often buried beneath a multi level metallization stack. Especially when the copper metallization production process was introduced, it brought new challenges to the PFA-community. Working with the customer closely, Strasbaugh has developed a successful process called whole wafer deconstruction (WWD) that be capable to remove layers in a controlled manner.

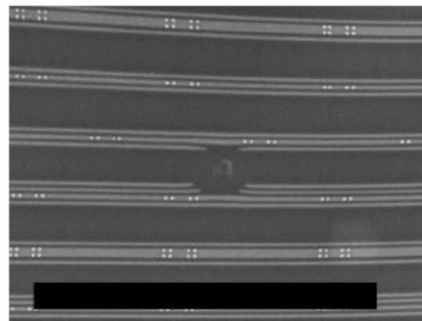


Figure 10. Failing site by SEM after WWD

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There is the tremendous time saving in sample preparation using WWD method in PFA analysis. It only takes a couple of hours instate of several days if using traditional FIB method. This enables PFA-teams to reduce the yield learning cycle effectively. The Figure 10 shows an example of an embedded defect causing an interruption of metal lines exposed by polishing into the ILD layer above it and reviewed with a SEM. Using EPD system (nPoint) can detect the targeted metal layer successfully (Figure 11)

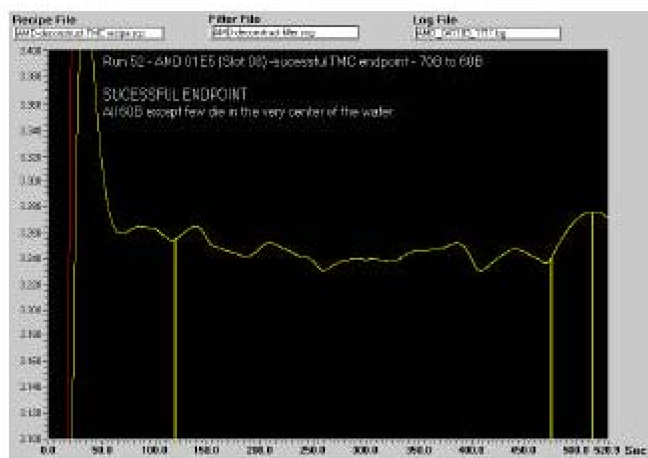

Figure 11. End Point control to stop WWD on M6.

Conclusion

Strasbaugh ViPRR Carrier technology has been widely used in industry, university for CMP applications and Research and development.

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