The using of a coating thickness gauge to get information about the polishing pad profile

Andreas Krüger[1], Marco Lisker[1]
[1] IHP – Leibniz-Institut für innovative Mikroelektronik, akrueger@ihp-microelectronics.com

INTRODUCTION

The conditioning of the polishing pad is important to achieve a stable removal rate and a small with-in wafer non-uniformity (WIWNU). Without conditioning or with underconditioning, a glazing effect occurs on the pad. As a result, the pad is not rough enough and there is no good slurry transport to the contact surface between the wafer and the pad. On the other hand, overconditioning leads to excessive loss of pad material [1].

BACKGROUND

Getting information about the wear of a polishing pad is important to optimize the pad usage time. In order to optimize the pad removal, generated by the pad conditioning, it is important to know the distribution of the pad thickness over the pad radius. Due to the removal of the pad material from its surface, the depth of the grooves decreases with decreasing pad thickness. If the pad grooves depth approaches zero, problems arise in de-chucking the polishing wafer from the polishing pad. At this point the pad has reached the end of its useful life and needs to be replaced.

This work shows how the layer thickness distribution over the pad radius can be determined with the help of a portable thickness measuring device.

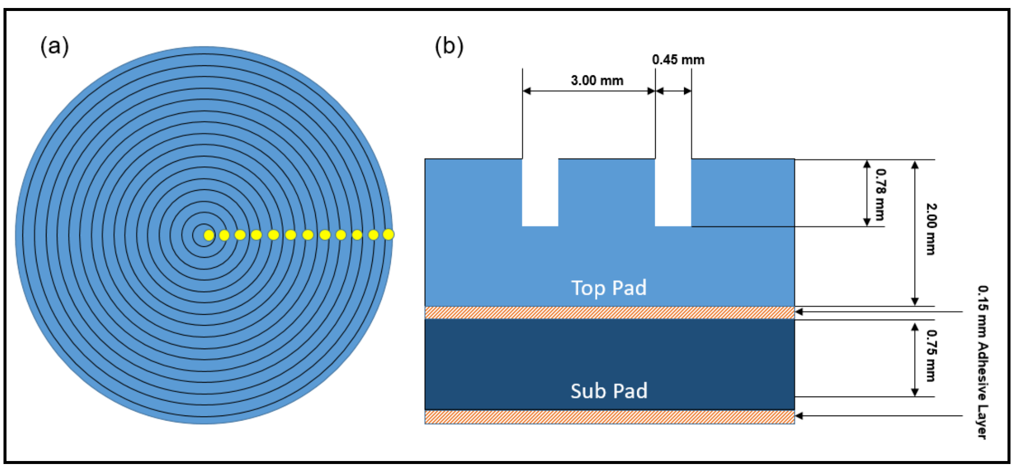

Fig. 1 (a) Schematic top view of the pad with measurement points & (b) a cross section of the pad with dimensions

EXPERIMENTAL

The investigation in this work was carried out on a Mirra Mesa polishing system from Applied Material (AMAT) with swing-arm conditioning. The conditioning disc is a BSL (metal brazed) type from EHWA DIAMOND. An IC1010 pad from Dow Chemical Company (DOW) with concentric grooves was used as the polishing pad. The polishing machine was mainly used for SiO_2 removal. The polishing pressures used were between 3 and 5 psi and the conditioning was carried out for 75 % of the used polishing time.

The thickness of the pad is measured using the QNix® 8500 device from “Automation Dr. Nix GmbH & Co. KG” with a dual measuring probe Fe 5 mm/NFe 5 mm. The measurement principle is based on the Hall Effect and eddy currents. The measuring device has a thickness resolution of ± 1 µm. However, the measurements up to 2 mm adds 2 % & above 2 mm adds 3.5 % of the measured layer thickness to the error. The measuring range for Fe extends from 0.2 mm to 5 mm, whereas for NFe extends from 0.05 mm to 5 mm. The NFe mode was used for the pad thickness measurements in this work.

A measuring ruler was made to always measure the same points on the polishing pad. This was aligned to the pad radius in the area of the notch on the pad edge. Twelve measuring points were measured at intervals of 20 mm in the range from 10 mm (center of pad) to 230 mm (pad edge) (Figure 1 (a)). In Figure 1 (b) you can see a cross section of the polishing pad. The sum of the thickness is 2.9 mm (0.75 mm [sub pad] + 0.15 mm [adhesive layer] + 2 mm [top pad]). In between the thickness measurements, the polishing system was used for polishing SiO_2 in the production line with different polishing pressures & polishing times.

In order to ensure the reproducibility of the measurement, a procedure was developed in which the polishing pad was first conditioned with water for 60 s before each measurement, then rinsed with water for 30 s and then spun dry for 60 s at a rotational speed of 100 rpm. This created the defined condition of the polishing pad before the measurements. The pad conditioning time was noted for each series of measurements.

The measurements were carried out on a daily basis. Since the production process has a very different daily throughput, the conditioning time of the pad varies from day to day.

DISCUSSION

The boxplot in Figure 2 illustrated the change in thickness of the pad with the pad conditioning time. The thickness measurements starts with measuring a new, dry, unconditioned planar pad. The initial pad thickness measured was 2.9 mm. In the certificate of analysis for the IC1010 pad used, the specified thickness of the sub pad and top pad were 0.72 mm & 2.03 mm respectively. The initial thickness of the pad is obtained by adding the thickness of the sub pad, top pad and the adhesive layers present between them and underneath the sub pad. After the “break in” procedure, where the pad is rinsed with water & conditioned for 120 s, the thickness of the pad measured was 3.2 mm.

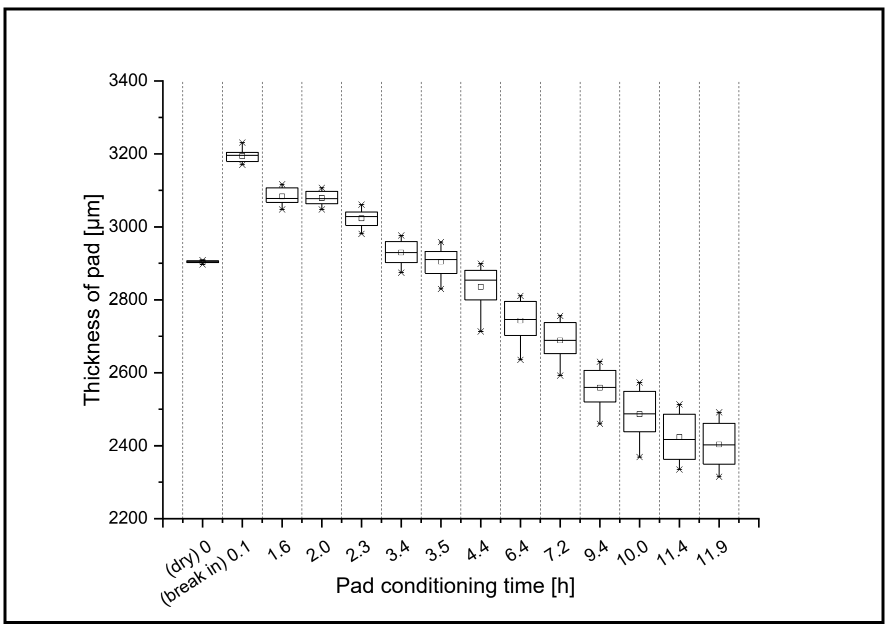

Fig. 2 Pad thickness for different conditioning times

The pores of the pad are opened up by the conditioning and they absorb water. During the polishing of wafers, the pad is conditioned 75 % of the polishing time. This reduces the pad thickness. After 10 hours of conditioning, the pad thickness decreases by 0.7 mm. The polishing pad reaches its end of life after 12 hours of pad conditioning at 2.4 mm thickness (0.8 mm of pad wear). This is the point at which the 0.78 mm of groove depth has been completely eliminated. This corresponds to a pad removal rate of 70 µm/h. This removal takes place linearly over the conditioning time (Figure 3 (a)).

An inhomogeneity with increasing pad usage time can be seen (Figure 3 (b)). The pad range increases continuously until it has been conditioned for 4 hours to the maximum value of approximately 175 µm, after which the pad range remains almost constant.

Further, it can be seen in Figure 4, that the pad wear in the pad center and the pad edge is higher than in the area in between.

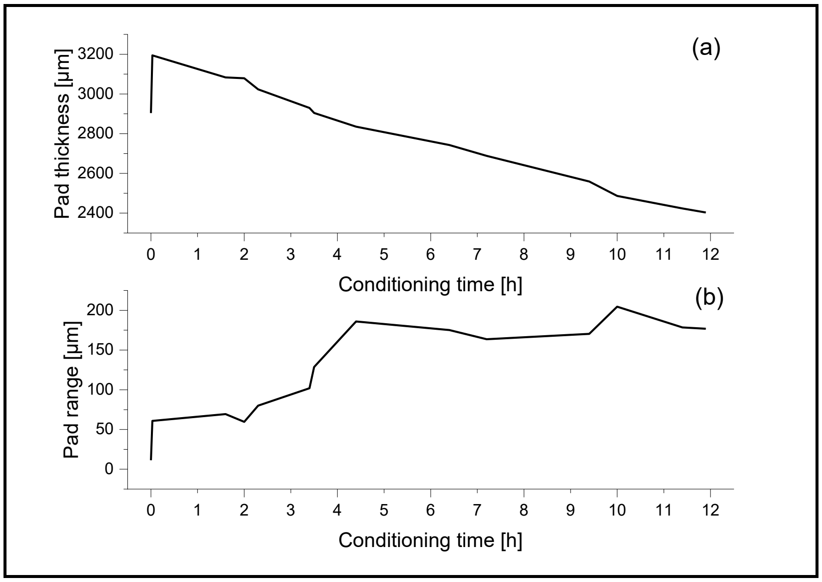

Fig. 3 (a) Mean pad thickness & (b) pad range for different conditioning times

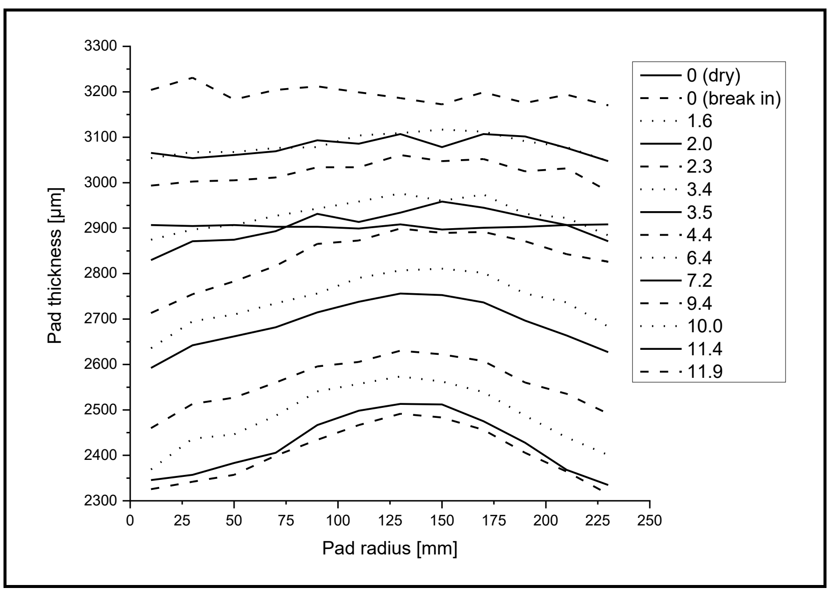

Fig. 4 Pad profiles for different conditioning times

The conditioning recipe (Figure 5) is set so that the conditioner dwell time is 20 % in the center and at the edge of the pad. In contrast, the length of stay in the other areas is between 6 % and 9 %. In order to increase the service life of the pad, the dwell time of the conditioning disc in the individual pad areas would have to be adjusted.

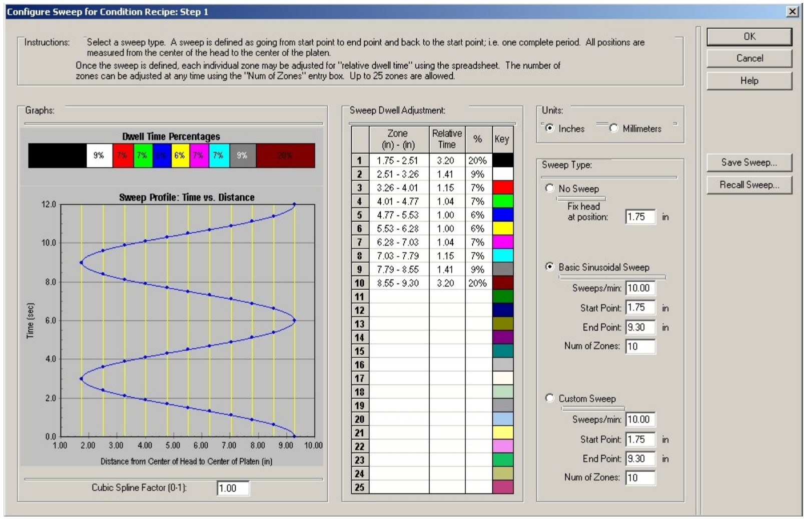

Fig. 5 Pad conditioning recipe

CONCLUSIONS

In this work it is shown that the layer thickness measuring device QNix® 8500 works well for a spot measurement of the material removal of a polishing pad (at any time between the polishing processes). A connection between conditioning setting and polishing pad abrasion is shown. In order to extend the service life of a polishing pad, the conditioning recipe can be optimized. With this method a homogenous material removal can be achieved.

[1] Norm Gitis, Raghu Mudhivarthi, "Microelectronic Applications of Chemical Mechanical Planarization", Chapter 4 "Tribometrology of CMP Process", p. 92.

Corresponding Author:
Andreas Krüger
Tel: +49 335-5625-716
E-mail: akrueger@ihp-microelectronics.com
Im Technologiepark 25
15236 Frankfurt (Oder), Germany