SYMPOSIUM I

Chemical-Mechanical Planarization

April 2 – 3, 2002

Chairs

Suryadevara V. Babu
Dept of Chemical Engr
Clarkson Univ
Ctr for Adv Matls Processing
Potsdam, NY 13699-5665
315-268 2336

Rajiv K. Singh
Dept of MSE
Univ of Florida
217 MAE
Gainesville, FL 32611
352-392-1032

Michael R. Oliver
CMP Business Unit
Rodel Inc
Portland, OR 97231-2403
503-621-9635

Nobuo Hayasaka
Semiconductor Co
Toshiba Corp
Process & Mfg Engr Ctr
Yokohoma, 235-8522 JAPAN
81-45-770-3607

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* Invited paper

SESSION I1: ADVANCES IN CMP CONSUMABLES I
Chair: Suryadevara V. Babu
Tuesday Morning, April 2, 2002
Golden Gate B1 (Marriott)

8:00 AM *I1.1
COMPARISON AND EVOLUTION OF COPPER CMP CONSUMABLE TECHNOLOGY. David R. Evans, Sharp Laboratories of America, Camas, WA.

Intensive investigation of copper CMP over the past decade has revealed that consumable technology is of critical importance. There are several reasons for this, but all are ultimately due to the chemical and material properties of copper and associated barrier layers. Moreover, in comparison to conventional dielectric polishing, copper CMP (and, perhaps, metal CMP in general) is of a much more chemical nature. This is a consequence of the fact that metal removal generally requires an oxidation-reduction mechanism while dielectric removal generally requires only simple hydrolysis. As any chemist knows, oxidation-reduction reactions are often notoriously hard to control and easily upset by contaminants. Of course, contaminants can be intentionally added to the chemistry for beneficial purposes in which case they become known as "proprietary additives". In addition, to the removal chemistry, abrasive and pad technology has also undergone considerable evolution. Indeed, free abrasive, fixed abrasive, and abrasiveless technologies have all been developed. In the case of fixed abrasive polishing, this has required modification of the pads as well, however conventional and abrasiveless polishing can be carried out with conventional polyurethane pads. This picture is further complicated by the various available hardware configurations and the use of multiplaten processes. In the present work, conventional, fixed abrasive, and abrasiveless processes have all been investigated. Morpohological evolution of polished copper surfaces has been measured and will be compared for various processing conditions and consumable sets. In addition, the effects of chemical interactions will be discussed. Further results related to the microscopic dynamics of the polishing process will also be presented.

8:30 AM *I1.2
DEVELOPMENT OF NEW ABRASIVE FREE COPPER CMP SOLUTIONS BASED ON ELECTRO-CHEMICAL AND FILM ANALYSIS METHOD. Jin Amanokura, Yasuo Kamigata, Masanobu Habiro, Hiroshi Suzuki, Masanobu Hanazono, Hitachi Chemical Co. Ltd., Yamazaki Works Semiconductor Materials Development Div., Ibaraki, JAPAN.

To reduce micro-scratches and to obtain minimized dishing and erosion, we developed "Abrasive Free Cu CMP slurries". During the development of these slurries, some Electro-Chemical examination was performed. One of the most effective knowledge was obtained through Tafel plot. Other attractive data were also obtained through Cu complex analysis and properties for these films. Based on these studies, high removal rate new Abrasive Free Cu CMP solutions were designed and developed. The mechanism of reduced dishing and erosion will also be discussed.

9:00 AM I1.3
STABLE ABRASIVE-FREE SLURRY FOR CHEMICAL MECHANICAL POLISHING OF COPPER. Ying Ma, William A. Wojtczak, Gregory T. Stauf, David Bernhard, Thomas H. Baum, Cary Regulski, Michael Jones, ATMI, Danbury, CT.

Chemical mechanical polishing (CMP) has become a crucial part of device generation and semiconductor processing, despite the fact that it requires the use of small abrasive particles. In contrast, fabs go to great lengths to keep such particles out of other device processing steps. CMP of copper presents significant challenges, including high defectivity, irreproducible results and unstable polishing compositions. ATMI has developed a Cu CMP composition which does not contain abrasive particles, yet provides high removal rates using standard pads and polishing tool conditions. It is stable for greater than 90 days and requires no on-site mixing, leading to significant improvements in manufacturability over existing technology. Copper removal rates for this slurry were above 3500 Å/min, with static etch rates below 10 Å/min and within wafer nonuniformity (WIWNU) of 7.8%. Dishing and erosion metrics were obtained on SEMATECH 954/854 AZ test wafers, and were satisfactory. Selectivity of Cu to TaN and TEOS oxide is 500:1 and 730:1, respectively. We will discuss removal rates, dishing, erosion, and within wafer nonuniformity for this composition as a function of tool parameters.

9:15 AM I1.4
PERFORMANCE COMPARISONS OF ABRASIVE FREE AND ABRASIVE CONTAINING SLURRIES FOR COPPER CMP WITH DIFFERENT PLATFORMS. John Nguyen, Speedfam-IPEC, Phoenix, AZ; Gerald Martin, Ronald Carpio, International SEMATECH, Austin, TX.

Typically, the commercially available abrasive containing slurries for copper CMP have shown some advantages in high removal rates, possibly low friction at low down force, and copper residues free regardless the polisher architecture, either rotary, orbital, or linear polishing. However, the abrasive containing slurries also have some disadvantages such as high dishing and erosion and high oxide losses, and micro-scratches due to the presence of abrasives. In contrast, the abrasive free polishing slurry has lower removal rate, and may be sensitive to polishing architecture, but it has good planarization, low topography, less micro-scratches, and most importantly its insensitivity to over-polish. At this stage, the best results for copper CMP are being achieved by the use of the multi-step and multi-slurry process in which copper is polished first, and barrier layers are polished with different set of consumables. The intent of this paper is to focused on the first step, bulk copper removal step, and to compare different approach for this first step; namely, the use of slurries containing abrasives with slurries that are free of abrasive on the orbital polisher. The process with AFP slurry on orbital polisher has produced very robust process window with excellent results, low topography, low erosion, and low cost of ownership.

9:30 AM *I1.5
MODELING AND MAPPING OF NANOTOPOGRAPHY INTERACTIONS WITH CMP. Duane Boning, Brian Lee, MIT Microsystems Technology Laboratories, EECS, Cambridge, MA; Noel Poduje, ADE Corporation, Westwood, MA; and W. Baylies, Baytech Group, Weston, MA.

As the demand for planarity increases with advanced IC technologies, nanotopography has arisen as an important concern in shallow trench isolation (STI) and other CMP processes. Previous work has shown that nanotopography, or small surface height variations in raw wafers 20 to 50 nm in amplitude extending across millimeter scale lateral distances, can result in substantial localized thinning of surface films (e.g. oxides or nitrides used in STI) after CMP. This nanotopography interaction with CMP depends both on characteristics of the wafer (heights and special wavelengths of the nanotopography) and of the CMP process (such as the planarization length).
In this paper we review and extend the previous work on modeling of nanotopography. Three approaches to predicting the post-CMP oxide thinning due to nanotography are compared. The first approach is the simplest, where a statistical aggregate effect is computed. Following the work of Schmolke, a transfer coefficient alpha is found, which captures the portion of nanotopography that is correlated with the final oxide thinning. The second approach is the most detailed, depending on explicit numerical simulation of pad elastic properties. In this case, a contact wear simulation is used to produce a detailed map of oxide thicknesses corresponding to any given pre-measured nanotopographical wafer surface. The third approach is a signal processing method, sitting somewhere between the previous two extremes in terms of approximation and complexity. In this last case, an effective two-dimensional transfer function is extracted which captures the spatial smoothing accomplished by CMP. This filter can then be applied efficiently to pre-measured nanotopography maps for other wafers to predict the final oxide thicknesses.
We also propose a predictive mapping of post-CMP oxide or nitride thickness to provide insight into the relative goodness of a wafer measured for nanotopography which is to be subjected to a CMP process. Specifically, we suggest that for post-CMP impact, maps and computation of areas having final nitride thickness outside of required ranges would be useful and practical. Such a map would complement the fundamental nanotopography height map data and metrics based directly on that data, and would enable evaluation, comparison, and development of improved wafers and CMP processes.

10:30 AM I1.6
ROLE OF NANOSCALE AND MICROSCALE WAFER-PAD-SLURRY INTERACTION PHENOMENA IN DESIGN OF SLURRIES FOR METAL CMP. Rajiv K. Singh, Seung-Mahn Lee and Wonseop Choi, Department of Materials Science and Engineering and Engineering, Research Center for Particle Science and Technology, University of Florida, Gainesville, FL.

Due to a large number of processing variables (>20) in a typical CMP process, it is quite difficult to accurately model the CMP process. Furthermore, the inter-dependence of the various processing variables complicates the interaction phenomena. Thus, the CMP models developed cannot adequately incorporate the role of all the variables in a CMP process. A more tractable and predictive solution to this problem is to understand the role of the processing variables on the microscale and the nanoscale effects during the CMP process. By determining this correlation, accurate models can be developed. This talk will focus on the effect of the processing variables (slurry characteristics, pad characteristics, tool variables) on the nanoscale and microscale effects during the CMP process. The nanoscale effects include the dynamics of formation of the surface modified layer and its removal, while the microscale effects include the surface coverage of abrasives on the wafer.

10:45 AM I1.7
EVALUATION OF THE CHEMICAL-MECHANICAL PLANARIZATION (CMP) PERFORMANCE OF SILICON NITRIDE AND SILICON CARBIDE AS HARD MASK MATERIALS FOR Cu-BASED INTERCONNECT TECHNOLOGY.
Wei-Tsu Tseng, Jia Lee, John Fitzsimmons, Sanjit Das, Glenn Biery, Edward Barth, Ronald Goldblatt, IBM Semiconductor Research and Development Center, Hopewell Junction, NY.

The introduction of Cu dual-damascene scheme to the multilevel interconnect technology imposes complexity as well as new challenges for the process. One of the major process challenges is that the complex stacks of Cu overburden and liner layers need to be removed by CMP in the field region and subsequently, the polish must stop within the hard mask (HM) layers underneath the liners. The hard mask materials commonly used in the semiconductor industry include silicon nitride (a- SiN:H) and silicon carbide (a-SiC:H). In this study, we evaluate the CMP performance of PECVD silicon nitride and silicon carbide as HM materials for Cu technology. The CMP rate ratio of a- SiN:H to a-SiC:H is about 3:2, suggesting that the latter is a better CMP polish stop layer. The CMP rates of silicon carbide, as we found that, can be made even lower by manipulating the structure and chemistry of the silicon carbide thin films during deposition. In addition, when bi-layer HM is used, e.g., a-SiC:H/a- SiN:H or a-SiC:H/SiO_2, the so-called "substrate effect" (Ref.) occurred so that the CMP rates are not a simple linear function of the two single-layer rates involved. The chemical and structural changes that lead to the change in CMP rates of a-SiC:H will be discussed and the rate change in the bi-layer HM stacks will be explained. Ref.: Y.-L. Wang et al., Thin Solid Films, 543, 308 (1997).

SESSION I2: STI PROCESSING
Chair: Michael R. Oliver
Tuesday Morning, April 2, 2002
Golden Gate B1 (Marriott)

11:00 AM *I2.1
ISSUES RELATED WITH STI SCALING FOR $<$ 0.15 MICRON CMOS TECHNOLOGIES. Katia Devriendt, Nancy Heylen, Evi Vrancken, Marc Meuris, IMEC, SPT Division, Leuven, BELGIUM.

Shalllow trench isolation (STI) has become the mainstream isolation technique of choice for deep sub-micron technologies, as it features superior scalability and fulfils the planarity requirements of deep sub-micron lithography compared to the former LOCOS techniques. However, the scaling of STI presents severe problems related to the trench etch into Si, the filling of high aspect ratio trenches and the planarization by CMP. The focus of the talk is on how the trench etch, the liner oxidation, the trench fill and the CMP steps should be optimised and integrated into the STI module. All steps can have an impact on the so-called trench corner 'parasitic effect' which is the major critical issue in the STI development. The CMP part includes pad (hard vs. soft) and slurry (high selective vs. low selective) engineering, and describes which modifications can be done to the standard STI process flow to achieve a better process performance. The most widely used option to deal with the pattern dependency of CMP, and hence avoid severe dishing and erosion effects, is the use of dummy structures, but also other alternatives are described, such as oxide reverse etch, dual nitride or other approaches which do only need one lithographic step (f.ex. fixed abrasive CMP). Finally, some electrical results of capacitor and transistor structures will be discussed.

11:30 AM I2.2
A NEW DIRECT CMP PROCESS FOR SHALLOW TRENCH ISOLATION. Joseph Li, Lam Research Co, Austin, TX; Chris Raeder, Val Wenner, Tito Tang, Advanced Micro Devices, Inc., Fab 25, Austin, TX; Kate Feist, Mark Barrick, Lam Research Co, Austin, TX.

Shallow trench isolation (STI) has become an enabling technology for sub-250 nm devices because of its higher packing density and better planarity relative to the local oxidation of silicon (LOCOS) approach. Direct STI CMP is one of the critical processes for the successful implementation of STI technology. In this paper, the development of a new direct STI CMP process was presented. This direct STI CMP process was developed with a self-stop STI slurry on Lam TeresTM CMP system with liner planarization technology and multi-zone air bearing platen. This slurry is a single-component slurry, composed with ceria abrasive and additives. All the development data were collected on wafers patterned with an MIT STI mask, which provides challenging structures for direct STI polish development. The polish time was controlled with Lam IR endpoint detection system. This CMP process shows low in-die trench oxide range (150-200 Å at 20-80% density), low sensitive to pattern density and low dishing (150-200 Å at 200um pitch). Application of this direct STI CMP process in manufacturing production was also presented. Another significant advantage of this direct STI CMP process is that the polishing process stops itself when the wafer surface is planarized, which gives large process window in the manufacturing production. The effects of trench oxide overlap on wafer clearance, process performance as well as process window were also addressed.

11:45 AM I2.3
MECHANISM AND AN EMPIRICAL MODEL OF FIXED ABRASIVE POLISHING PROCESS ON A WEB-FORMAT TOOL.
R. Venigalla and S.V. Babu, Department of Chemical Engineering, Center for Advanced Material Processing, Clarkson University, Potsdam, NY; L. Economikos, IBM Corporation, East Fishkill Facility, NY.

With its excellent selectivity to topography and high removal rate of oxide, the fixed abrasive polishing process is a very good candidate for Shallow Trench Isolation (STI) polishing. This work attempts at understanding the fixed abrasive polishing mechanism from a fundamental perspective by polishing STI test wafers with different pattern densities for different times. It was found that there was no significant removal in the recessed ('DOWN') areas till the step height was reduced to about 200Å and that the polish rate in the 'UP' area decreases once this critical step-height has been attained. At this point, the polish rate of the 'DOWN' area increases and approaches that of the 'UP' area, and continues later at that of the blanket wafer. An exponential model for the polish rate decay of the 'UP' area has been proposed in this work. The existence of pattern density interdependence in fixed abrasive polishing has been identified in this work. It has also been shown that it is critical to have structures on the wafer that can cause sufficient activation of the pad to enable polishing.

SESSION I3: ADVANCES IN CMP CONSUMABLES II
Chairs: Rajiv K. Singh and Manabu Tsujimura
Tuesday Afternoon, April 2, 2002
Golden Gate B1 (Marriott)

1:30 PM *I3.1
SILVER DAMASCENE PROCESS WITH CAP LAYER.
Manabu Tsujimrua, Ebara Corporation, Precision Machinery Group, Tokyo, JAPAN.

Development of semiconductors has proceeded according to broad frameworks such as the International Technology Roadmap for Semiconductors (ITRS). A key development in semiconductor technology involves the adoption of several new materials, such as Cu, low-k and high-k materials, and noble metals in capacitors, transistors, and/or interconnects. These developments will likely lead to wider application of the planarization process to new processes and new materials, and call for even stricter planarization performance requirements. One example involves planarizing Ag interconnects with an optimal cap layer configuration for reducing RC delays. The Cu interconnect process is currently used to reduce wire resistivity. One material that has been proposed as a successor to Cu is Ag. Many low-k materials have been developed with the goal of reducing dielectric constant (k). However, damascene design and matters such as cap layer configuration are also important considerations in reducing the effective dielectric constant (k eff). Our report herein begins by proposing Ni-B deposited by electroless plating as a candidate cap material, due to the following characteristics: (1) it offers good selectivity for Ag interconnects; (2) it provides good barrier effects through thermal processes; and (3) it provides good controllability of deposition rates. Next, we report that Ag damascene with Ni-B cap layer can be realized through electroplating and polishing of Ag interconnects. Although Ag polishing technologies are currently not fully developed, we suggest that they may nevertheless be successfully applied to polish Ag.

2:00 PM I3.2
VARIABLE SELECTIVE REMOVAL OF BARRIER TaN/Ta TO COPPER AND TO TEOS. Jinru Bian and John Quanci, Rodel Inc. Newark, DE.

In copper chemical mechanic polishing (CMP), first step slurry is used to remove bulk copper film and to achieve planarization, while second step slurry is used to a barrier film removal. Selective removal of the barrier layer to TEOS and / or Cu in the second step copper slurry is a challenging topic. Different wafer topographies in the industry may require different second step selectivities. Polishing experiments show that by varying slurry compositions, selectivities of either TaN/Cu and / or TaN/TEOS from less than 1 to about 30 can be achieved, while maintaining a constant removal rate of the barrier up to more than 2000 A/min. Therefore, it is possible to have selectivities of TaN/Cu/TEOS in any ratios within a set of ranges to satisfy different industrial requirements and applications.

2:15 PM I3.3
THE EFFECT OF THE OXIDIZING AGENT ON OXIDIZING AGENT ON COPPER MECHANICAL POLISHING (CMP).
Ajoy Zutshi, Yongsik Moon, Kapila Wijekoon, Applied Materials, CMP Product Business Group, Santa Clara, CA.

Copper CMP is required for the multilevel interconnection scheme in the advanced integrated circuit (IC) devices. Typical slurries currently used for polishing of copper utilize oxidizers and abrasive for controlled removal of materials. This study focuses on the role and effect of the oxidizing agent on Cu CMP performance. The material removal rate decreased as the concentration of the oxidizing agent in the slurry increased and the rate approached a constant value beyond a certain oxidizer concentration. The effect of the concentration was more evident in the condition of high pressure and high velocity during CMP. The material removal rate and its non-uniformity for electroplated copper films were measured to see the effect of the oxidizing agent in Cu CMP. Typically, the chemical-mechanical removal of metal is determined by a) the conversion of metal to metal oxides, b) the rate (kinetics) of reaction and c) the removal of metal oxides with the abrasives. The conversion of metal to oxide is easily described by the thermodynamics of reactions. The kinetics of reaction is more complex, and have to take into account the dynamic effects present during polishing, including friction, turbulent flow, applied pressure and linear velocities. Abrasion theories (including Archard's wear model) can then be applied to removal of metal oxides, and can be correlated to mechanical properties of the material removed, including Modulus, Hardness, Fracture strength (or Fracture Toughness). In this study, a detailed analysis is presented to identify the contribution of each of the steps, i.e. the reaction thermo-dynamics, kinetics and abrasion process, to determine the rate controlling step in the copper polishing process. For the abrasive-free slurry polishing, a new abrasion model is proposed. As a case study, an analysis of the change in the concentration of the oxidizing agent and its effect on polish behavior is presented. This analysis will assist in further optimizing the combination of chemistries and abrasives to develop an optimized copper polishing recipe.

2:30 PM I3.4
NEW SLURRY FORMULATION FOR COPPER-CMP PROCESS IN A DAMASCENE INTEGRATION SCHEME.
V. Terzieva, B. Sijmus, M. Meuris, IMEC, Leuven, BELGIUM; L. Puppe, G. Passing, BAYER AG, Leverkusen, GERMANY.

The silicon IC industry is rapidly moving to adopt copper as the material of choice for circuit interconnects. Because of the lack of etching processes to remove copper, these interconnects must be patterned with a Damascene process, in which copper is deposited over a film with trenches etched in an insulator material. The chemical mechanical polishing step is further introduced to remove the overburden Cu material leaving the wafer surface as flat as possible. The planarization task in Cu-CMP is more challenging than in other CMP processes due to larger topography variations and it has to be accomplished twice: while dealing with incoming topography and while polishing heterogeneous surface during barrier removal. Since different materials are polished dishing and erosion are introduced. In this work novel slurries both for copper and tantalum nitride removal were developed. In the first step the Cu bulk is removed, by using high selective slurry, which stops on the underlying TaN barrier. The selectivity of Cu vs. TaN achieved with this slurry is larger than 1/100. High selective second step slurry is further introduced for removing the barrier material. In the present work data concerning dishing and erosion will be presented as a function of line width and pattern density across the wafer. The influence of the selectivity of the slurries on erosion and dishing will be discussed. The total copper loss calculated out of the step height measurements will be compared with electrical data. Electrical yield measurements on shorts and opens of meander-fork structures will be shown.

3:15 PM I3.5
ENGINEERING THE INTERACTION FORCES TO OPTIMIZE CMP PERFORMANCE.
G. Bahar Basim, Ivan Vakarelski, Pankaj K. Singh, Brij M. Moudgil, University of Florida, Department of Materials Science and Engineering and Engineering, Research Center for Particle Science and Technology, Gainesville, FL.

The rapid advances in the microelectronics industry demand significant improvements in the Chemical Mechanical Polishing (CMP) processes. As the sub-0.1mm (minimum feature size) regime of the device dimension is approached, a very thin layer of material removal with atomically flat and clean surfaces has to be provided during manufacturing. To achieve an effective polishing it is necessary to minimize the surface defects while attaining a good planarity with optimal material removal rate. These requirements can be met by engineering the particle-particle and pad-particle-substrate interactions during the polishing operations. Particle-particle interactions control the stability of the CMP slurries, which has to be achieved under extreme environments of pH, ionic strength, pressure and temperature. In this study, silica-silica polishing was selected as a model system. Silica CMP slurries were stabilized at high pH (10.5) and salt concentration (0.6 M) utilizing the repulsive force barrier introduced by the self-assembled surfactant structures. It was observed that to enhance CMP performance, the control of particle-particle interactions was necessary but not sufficient. An efficient CMP process also required the control of pad-particle-substrate interactions. Therefore, initially the down force applied per abrasive particle was estimated by determining the number of particles in contact with the wafer surface during polishing. Simultaneously, the effective methods of controlling particle-substrate interactions by manipulating the interaction forces were studied at a single particle-surface interaction level utilizing Atomic Force Microscopy (AFM) technique. The results of the force and friction analyses conducted by AFM were correlated with the polishing results to determine the necessary conditions that lead to optimal material removal rate response with minimal surface deformation. The fundamental understanding developed in this investigation is expected to lead to the development of guidelines for the design of optimally performing CMP slurries.

3:30 PM I3.6
MIXED ABRASIVE CMP: A STUDY ON METAL AND DIELECTRIC FILMS.
A. Jindal, S. Hegde and S.V. Babu, Department of Chemical Engineering, Center for Advanced Material Processing, Clarkson University, Potsdam, NY.

Some of the problems associated with the use of single abrasive slurries, such as poor polish rate selectivity, surface defects and slurry unstability, can be overcome by using mixed abrasive slurries (MAS). MAS consists of more than one type of abrasive particle dispersed together in a chemical solution. Several experiments are being carried out to understand the polishing mechanism of copper (Cu), tantalum (Ta), oxide (SiO_2) and nitride (Si_3N_4) films using MAS. This paper presents some of the results from an investigation of CMP of these films with slurries containing mixtures of alumina, silica and/or ceria abrasives obtained from different sources. A significant improvement in the polish rates, and surface defects and slurry stability has been achieved by a suitable combination of abrasives in a given chemical environment. A possible mechanism of these improvements will be presented.

3:45 PM I3.7
INVESTIGATIONS ON THE ROLE OF ABRASIVE SHAPE, SIZE, MORPHOLOGY IN CMP.
Seung-Ho Lee, Zhenyu Lu, Egon Matijavic, and S.V. Babu, Center for Advanced Materials Processing (CAMP), Departments of Chemistry and Chemical Engineering, Clarkson University, Potsdam, NY.

The role of abrasive particle characteristics is an essential aspect of chemical-mechanical polishing (CMP). We will report the results from an investigation of the effects of particle composition, size, shape, and hardness on the planarization of copper and tantalum in the presence of different slurry chemistries. In order to quantify various properties, well-defined dispersions of uniform particles of simple and composite dispersions are being used. The paper describes the preparation of different kinds of such dispersions, including those of silica, iron oxide (hematite), cerium oxide, and of hematite coated with silica. Some of the CMP polish rates and surface roughness data as a function of particle shape, size and coating thickness will also be reported.

4:00 PM I3.8
INVESTIGATION OF NEAR SURFACE MORPHOLOGY OF SiO_2.
Jeremiah T. Abiade, Valentin Craciun, Rajiv K. Singh, University of Florida, Dept. of Materials Science and Engineering and Engineering, Research Center for Particle Science and Technology, Gainesville, FL.

Planarization of silicon dioxide due to chemical mechanical polishing (CMP) relies on chemical dissolution or modification of the surface layer, adsorption of dissolution products onto polishing media and subsequent removal of the modified layer via abrasive particles suspended in an aqueous media. The rate, at which this chemically modified layer is created, is understood to be controlled by the rate that water diffuses into the silicon dioxide network. It is also understood that dissolution and subsequent chemical modification of the silicon dioxide surface is enhanced in high pH environments. In order to gain further insight into the chemical component of the synergistic CMP force required to planarize a surface, we have investigated and sought to characterize the modification of the silicon dioxide surface due to CMP. Using multi variable angle spectroscopic ellipsometry and x-ray reflectometry we have determined a modified surface layer thickness of 2-3 nm best fits experimental data.

SESSION I4: CMP MODELLING
Chairs: Nobuo Hayasaka and Katia Devriendt
Wednesday Morning, April 3, 2002
Golden Gate B1 (Marriott)

8:00 AM *I4.1
SCANNING FORCE MICROSCOPY STUDIES OF COMBINED STRESS AND CHEMICAL STIMULATION OF SURFACES. Tom Dickinson, Washington State University, Dept. of Physics and Materials Science Program, Pullman, WA.

Bond breaking at surfaces due to stimuli such as exposure of materials to radiation, mechanical stress, or chemical agents are well established. We discuss in general the role of multiple stimuli in the degradation and modification of materials and solid surfaces. We then show the consequences of combining localized mechanical stress (due to localized contact with a scanning force microscope–SFM tip) and exposure to aquous solutions. The experiment simulates many features of a single particle-substrate-slurry interaction in CMP. We examine surfaces of inorganic single crystals, glasses, and silicon nitride. We also present results on tip induced recrystallization (at small normal forces) and unique patterning produced by scanning in super-saturated aquous solutions. Finally, studies of exposing polymer surfaces to stress and organic solvents will be discussed. Models will be presented to explain these observed nanometer scale surface modifications.

8:30 AM I4.2
LARGE-SCALE MOLECULAR DYNAMICS SIMULATIONS OF CMP OF a-SiO_2. Evgueni Chagarov and James B. Adams, Arizona State University, Dept of Chemical and Materials Engineering, Tempe, AZ.

Large-scale classical molecular dynamics simulations have been carried out to investigate physicochemical processes during CMP of a-SiO_2. Specifically, polishing of different types of surface topography by slurry particles of different geometry has been modeled to get a microscopic insight into temperature and internal pressure dynamic distribution in substrate features. In addition indentation of slurry particles into a-SiO_2 surface has been investigated to evaluate collateral thermal and stress shock. Different degrees of hydrolysis have been mimicked by H atoms implantation into a-SiO_2 network. All types of simulations have been performed by different relative velocity of surface-particle motion and different bulk temperature to estimate influence of these factors. High-quality visualization allowed recovering of dynamic picture of material displacements as well as thermal and stress field evolution.

8:45 AM I4.3
MECHANISTIC UNDERSTANDING OF MATERIAL DETACHMENT DURING CMP PROCESSING. Wei Che, Youngjin Guo, Abhijit Chandra, Iowa State University, Dept of Mechanical Engineering, Ames, IA; Ashraf Bastawros, Iowa State University, Dept of Aerospace Engineering and Engineering Mechanics, Ames, IA.

A combined experimental and numerical approach has been devised to understand the abrasion aspects of material removal mechanisms of ductile copper and aluminum films on silicon wafers during Chemical mechanical planarization. The experimentally observed trends of the deformation pattern and the force profiles from micro and nano-single scratch experiments are used to guide numerical simulation using finite element simulation at the continuum scale and molecular dynamics simulation at the atomistic scale. Such integrated approach has provided several plausible mechanisms for material detachments through a combination of surface plowing and shearing under the abrasive particles. The gained insights can be integrated into mechanism-based models for the material removal rate in these processes as well as addressing possible defect formation.

9:00 AM I4.4
INFLUENCE OF SLURRY CONCENTRATION ON THE MECHANICAL REMOVAL DURING CMP. Kevin Cooper, Janos Farkas, John Flake, Yuri Solomentsev, Motorola Advanced Product Research and Development Laboratory, Austin, TX; Jennifer Cooper, Johannes Groschopf, Advanced Micro Devices, Austin, TX.

Chemical mechanical planarization process (CMP) is a technology widely used in variety of industrial applications ranging from optical lenses polishing to storage media and semiconductor manufacturing. In semiconductor manufacturing the two most commonly used applications of CMP are global wafer-scale planarization of dielectric layers and planarization of metal damascene structures in the back end of line (BEOL) processing. An important characteristic of a CMP process is the overall removal (polishing) rate of the surface. Removal rate R is traditionally described in terms of the Preston's law [1]. This law postulates that the removal rate, R, is proportional to the product of the relative velocity of the polishing and polished surfaces v and the pressure P exerted on the polished surface. That is: R= APv [1] where A is a constant (Preston coefficient). In this work we studied the dependence of the Preston coefficient, A, on the solid content of the slurry. Specifically, the influence of slurry solid concentration on removal rates has been studied for both 200 mm TEOS and copper wafers. We have shown that CMP removal rate for both TEOS and copper wafers scales linearly with the mean separation distance between particles. The impact of slurry concentration is further characterized by atomic force microscopy. [1] F. Preston, J. Soc. Glass Technol., 11 247 (1927).

9:15 AM I4.5
TOPOGRAPHY REDUCTION DURING BARRIER CMP IMPROVED DUE TO TANTALUM OXIDATION. Paul Lefevre, Katsuyoshi Ina, Kenji Sakai, Kazusei Tamai, Scott Rader, Fujimi Corporation, Elmhurst, IL.

Barrier CMP can reduce the topography generated during Cu CMP. In case of selective barrier CMP slurry like 1:10:1, it is expected that the topography reduction could not exceed the Ta thickness. Some recent observations made at Fujimi show that the topography reduction can be twice larger than the Ta thickness without dielectric loss. This paper presents the chemical mechanical phenomenon that is responsible for this 50 nm high topography reduction during barrier CMP. At the end of the Cu CMP, Ta is exposed to oxidizer and some amount of Cu ions taken from the copper pattern that catalyze the oxidation of the Ta. This process can oxidize the entire thickness of the Ta which becomes Ta_2O_5. Ta oxide layer can be as much as 2.3X thicker than original Ta layer. The oxidation rate is very dependant of the amount of Cu ions during the reaction. 25 nanometers of Ta can be completely oxidized in less than 10 seconds in the high copper density structure. It can take more than 60 seconds to oxidize the same thickness in low copper density areas. This phenomenon explains why topography reduction can be twice higher than initial Ta thickness. This mechanism explains why after Cu CMP it is likely to have more than 30 nm dishing on copper lines. The last and more important consequence is that this reduces final topography and total copper metal loss at the same time by about 30 nm. Obviously very high selectivity Cu slurry (Cu:Ta about 1000:1) is necessary to have no Ta erosion nor Ta_2O_5 erosion during copper CMP. A high selectivity slurry is required during barrier CMP in order to reduce the loss of copper and Dielectric during Ta_2O_5 CMP.

9:30 AM I4.6
EFFECTS OF FLUID INTERFACIAL PRESSURE ON COPPER CHEMICAL MECHANICAL POLISHING. Chunhong Zhou, Gary Ng, Inho Yoon, Steven Danyluk, School of Mechanical Engineering, Gerogia Institute of Technology, Atlanta, GA; M.K. Carter, Lily Yao, EKC Technology, Inc., Hayward, CA.

This study addresses dishing and erosion of copper vias deposited on silicon wafers. Prior work has shown that a negative pressure exists at the interface between the wafer and pad during chemical mechanical polishing. The magnitude of the negative pressure can be of the order magnitude of the loading pressure. The distribution of the negative pressure is nonuniform and thus affects the polishing rate and polishing nonunifomity within the wafer. The nonuniformity in the polished SiO_2 has been linked to this negative pressure. In this presentation, the influence of the negative fluid pressure on dishing and erosion are investigated, especially, the relative speed and morphology of the pad, which are the critical factors related to the interfacial fluid pressure.

10:15 AM I4.7
INVESTIGATION OF THE DISHING OF DAMASCENE METAL FEATURES USING COMPUTATIONAL FLUID DYNAMICS. David R. Campbell, CFD Simulations, Portland, OR; and Andrew F. Miller, Structured Solutions, Portland, OR.

The onset and progression of the dishing of damascene metal features has been investigated using a computational fluid dynamic (CFD) method. In this method, the polishing action of the pad-forced slurry as it moves over the feature surfaces is simulated by the fluid dynamics of the slurry motion. The resulting numerical analyses provide both the fluid pressures and velocities parallel to the polish surfaces, and these quantities are then used to predict the rates of material removal assuming Preston's equation holds. The dishing phenomena has been followed as a function of the polish removal rate ratio between the sunken metal line and the insulating matrix. The relative importance of mechanical vs. chemical metal removal mechanisms are examined at various times during the evolution of the dished structures.

10:30 AM I4.8
SIMULATION OF NANOSCALE POLISHING OF COPPER WITH MOLECULAR DYNAMICS. Y. Ye, R. Biswas, J.R. Morris, Dept. of Physics, Microelectronics Res. Ctr. and Ames Lab, Iowa State Univ, Ames, IA; A. Bastawros, Dept. of Aerospace Engineering and Engineering Mechanics, Iowa State Univ, Ames, IA; A. Chandra, Dept. of Mechanical Engineering, Iowa State Univ, Ames, IA.

With a view to understanding the fundamental mechanisms underlying chemical mechanical polishing of copper, we simulate the nanoscale polishing of a copper surface by a tool or single abrasive particle. The atomistic mechanisms of an individual surface polishing event are simulated with molecular dynamics using the embedded atom method. This is a first step towards understanding the complex processes involved in chemical mechanical planarization of metals. We find nanoscale cutting/polishing comprises of two steps: material removal as the tool machines the top surface, followed by relaxation of the work-material to a low defect configuration, after the tool or abrasive particle has passed over the machined region. During nanometric cutting there can be a local region of higher temperature and stress below the tool. The relaxation process anneals this excess energy and leads to a lower dislocation work-material. At high cutting speeds (180 m/s), the machined surface is rough, but the work-material is dislocation free with a large excess energy annealing the work-material. At lower cutting speeds (2 - 18 m/s), the machined surface is smooth, with dislocations remaining in the substrate and there is only a small excess temperature in the work-material after machining. The variation of cutting forces, coefficient of friction and work-material configuration with the rake angle of the abrasive particle/tool in individual polishing events will be presented. Future research directions relevant to chemical mechanical polishing will be discussed. Supported by the NSF and the American Chemical Society through the Petroleum Research Fund.

10:45 AM I4.9
MOLECULAR SIMULATIONS OF THE MOLECULAR MECHANISMS OCCURRING DURING CHEMICAL- MECHANICAL POLISHING. Stephen H. Garofalini, Department of Ceramic and Materials Engineering, Rutgers University, Piscataway, NJ.

The molecular dynamics (MD) computer simulation technique is being used to address the molecular aspects of chemical-mechanical polishing (CMP) of oxide surfaces. The simulations are designed to evaluate the atomistic interactions between two oxide surface such as soft/soft, hard/hard, and soft/hard materials combinations in the presence of moisture. One surface is brought into contact with the second surface and moved laterally across the second surface in order to determine interface behavior, material removal, and smoothing of the substrate as a function of pressure and moisture. The computations allow for chemical reactions caused by the presence of water molecules. Results show smoothing of an oxide surface containing an asperity as the surfaces slide. Moisture between the surfaces is shown to play an important role with respect to bond rupture and surface smoothing. Simulations of the molecular mechanisms of removal of layers of a hard surface (alumina) by contact sliding with a soft material (silica) in the presence of moisture will be presented.

11:00 AM I4.10
UNDERSTANDING AND ADDRESSING THE FUNDAMENTALS OF CMP REMOVAL RATE NONUNIFORMITY. Travis R. Taylor, C. Shan Xu, LAM Research Corporation, CMP/Clean Products Group, Fremont, CA.

In general, CMP tools operate to remove material as a function of the velocity and pressure the wafer experiences (Prestons equation). The typical mode for polishing on most CMP affords inhomogeneous velocity and pressure distributions which are averaged together to give the optimal removal rate uniformity performance. We have developed a new technique for understanding fundamentals of removal rate nonuniformity. The technique decouples the nonuniformity contributions from the inhomogeneous pressure and velocity distributions the wafer experiences by making the velocity distribution exactly uniform so effects of the inhomogeneous pressure distribution can be observed directly. The homogeneous velocity distribution is accomplished by decreasing the carrier rotational speed to 0 rpm and keeping the linear pad velocity constant. The data from such an experiment is captured using a high resolution metrology recipe to generate a removal rate contour plot. We have developed algorithms for correlating the nonuniformities shown in removal rate contour plots with the nonuniformities generated on blanket wafers with normal carrier rotational speeds. This correlation provides valuable information relevant to the optimization of process parameters and design of hardware that will eliminate or diminish undesirable polishing characteristics. We will present and discuss the development of the above mentioned algorithms and show how this information has led to the development next-generation hardware for advanced removal rate uniformity control.

11:15 AM I4.11
ELECTROCHEMICAL MEASUREMENTS TO UNDERSTAND THE DYNAMICS OF THE CHEMICALLY MODIFIED SURFACE LAYER FORMATION DURING COPPER CMP. Seung-Mahn Lee, Wonseop Choi, Valentin Craciun and Rajiv K. Singh, Department of Materials Science and Engineering and Engineering, Research Center for Particle Science and Technology, University of Florida, Gainesville, FL.

The planarity, defectivity and the polish rate in a CMP process are dependent of the nano-scale chemical and mechanical interactions involving the formation and the removal of a chemically modified surface layer. The objective of this talk is to provide an understanding of the dynamics of the chemically modified surface layer formation during copper. We have performed in-situ electrochemical measurements, which provide information on the chemical changes on the surface due to additives in the slurry. For this purpose, chronoamperometry was applied for in-situ electrochemical measurements to determine the dynamics of chemically modified surface layer formation. The rate of formation of the surface layer and the kinetics of passivation were also determined. Ex-situ measurements (XPS, XRR and VASE) were conducted to confirm and validate the electrochemical results. The results show that hydrogen peroxide in the slurry led to the formation of a surface layer at a constant rate, whereas the addition of BTA inhibited the formation of this layer. The talk will address the chemical additive effects on the dynamics of surface layer formation during the CMP process.

11:30 AM I4.12
EFFECT OF LEVELING ADDITIVES IN COPPER PLATING BATH ON CMP. J. So, Rodel, Newark, DE; G. Banerjee, Rodel, Phoenix, AZ; J. Calvert, B. Mikkola, J. Rychwalski, Shipley Microelectronics, Marlborough, MA.

Copper is now the interconnect metal of choice for feature sizes of 180 nm and below. Electrolytic deposition of copper is now recognized as the technology of choice for metallization of patterned silicon wafers. The electrodeposited copper surface is subsequently planarized using a chemical mechanical planarization(CMP) technique. Minimal surface roughness and topography after copper deposition is essential in order to achieve a surface roughness average of less than 1 nm after CMP. In this paper, we show the effect of two different leveling additives on the surface roughness of the wafers after plating and their effect on the subsequent planarization process. We will compare the results with wafers plated without a leveling additive in the plating bath. All the wafers were plated and planarized using proprietary chemical formulations. We will discuss the observed metal removal rates, non-uniformity, dishing, etc. in the paper.

11:45 AM I4.13
OPTIMIZATION OF DEPOSITION THICKNESS AND OVER POLISHING TIME TO MINIMIZE WAFER LEVEL TOPOGRAPHY IN COPPER CMP. J.M. Kang, S. Wu, T. Selvaraj, B. Lin, P.D. Foo, Institute of Microelectronics, DSIC, Singapore, SINGAPORE.

Topography after CMP is one of the main issues in constructing reliable Cu interconnects. The wafer level topography is greatly influenced by many polishing properties such as removal uniformity and planarization efficiency, and also by many polishing variables. Among the variables, Cu deposition thickness and over polishing time are easily controllable, and closely related to the topography. For given polishing properties, the topography can be minimized through the optimization of Cu deposition thickness and over polishing time. A model is proposed to account for the correlation between the polishing properties and the variables for the minimum of wafer level topography. Numerical result of this model shows a strong dependency of Cu deposition thickness and over polishing time on the removal uniformity, dishing susceptibility and over plated bump size.

SESSION I5: CMP PADS AND DEFECTS
Chairs: John F. Quanci and Duane S. Boning
Wednesday Afternoon, April 3, 2002
Golden Gate B1 (Marriott)

1:30 PM *I5.1
CHEMICAL AND MECHANICAL BALANCE FOR DEFECTIVITY REDUCTION IN COPPER CMP. Yuzhuo Li, Xiaojing Shi, Jason Keleher, Center for Advanced Materials Processing, Department of Chemistry, Clarkson University, Potsdam, NY.

Key issues in CMP today include reduction of surface defectivity and enhancement of planarization efficiency. More specifically, the polished surface should be free of defects such as scratches, pits, corrosion spots, and residue particles. It is our experience that a defect-free surface can be most effectively obtained by balancing the chemical and mechanical strengths of the polishing ensemble. A high planarization efficiency can be realized through the control of polishing rate and selectivity among different materials on the surface depending upon their relative topographical locations. To accomplish these goals, we have investigated a wide range of pathways including reduction of oversized particles, use of unique novel abrasive particles or functionalized conventional abrasive particles, and development of polishing solution without abrasive particles (Abrasive Free System). In this talk, some examples will be given on the use of these new and surface functionalized abrasive particles for the development copper CMP slurries. In addition, some preliminary results on the use of an abrasive free system for low k dielectric film CMP will also be discussed.

2:00 PM I5.2
Abstract Withdrawn.

2:15 PM I5.3
CMP PAD CONDITIONING AND PAD SURFACE CHARACTERIZATION. A. Scott Lawing, Rodel, Inc., Phoenix, AZ.

A comprehensive program to understand the relationship between pad conditioner design, conditioning process, pad surface morphology and polish performance has been initiated. Typically, pad conditioning is achieved through the use of a diamond abrasive disc to modify the pad surface. In this program, the ability to manipulate pad conditioner surfaces by changing parameters such as diamond crystal size, diamond crystal morphology and crystal surface density is being utilized to generate a range of pad surfaces on a variety of pad platforms and in a range of different CMP applications. The effects of process variables and associated consumables such as slurry type on the pad surface are also being considered. In this paper, a methodology to quantitatively characterize pad surfaces is introduced. When pad surface x,y,z data is represented as a histogram in the form of surface area (or point frequency) as a function of pad height, characteristic features are observed in the height spectra. In most cases these spectra can be accurately modeled with 1 or 2 modified Gaussian peaks, from which a handful of characteristic fitting parameters can be extracted. This methodology allows for the quantification of both subtle and gross changes in pad surface statistics. Polish performance metrics have been correlated to a number of the extracted peak parameters, and more conventional surface statistics such as average roughness have shown correlation in some polishing systems as well. Recent results and future directions for the research program will be discussed.

3:00 PM I5.4
EFFECT OF SLURRY CONDITIONING AND TEMPERATURE TREATMENT ON THE PROPERTIES OF CMP PADS. Alex Tregub, Mansour Moinpour, and Jamshid Sorooshian[a], Intel Corporation, Fab Material Operations, Santa Clara, CA; [a]currently, Ph.D. student at the University of Arizona.

During a traditional CMP process, which involves application of polishing pads and slurry, the pad properties can be changed as the result of slurry/rinse water absorption and increase of the pad temperature due to mechanical friction between a polymer-based pad and a silicon wafer. Both slurry/rinse water adsorption and pad heating can substantially and irreversibly change the physical and mechanical properties of the pads and their chemical structure. The polyurethane-based pad was exposed at room temperature to DI water and to slurry for different time durations. Additionally, to simulate the effect of slurry pH on the slurry absorption and pad properties, the pad samples were exposed to various pH buffer solutions. The adsorption was monitored using measurements of the weight changes of the exposed specimens before and after immersion. The liquid uptake was calculated using equation (1): $W_g = 100(W_t - W_0)/W_0$ (1) where W_g is the percent weight change, W_0 is the dry specimen weight before immersion, and Wt is the blotted specimen weight after immersion. The weight gain of the pad specimens followed Fickian behavior. Diffusion coefficients were calculated using equation (2) that describes the linear part of the dependence $W = W(t^{1/2})$: $W = W_m[(4/\pi)\ (Dt/d^2)]^{1/2}$, (2) where W_m is the weight gain at saturation, D is coefficient of diffusion, d is the specimen thickness, and t is time of exposure. To monitor the retention of the pad properties after exposure, the following thermal and mechanical techniques have been employed during the study: Dynamical Mechanical Analysis (DMA), Modulated Differential Scanning Calorimetry (MDSC), Thermal Gravimetric Analysis (TGA), and Thermal Mechanical Analysis (TMA). The effect of temperature on the pad properties was studied using DMA, TMA, MDSC, and TGA measurements performed on the pad specimens annealed at different temperatures for various time. Using a time-temperature superposition analysis for DMA results, obtained at different oscillating frequencies, a long-term prediction of the pad properties exposed to the elevated temperatures was obtained. Additionally, activation energies of the glass transition were calculated for the pads exposed to various aqueous environments and annealed at different temperatures. Conclusions. 1. Effect of pad exposure to various aqueous environments that are typical for CMP applications has been studied. 2. Temperature conditioning was shown to optimize pad polishing properties.

3:15 PM I5.5
ANALYSIS OF LOCAL PLANARIZATION WITH POLISHING TIME, FILM THICKNESS, CHEMICAL NON-UNIFORMITY, LINE DENSITY, LINE WIDTH, AND PAD VISCOELASTIC PROPERTIES. Jinru Bian, John Quanci, Rodel Inc., Newark, DE.

The theoretic models in local planarization, in chemical mechanic polishing process, as a function of polishing time and film removed have been reviewed. The relative equations have been re-derived in a systematic and correlative way. Analysis is further extended to explain the experimental phenomena that step height of local planarization is an exponential related function of metal line width for the same line density, by consideration of pad viscoelastic and relaxation properties.

3:30 PM I5.6
STUDY OF DEFECT FROM Cu/BLACK DIAMOND CMP PROCESS. Shaoyu Wu, Ning Li, J.M. Kang, T.W.M. Lam, B. Lin, T. Selvaraj, S.P. Zhao, K. Rakesh and P.D. Foo, Institute of Microelectronics, DSIC-MD, SINGAPORE.

Black Diamond (BD) is gaining popularity as a low k dielectric for copper/low k integration. However, because of lower hardness and more hydrophobic in nature of BD film surface comparing with those of the conventional oxide, some specific defects appear during CMP process of Cu/BD patterned wafers. In this study, the patterned wafer inspection systems, AIT II, and SEM review station are used to review and to classify such defects generated from CMP process. Using conventional Cu/Oxide CMP process, the percentage of these specific defects from Cu/BD CMP is typically more than 60 of total defect count. By modifying the composition of slurry with new additives and optimization of polishing and cleaning parameters, the total defect count can be reduced by 70%, in which the amount of specific defects is less than 5% of total defect count.

3:45 PM I5.7
DELAMINATION BEHAVIOR OF Cu–LOW-k STACK UNDER DIFFERENT ABRASIVE DENSITIES IN SLURRY. A.K. Sikder, P.B. Zantye, S. Thagella and Ashok Kumar, Center for Microelectronics Research, University of South Florida, Tampa, FL.

The dielectric constant of the interlayer dielectric films generates high parasitic capacitance, which leads to increased signal propagation delay-time and cross-talk. A low dielectric constant material is required in order to improve the device performance. In the 50 nm node, the International Roadmap for Semiconductors (ITRS) predicts a need for dielectrics with a bulk K value of <1.3 and effective K value <1.5 for the dielectric stack. Mechanical characterization of low dielectric constant (low-K) materials has shown that lower K typically also means lower elastic modulus and hardness. Due to lower mechanical strength, reduced cohesive strength and lack of compatibility with other interconnect materials, major challenges involve in chemical mechanical polishing (CMP) of these low-K materials. In this study we have investigated the polishing behavior of patterned copper samples with underneath different low-K materials using slurry with wide range of concentrations of abrasives. CMP micro tribometer was used to polish the samples with different rotation of platen (0.2 to 1.5 m/s) and down force (1-6 psi). Friction co-efficient and wear behavior were also measured at different conditions. Atomic force microscopy and scanning electron microscopy were used to investigate the polished surface. As the abrasive density increases in the slurry the delamination increases on the sample surface. Attempt has been made to find the mechanisms of delamination due to the effect of abrasives.

4:00 PM I5.8
EFFECTS OF THE POROSITY AND SIZE OF NANOPOROUS SiO_2 PARTICULATES ON SiO_2 CMP PERFORMANCES. K.S. Choi, R. Vacassy and R.K. Singh, Department of Materials Science and Engineering and Engineering, Research Center for Particle Science and Technology, University of Florida, Gainesville, FL.

The aim of this study is to investigate the effect of the porosity rate and particle size of nanosized silica particles on the SiO_2 Chemical Mechanical Polishing (CMP) performances. The silicon dioxide particles with the different porosity rates and sizes have been synthesized by a precipitation technique involving the hydrolysis reaction of a silicon alkoxide in ethanol. The formulation of microporosity is obtained by the absorption of an organic compound (glycerol) as the porogen and the microporosity of as-synthesized silica particles can be controlled by the concentration of glycerol and reaction time. The particle size of silica particles can be controlled by several parameters such as the concentrations of Ammonium hydroxide and water, reaction time, and the calcination temperature and time. The effects of the microporosity and size of spherical silica particles on SiO_2 wafer polishing have been examined in this experiment. The SiO_2 CMP has been carried out with as-synthesized nanoporous SiO_2 particle slurry as a function of the porosity rate, pH, and the solid loading. In this study, the porosity of SiO_2 particles considerably affected the surface removal rate of SiO_2 wafers. The higher the porosity rate of SiO_2 particles, the higher the removal rate of SiO_2 wafer surface. On the other hand, the size of microporous SiO_2 particles also affected the surface removal rate in SiO_2 CMP performances. The larger particle size and higher solid loading resulted in a higher surface removal rates with a rough surface qualities. The surface qualities of polished wafers have been examined by Atomic Force Microscopy (AFM).