Experimental Detection of the Chemical Mechanical Polishing (CMP) Process End Point for different Interconnect Materials

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The constant push towards sub-micron miniaturization of the device dimensions, increased density of devices, and faster processing power has led to the development of new interconnect technologies that use Copper and ultra low-k (k≤2.2) polymer based dielectrics. The incorporation of Copper as a replacement for previously used conducting interconnect material, Aluminum (and Aluminum alloys), has further reduced the resistance of the metal interconnects and improved the performance of the ICs. Due to the reduced feature sizes, the surface planarity of the deposited thin films is critical in device fabrication. Thus, the reason for the extensive and ever increasing use of the CMP process in the field of semiconductor fabrication may be traced to all of these aforementioned factors [1]. As precious little is known about all the microscopic, electrochemical and molecular phenomena and interactions that occur during this tribochemical process, experimental approach has traditionally been adopted to characterize and optimize the CMP process [2]. In this research, the real time CMP process has been simulated on the CETR Inc., CA, Universal Bench-top Tribometer (UBT) (fig 1). The UBT is an in situ CMP process characterization tool. The platen speed, down force, slider movement are some of the input parameters, while Acoustic Emission (AE) signal, Coefficient of Friction (COF), frictional force are the different output parameters displayed in situ during the process. The end point detection is one of the most crucial issues in CMP process optimization as excessive polishing results in removal of unwanted material from the underlying thin film, extensive surface damage, deformation and thus a comprehensive increase in the CMP process budget. The effective end point detection is also critical to achieve a high degree of global and local planarization and uniformity. Different interconnect materials namely Cu and SiC, barrier material namely Ta and different interlayer dielectrics namely SiO_2, Low-k A, Low-k B and SiLk. These materials were planarized in different Cu and barrier material selective colloidal and non colloidal abrasive, and abrasive free slurries. Every material has a characteristic COF and AE when polished in a particular pad and slurry. The change in the values of COF and AE upon the exposure of the underlying material during the CMP process is used to detect the end point of that particular process. The figures (Fig 2, Fig 3 and Fig 4) show the corresponding COF and AE values for Cu (interconnect metal layer), Ta (barrier layer) and SiO_2 (dielectric layer) at different down force (Psi) and liner velocity (m/s). These standard values could be used to determine the complete removal of a particular material from the surface of the wafer. Furthermore, the COF, A.E. along with the material removal rate are used to determine the selectivity of specific slurry towards a particular material.

References:

1. J.M. Steigerwald, S.P. Murarka, R.J. Gutmann, Chemical Mechanical Planarization of Microelectronic Materials, Wiley-Interscience, New York, 1997

2. A. K. Sikder, Frank Giglio, John Wood, Ashok Kumar and J.M. Anthony, J. Elec. Mater.,30, (2001), pp.1522

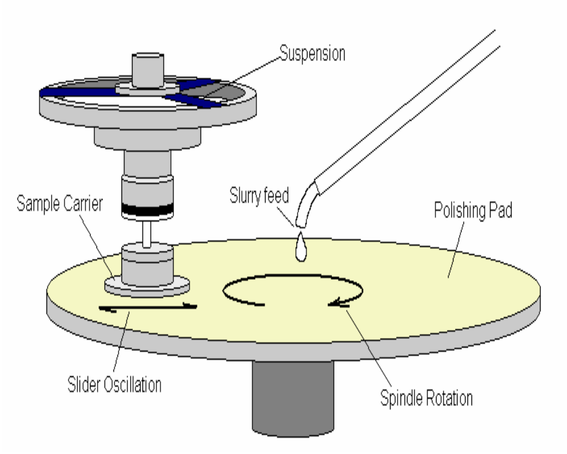

Fig.1 Schematic of the CMP process

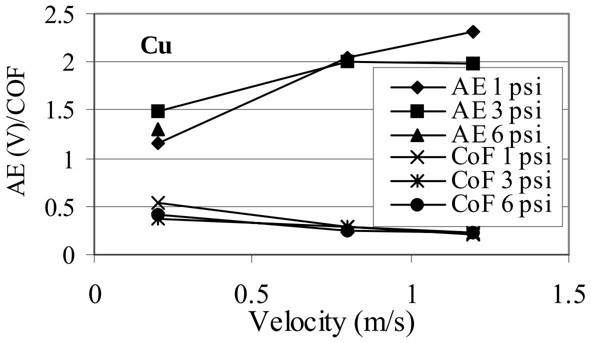

Fig.2 The variation of AE and COF for Cu (interconnect) at different velocity (m/s) and down force (Psi)

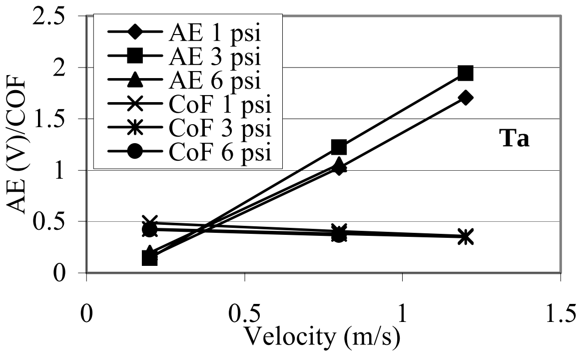

Fig.3 The variation of AE and COF for Ta (barrier layer) at different velocity (m/s) and down force (Psi)

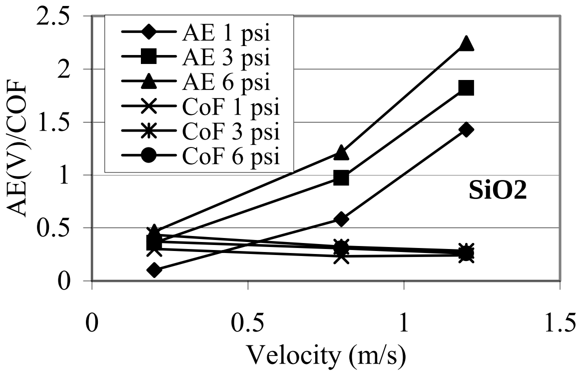

Fig.4 The variation of AE and COF for SiO_2 (interlayer dielectric layer) at different velocity (m/s) and down force (Psi)