

Improving process stability, pad life, defectivity and cost with better pad conditioning in Chemical Mechanical Planarization (1)

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Diamond pad conditioners used in Chemical Mechanical Polishing play an important role in process stability, wafer removal rate decay, pad life and defects. During pad conditioning process the diamonds on the conditioner which are held in place by a bonding material, cut the pad surface under applied down force on the pad conditioner to regenerate the pad asperities and to remove slurry and pad debris from the pad surface. Different CMP processes use a variety of slurries which contain harsh chemicals from highly acidic to basic in nature, these chemicals present in the slurry attack the pad conditioner resulting in bonding material corrosion. Various methods (sintering, brazing, electroplating and CVD coating) and materials (Nickel, CVD diamond, DLC, polymers, etc.,) are used for bonding the diamonds to substrate of the conditioner. The constant interaction of conditioner with slurry chemicals, abrasives in slurry, pad surface and mechanical forces leads to diamond and bonding material wear.

CMP pad conditioner challenges

- ▶ Presence of aggressive diamonds would lead to high, uneven pad cut rate and reduction in pad, conditioner life.
- ▶ Diamonds bonded with methods such as sintering, brazing and electroplating have very high variation in diamond protrusion, leading to only a small amount of working diamonds.
- ▶ Diamond fallout due to leaching and wear of the bonding material leads to large arc shaped scratches on the wafer.
- ▶ Higher pad cut rate and material removal rate decay over conditioner lifetime would lead to unstable process.
- ▶ Diamond shape and size has a considerable amount of impact on pad life and uniformity.
- ▶ Choosing a pad conditioner strongly depends on the process that it would be used and type of pad. Inappropriate selection of conditioning process parameters and conditioner might lead to process instability, higher defectivity and pad cut-rate, shorter pad and conditioner life.

Criteria for selection of CMP pad conditioners

- Higher number of working diamonds provides uniform pad conditioning and reduces stress on working diamonds, avoiding broken diamonds.
- Diamond bonding should be strong enough to overcome high mechanical forces during conditioning and should also be chemically inert to avoid leaching of matrix material from slurry chemicals.
- Stable pad cut rate and wafer removal rate across the conditioner life; leads to more stable CMP process and improved pad life.

- Diamond shape, size, density and protrusion, which control the wafer polishing characteristics.
- Substrate flatness impacts the pad wear and pad surface profile/uniformity.
- Low variation in diamond shape, size and density for conditioners from within and from batch to batch.

Entegris **Planargem™** CMP pad conditioners help in meeting the above mentioned pad conditioner selection criteria and also overcome the challenges posed by the pad conditioners in the CMP processes. Use of Planargem pad conditioners would help in

- ▶ Improved process performance
- ▶ Reduced defectivity and cost of ownership
- ▶ Improved conditioner and pad life
- ▶ Reduced tool down time and highly stable process.

Planargem CMP pad conditioners

Planargem CMP pad conditioners have CVD diamond coated over the substrate and diamonds. The diamonds and CVD diamond coating are chemically bonded to the Silicon Carbide substrate making it the strongest bonding material and process used to produce superior quality CMP pad conditioners. The advantages of Planargem pad conditioners are



- No diamond pullout – CVD diamond grown encapsulation is the strongest matrix material
- Presence of tiny diamond facets on the diamonds acts as extra conditioning surface.
- Diamond is chemically compatible
 - Stable in aggressive chemistries.
 - Works in various CMP processes and applications.
 - Exceptional cleanliness – very low extractables.
- Excellent conditioner life
 - Uniform diamonds – High percentage of working diamonds ~ 80%.
 - Reduced stress on diamonds eliminates cleaving failure mode.
 - Maintains sharpness longer with uniform and stable pad conditioning.
 - Lower drop in pad cut rate over time.
- Available with smaller diamonds
 - Gentler conditioning.
 - Excellent for 32nm & lower.
 - Increased Pad life.



Improving process stability, pad life, defectivity and cost with better pad conditioning in Chemical Mechanical Planarization (2)

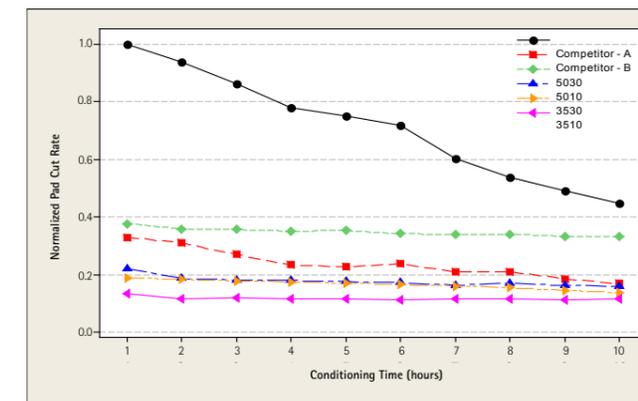
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Planargem conditioner performance

Planargem conditioners have superior performance compared to leading competitor conditioners available in the market.

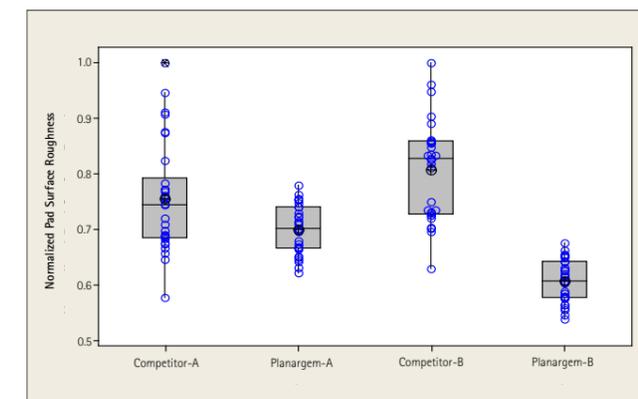
- ▶ Planargem conditioners have lower drop in cut rate compared to competitor conditioners (fig. 1). **Lower drop in cut rate would lead to process stability and increased pad, conditioner life.**

Fig. 1 Pad Cut Rate Data of Planargem Conditioners vs. Competitor Conditioners.



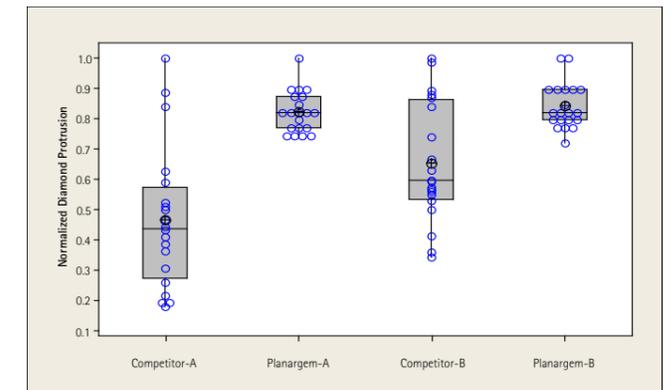
- ▶ Planargem conditioners have tighter and uniform pad surface roughness compared to competitor conditioners (fig. 2). **Uniform pad surface roughness would help in achieving stable wafer removal rate and better WIWNU.**

Fig. 2 Pad Surface Roughness – Planargem vs. Competitor Conditioners



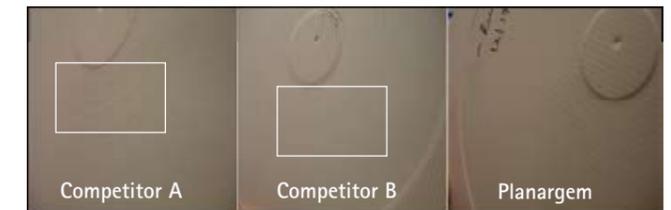
- ▶ Planargem conditioners have better diamond protrusion and more number of working diamonds (fig. 3) compared to competitor conditioners. **Better diamond protrusion and higher number of working diamonds gives better uniformity and reduces stress on working diamonds, avoiding broken or diamond fallout.**

Fig. 3 Diamond Protrusion – Planargem vs. Competitor Conditioners



- ▶ **Less variation in diamond protrusion gives better pad profile leading to good WIWNU.** Due to the presence of very aggressive diamonds pad profile might deteriorate and lead to WIWNU issues (fig. 4). Step like features can be observed on pad samples conditioned using competitor conditioners with aggressive diamonds.

Fig. 4 Pad Surface Post-conditioning – Planargem vs. Competitor Conditioners



- ▶ Entegris Planargem conditioners help customers minimize above mentioned issues while maximizing process performance, increased pad and conditioner life, increased process stability and lower tool down time. ■

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