Evaluation of the Properties of Polyurethane Pads and their Correlation to the Performance in the CMP Process

P. Zantye, A. K. Sikder, A. Kumar, A. Belyaev, I. Tarasov, and S. Ostapenko
Nanomaterials and Nanomanufacturing Research Center, University of South Florida, Tampa, Florida-33620

The fundamental reason behind the increasing implementation of Chemical Mechanical Polishing (CMP) process at different stages of the microelectronic device fabrication process flow can be traced to the need for a very high degree of global and local planarization on the surface of the wafer due to the progressive shrinking of the minimum feature size of the device. With the CMP process taking a considerable amount of the entire semiconductor process budget, there is a growing demand for the CMP know-how, process equipment, consumables and peripherals. One such CMP consumable, where there is extensive scope for development and improvement, in order to meet the ever increasing process reproducibility and reliability demands of the semiconductor industry, is the CMP polishing pad. The polishing pad, which is made up of a matrix of cast polyurethane foam with filler material to control hardness or polyurethane impregnated belts [1], considerably and directly affects the wafer to wafer non uniformity (WTWNU) and the within wafer non uniformity (WIWNU). In order to improve the yield of the CMP process, to get a highly planar defect free uniform wafer surface and to reduce the overall manufacturing costs involved, there is a need to extensively study the fundamental properties of the CMP pads and the materials involved there in. The scanning Ultrasound Transmission (UST) (Fig. 1), a nondestructive technique developed at the University of South Florida (USF) works on the principle of ultrasound permeability through absorbing visco-elastic medium [2]. The difference in the ultrasound absorption in the areas of varying density and viscosity is used to determine the non uniformity within a single pad by giving an in depth idea of the physical characteristics of the given pad. In this study, full-size up to 32” diameter donut-shaped CMP pads were measured. The 6 inch coupons cut from the areas of various UST amplitudes are further analyzed using the Dynamic Mechanical Analysis (DMA) technique. The DMA characterizes the modulus-temperature profiles of the pads at undergoing flexural deformation at different frequencies (Fig.2) there by giving an estimation of the mechanical properties of the visco-elastic polyurethane pad material [3]. The coupons taken from the similar areas from another pad of the same type (the coupons used for DMA cannot be used as DMA is a destructive testing technique), are then tribologically tested using the simulated CMP process using the CMP Universal Bench-top Tribometer (UBT) (Fig. 3). This form of tribological testing is performed to establish a co-relation between the variation of homogeneity and mechanical properties with CMP process performance of the pad. Various pads, namely: i) IC 1000 A4 perforated, ii) IC1000 B 4 K grooved and iii) Suba IV plain, with different surface texture, were used in this analysis. A sample of UST mapping of a 15” X 32” dual layer pad is shown in Fig. 4.

References:
1. J.M. Steigerwald, S.P. Murarka, R.J. Gutmann, Chemical Mechanical Planarization of Microelectronic Materials, Wiley-Interscience, New York, 1997
2. D. G. Totzke, et.al. NIST conference, 2001, pp. 259
3. A.K. Sikder, et.al, Mat. Res. Soc. Symp. Proc. Vol 671, (2001), pp M1.8.1

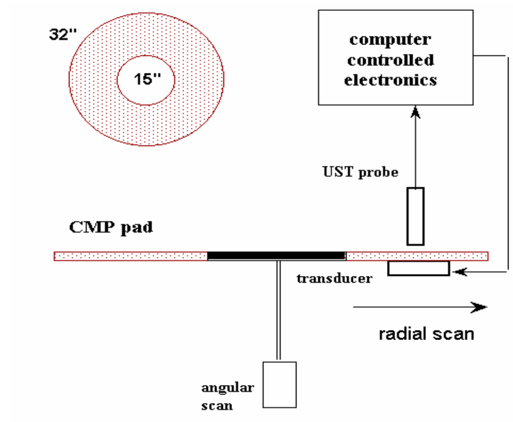

Fig. 1 Schematic Diagram of UST System

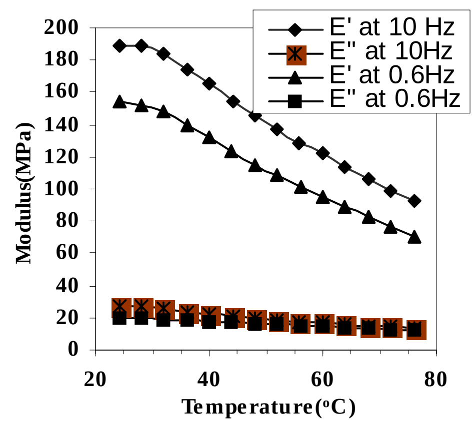

Fig. 2 A plot of the variation of Storage modulus with temperature of the IC 1000 A4 perforated pad at different frequencies using of DMA method

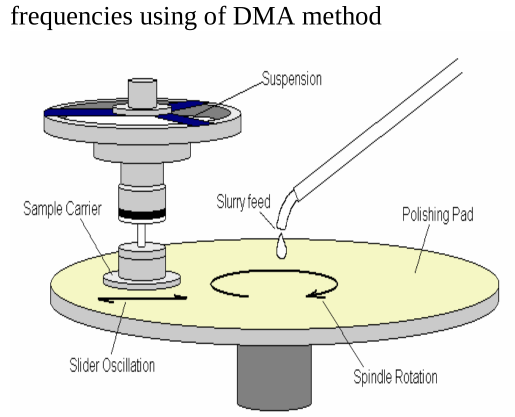

Fig. 3 Schematic of the CMP process

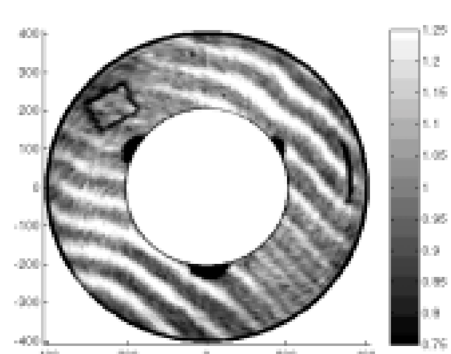

Fig. 4 UST map of 15”x32” full size dual-layer CMP pad. The UST amplitude is normalized to the average value (16% of transmission coefficient in this pad).