CMP IN-SITU PAD CONDITION MONITORING WITH PADPROBE™

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Abstract

The novel PadProbe™ has been installed on advanced polishers mod. 6EC and 6EG, for in-situ monitoring both the acceptable process window and pad end-of-life. It measures two crucial parameters simultaneously, pad condition and pad wear. The correlation of the former one with both the removal rate and non-uniformity of polishing is shown; as long as it is constant the wafers are uniformly polished, as soon as it deviates from the process window there is an immediate need for process adjustment. When pad condition slips out of the process window while pad wear is low, the likely adjustment is conditioner cleaning or replacement. When pad condition is outside the process window while pad wear is high, the typical adjustment is pad replacement.

Experimental system

A small novel PadProbe™ by CETR has been installed and tested on Strasbaugh CMP machines mod. 6EC and 6EG. The simple non-invasive installation is shown in Fig. 1 (corrosion protection cover is not shown). In addition to the stationary probe placement, which seems to be sufficient, its scanning over the pad surface can be accommodated. The PadProbe™ allowed for continuous in-process control of two crucial CMP parameters, Pad Condition and Pad Wear.

Fig. 1. PadProbe™ installed on the Strasbaugh CMP machine

Experimental results

The first series of experiments consisted of polishing oxide wafers with and without in-situ conditioning. Both Pad Condition (in-situ) and Removal Rate (post-polish) were measured. During polishing without conditioning (Fig .2, left graph) the Pad Condition dropped, which reflected pad deterioration, and indeed, Removal Rate reduced. Four one-way full-surface sweeps of the conditioner arm (Fig. 2, right graph) were sufficient to maintain stable polishing, characterized by both the Pad Condition and Removal Rate within the process window.

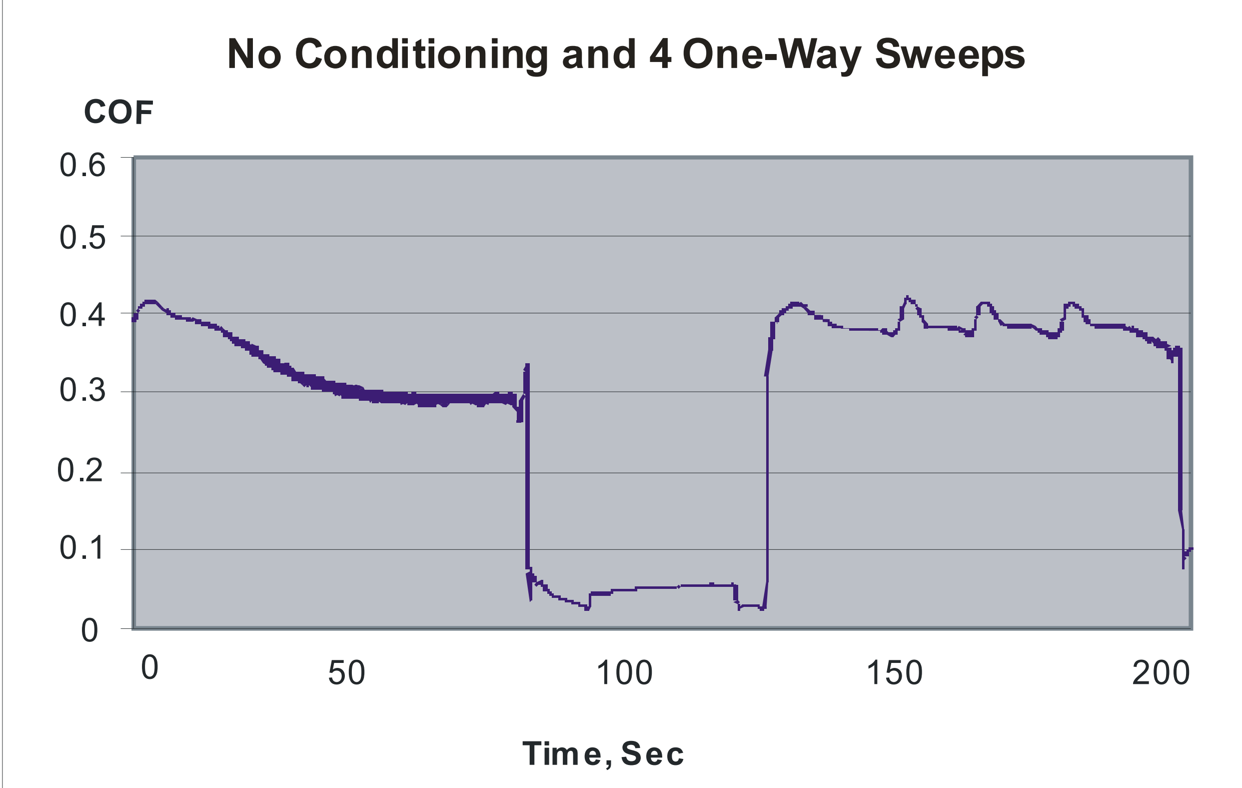

Fig. 2. Pad Condition During Polishing With (Right) and Without (Left) Conditioning

The second series of tests consisted of comparing two conditioners, newer and more aggressive with a used and dull one. The newer conditioner caused more pad wear and brought both the Pad Condition and Removal Rate to the higher levels than those for the used conditioner (see Fig. 3 below). Again, the Pad Condition and Removal Rate showed good correlation.

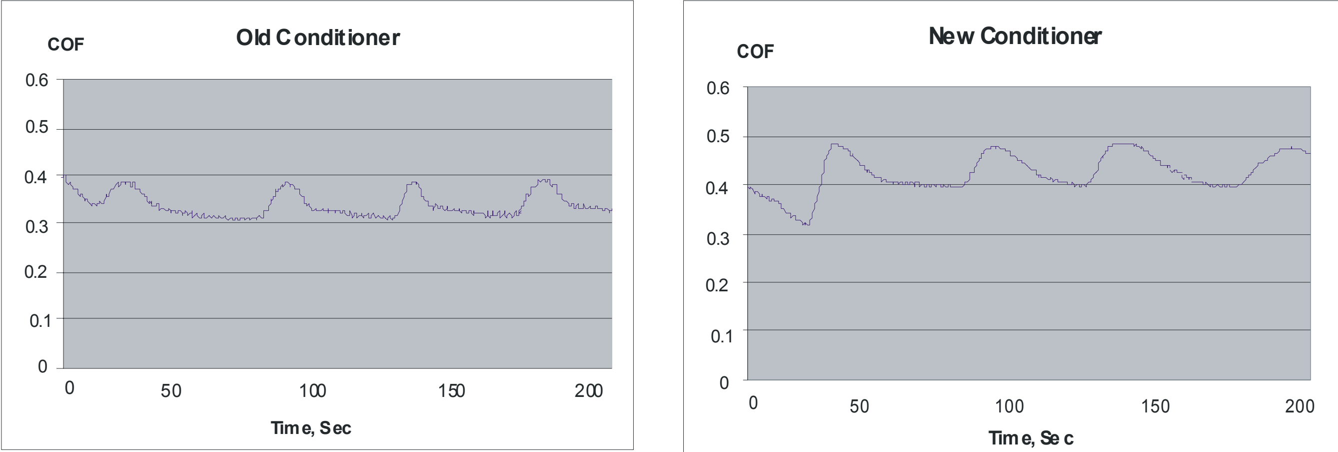

Fig. 3. Pad Condition With Older and Newer Conditioners

The third series of experiments consisted of polishing oxide wafers with in-situ conditioning of varied duty cycles, from one two-way sweep to four two-way sweeps. Both Pad Condition (in-situ) and Removal Rate (post-polish) were measured. As seen in Fig .4, Pad Condition dropped (as pad deteriorated) during polishing and restored to its working level (as pad refreshed) during each conditioner sweep. The Removal Rate correlated well with the average Pad Condition during each test, being the lowest for the one-sweep test and the highest for the four-sweep test.

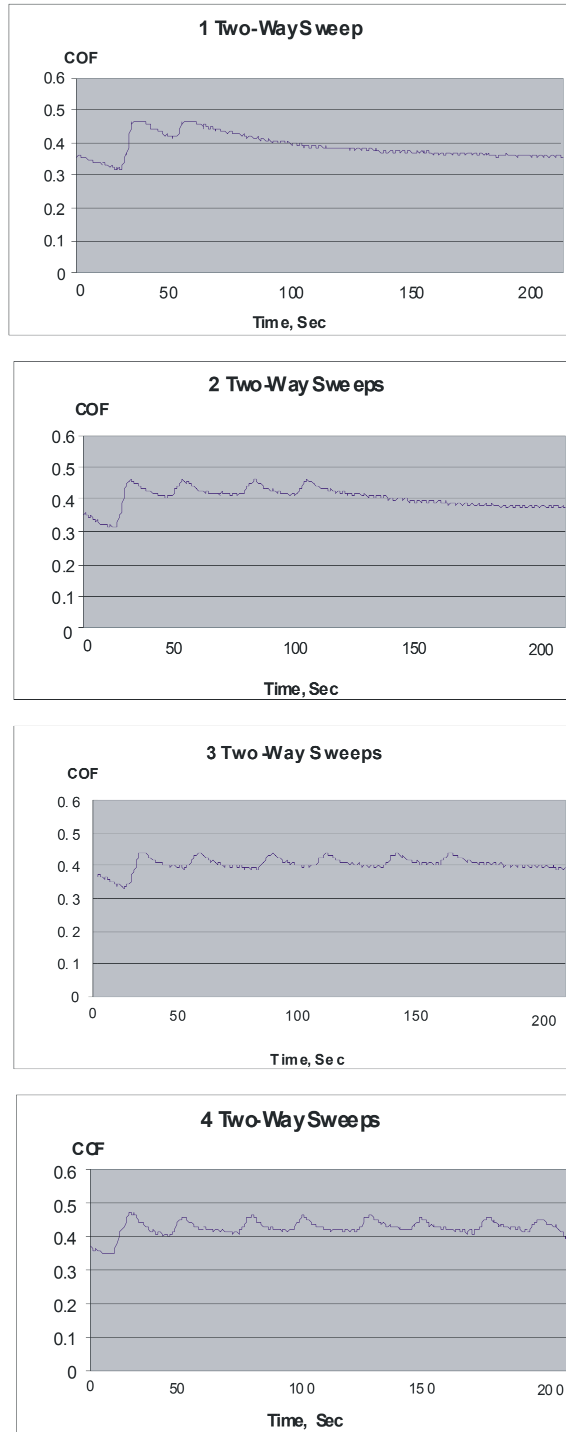

Fig. 4. Pad Condition During Polishing with Periodic Conditioner Sweeps

The last test consisted of continuous pad conditioning for several hours, with in-situ measurements of Pad Wear, then followed by manual pad geometry measurements to check its wear. It was confirmed that the Pad Wear values obtained in-situ (see Fig. 5, where minute up-and-down fluctuations reflect table tilt and deformations when the conditioner arm comes close to and then and goes away from the probe) correspond to the post-test measurements, while the growth of Pad Condition during conditioning reflects the higher wafer removal rate of the conditioned pad.

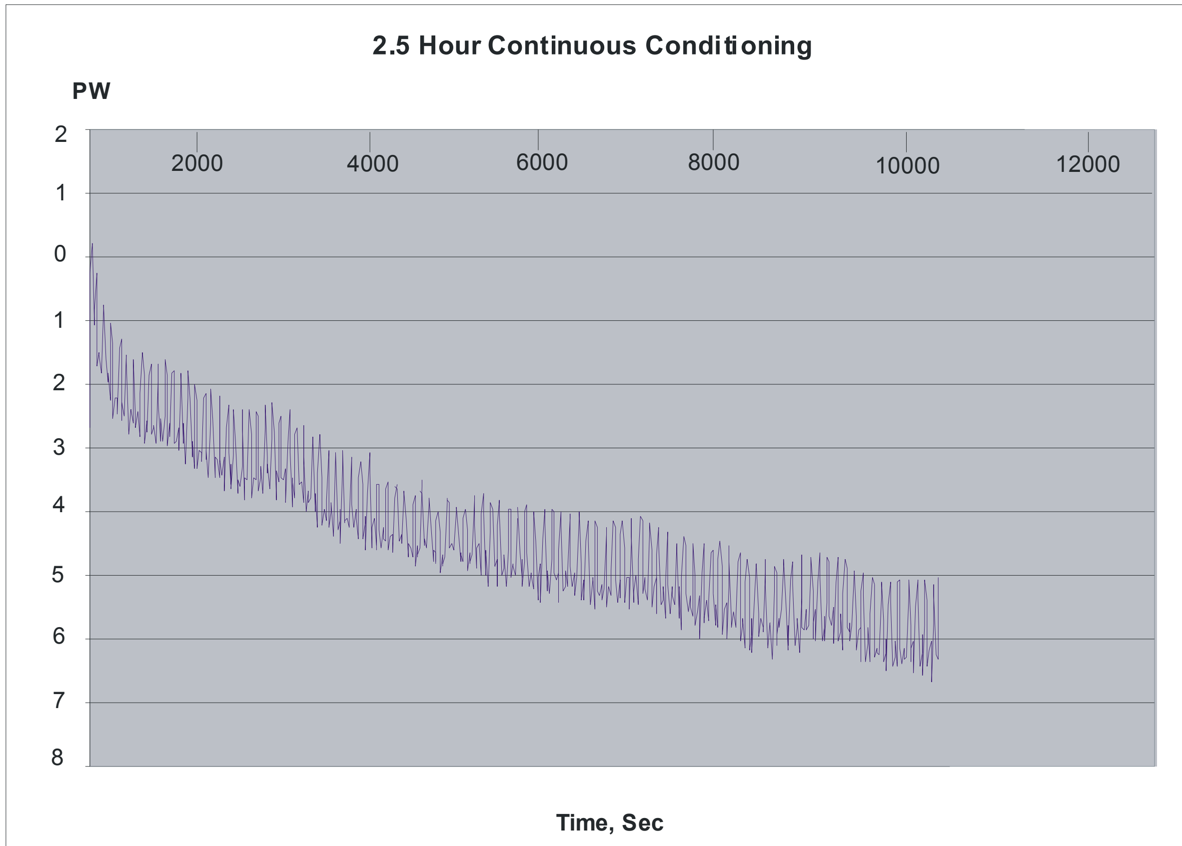

Fig. 5. Pad Wear during Continuous Conditioning

Conclusions

The PadProbe™ is effective for CMP process development:

1 - accelerates process optimization by indicating in-situ when to start and finish pad conditioning, when more or less conditioning is required,
2 - accelerates process optimization by indicating in-situ how stable is the process,
3 - indicates pad durability.

The PadProbe™ is effective in Fab production:

1 - alarms when the process deviates out of its normal window,
2 - alarms when either pad or conditioner is worn out and has to be refreshed or replaced.

It allows for substantial cost savings in the Fab due to less frequent pad replacements, reduction in usage of test wafers and shortening pad conditioning. It is a simple upgrade for all Strasbaugh polishers.