Manufacturing Science and Technology
Room 131 - Session MS-MoM

Metrology and Inspection for Manufacturing

Moderator: C.R. Brundle, Applied Materials

9:40am **MS-MoM1 Optical Digital Profiling for Production Applications*, K. Barry*,** *J. Kretzschmar, N. Jakatdar,* Timbre Technologies, Inc. **INVITED**

As the industry drives down feature sizes, the need for more advanced characterization techniques becomes imperative. Gate lengths are quickly approaching the sub-one hundred-nanometer regime. Traditional techniques are not keeping pace with the precision and accuracy needs of the IC industry. Additionally, with the onset of 300mm wafer production, it will be imperative for tools to be able to measure critical parameters and adjust processing conditions on a wafer-by-wafer basis. The industry is experiencing a paradigm shift in critical dimension metrology. Optical Digital Profilometry (ODP), developed by Timbre Technologies Inc. (Fremont, Calif.), is an optical, nondestructive, in-line profile measurement methodology utilizing Maxwell's principles to generate digital cross-sectional representations of IC features. One advantage is that ODP has been proven extendible beyond the 70nm node by utilizing spectroscopic ellipsometry to measure physical structures with precision an order of magnitude better than currently available CD-SEMs. Another advantage lies in Optical Digital Profilometry's ability to generate digital cross-sectional information in real time enabling advanced process control (APC) of IC manufacturing lines. In this paper we present results from monitoring production wafers via ODP of shallow trench isolation (STI) structures at the post-etch, post-clean step, also referred to as final inspect (FI). These results show ODP to be a viable method for in-line CD, depth, and profile metrology, with sub-nm repeatability and excellent correlation to XSEM and CD-SEM.

10:20am **MS-MoM3 Critical Dimension and Profile Measurement by Optical Scatterometry for Sub-0.15 µm Advanced Gate and Shallow Trench Isolation Structures*, D. Mui*,** *H. Sasano, J. Yamatino, M.S. Barnes, K. Fairbarn,* Applied Materials

The use of a non-destructive optical scatterometry (OS) technique for measuring critical dimensions (CD) and cross-sectional profiles in advanced gate and shallow trench isolation (STI) structures with sub-0.15 µm feature size has been evaluated. Conventional scanning electron microscopy (SEM) technique was used as the reference for comparison. 8" Si wafers with various feature sizes and profiles were used in this study. A bias between optical-CD (OCD) and SEM-CD measured on the same feature was observed. Measurements on different OS tools from different vendors showed consistently smaller CDs than those measured on a SEM tool. This CD bias was observed to be profile dependent ranging from 2 to 20 nm in our study. Good correlation between the two CD metrologies was obtained for a given wafer when a constant bias was added to the OCD data set. For profile comparison, various profiles including - bowed, tapered, notched, and vertical, were etched and measured. In general, good correlation was obtained between the non-destructive OS and destructive SEM techniques.

10:40am **MS-MoM4 Wafer Inspection with HDI Surface Reflectance Analyzer*, A. Surdutovich*,** *G. Conti, H.T. Nguyen, H. Hao,* Applied Materials; *G.H. Vurens,* HDI Instrumentation

Scanning Reflectance Analysis (SRA) is being widely used in the hard disk industry for metrology of thin film disks. The technique has been evaluated for wafer inspection. This technique provides a means to generate high resolution maps of thickness variation and empirical chemistry variation of films on a wafer in less than one minute. Low k CVD films have been measured with HDI SRA and an application has been developed for mapping out separately chemical and thickness variations across the whole wafer area. Detection of organic contamination on Cu seed film has also been investigated.

11:00am **MS-MoM5 Using SQUIDs for Failure Analysis in the Semiconductor Industry**, *T. Venkatesan, L.A. Knauss,* ***A. Schwartz,*** Neocera, Inc. **INVITED**

With the arrival of flip-chip packaging and multi-level metallization on dies, present tools and techniques are having increasing difficulty in meeting failure analysis needs. Recently a magnetic field imaging system has been demonstrated to localize shorts in buried layers of both packages and dies. This system uses a SQUID (Superconducting Quantum Interference Device), which is a very sensitive magnetic sensor that can image magnetic fields generated by magnetic materials or currents (such as those in an integrated circuit or package). These currents (as low as microamperes) can be detected even when they are buried deep within a package or assembly. Since magnetic fields are not affected by most materials used in circuit technology, magnetic field imaging can be applied to several vertical layers enabling problem detection in a multi-layer stack involving the die, solder bumps, package, BGA and board. The current density distribution in the sample can then be calculated from the magnetic field image providing a map of current flow in the assembled device. This can be helpful for design verification and short localization, including determining which layer of the structure contains the defect. To image these devices, the SQUID must be cooled to temperatures around 77K while the sample is at room temperature. In order to image these parts non-invasively, the system has been designed to keep the SQUID cold and in vacuum while the sample is at room temperature in air. The design of this system as well as the application to failure analysis will be presented. Peak localization of defects to ± 5 microns has been demonstrated in the best case with sub-10 microns being typical.

11:40am **MS-MoM7 Development of a 300 mm Wafer Defect Analysis Tool Integrating High Resolution Auger Spectroscopy and Ultrahigh Resolution Immersion Lens SEM Microscopy*, W.K. Ford*,** *M. Jaehnig, P. Hudson,* Intel Corporation; *T. Dingle, K. Troost, L. Christman, J. Jackman, M. Verheijen,* FEI Company; *P. Belcher,* Thermo VG Scientific

The challenge of defect analysis and material characterization in a Si semiconductor fab becomes increasingly difficult with each process generation. Scaling steadily decreases the size of circuit features, permitting smaller and smaller particle defects to impact the yield of the device. Simultaneously, nanometer-scale thin films are commonly being used as gate dielectrics, metal adhesion and barrier layers, and interfacial treatments. These two trends produce challenges to process development and manufacturing that can be addressed using surface analytical tools such as the Auger microscope. This paper describes the development of an advanced Auger microscope believed suitable for 0.13 µm, 0.10 µm, and 0.07 µm process generations. It is in this range that the large excitation volume of the electron beam even at the lowest practical primary beam energy renders as ambiguous the commonly used x-ray analysis (EDS) methods, and that ultra sensitive mass spectroscopy (TOFSIMS) fails to have suitable lateral spatial resolution. The Auger microscope described herein has been developed using an immersion mode objective lens for ultimate imaging capability, providing simple, rapid transition between ultra high resolution SEM imaging and Auger spectroscopy. It is based on a UHV 300 mm wafer-capable platform using industry standard interfaces and incorporates a new, highly effective stage technology, which provides for the required stage navigation accuracy and speed, versatile sample positioning including high angle tilting, and full integration with standard CAD software interfaces. A high sensitivity Auger detector is used that provides the high spectral energy resolution often required for chemical analysis. These capabilities will be demonstrated using a full range of examples derived from Si process development and manufacturing.

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