

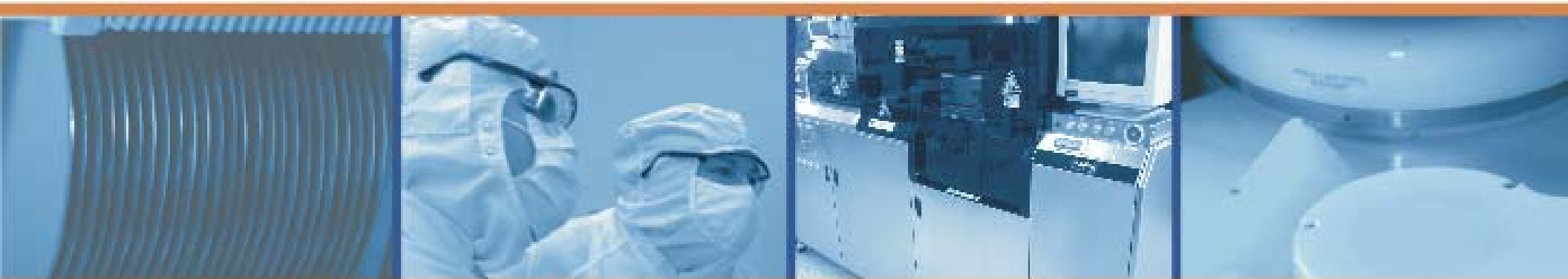
# Pad Conditioning Optimization and Impact on the CMP Process

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## Historical background

### SteadySweep™ conditioning arm

### Process Results

- Sweep segmentation optimization
- Conditioning force process window
- Baseline process comparison

### Conclusions

## Rotational polishing platforms

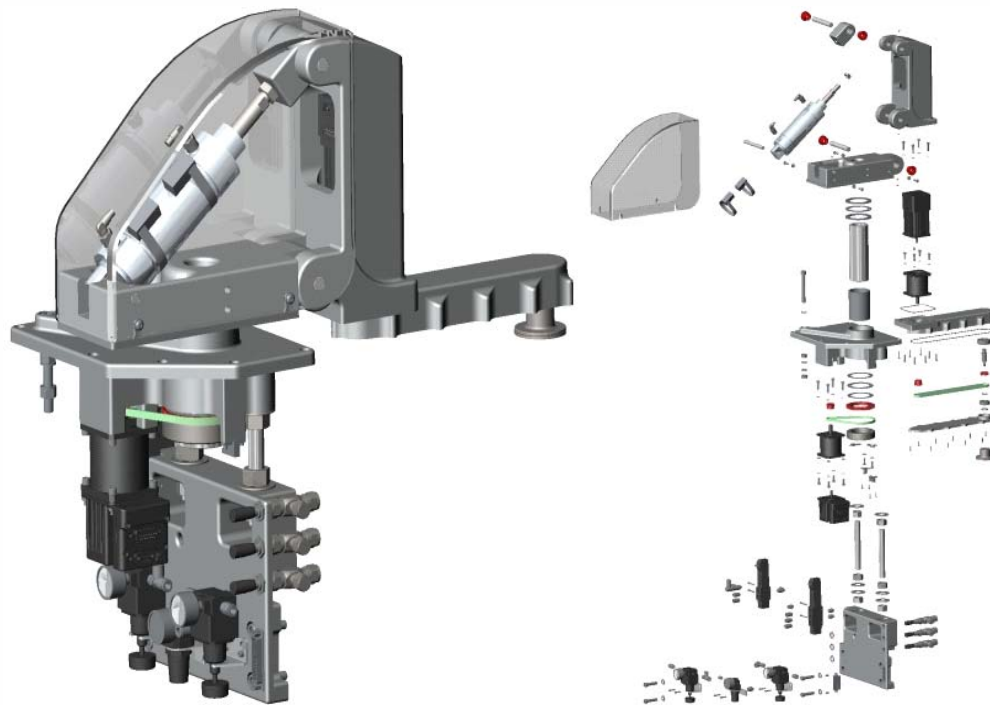
- First production-proven type of polisher
- CMP started with traditional oxide process:
  - » IC pad, fumed silica slurry, diamond conditioner
  - » Original pad conditioners not designed for today's processes
- Still the dominant type of polisher

## Most processes require pad conditioning

- At the very least ... breakin conditioning
- Oxide processes especially sensitive to glazing
- Copper may require very delicate balance

Impact of conditioning is often underestimated

## Conceptual Design Phase



## Actual Field SteadySweep Retrofit



- Early prototype version
- Installed on IPEC372M polisher



Force	0.5 to 20 pounds
Rotational Speed	0 to 200 rpm
Modes of operation	<ol style="list-style-type: none"><li>1. Breakin (new pad)</li><li>2. In-situ (during polish)</li><li>3. Ex-situ (between wafers)</li></ol>
End effector size	2 inch through 7 inch diameter (custom sizes upon request)
Platforms supported	IPEC 372, 372M, 472 Strasbaugh 6DS-SP, 6EC, etc. Virtually any rotational polisher

- **Phase 1: Optimize sweep segmentation**

Through the life of a pad, non-uniform wear in the wafer track can induce variation in the remaining pad thickness. If not controlled, this can contribute to increasing within-wafer non-uniformity (WIWNU) as more wafers are polished. The first portion of this work was directed at optimizing the segmentation of the conditioning sweeps to maintain a reasonably flat cut profile across several hours of conditioning.

- **Phase 2: Characterize conditioning force**

One of the primary advantages of the SteadySweep™ pad conditioner is the ability to maintain constant pressure across the entire conditioning sweep through a wide range of pressures. This phase of the experiment was aimed at characterizing the process impact of changes in applied pressure from as low as 0.5 lbs to as high as 15 lbs.

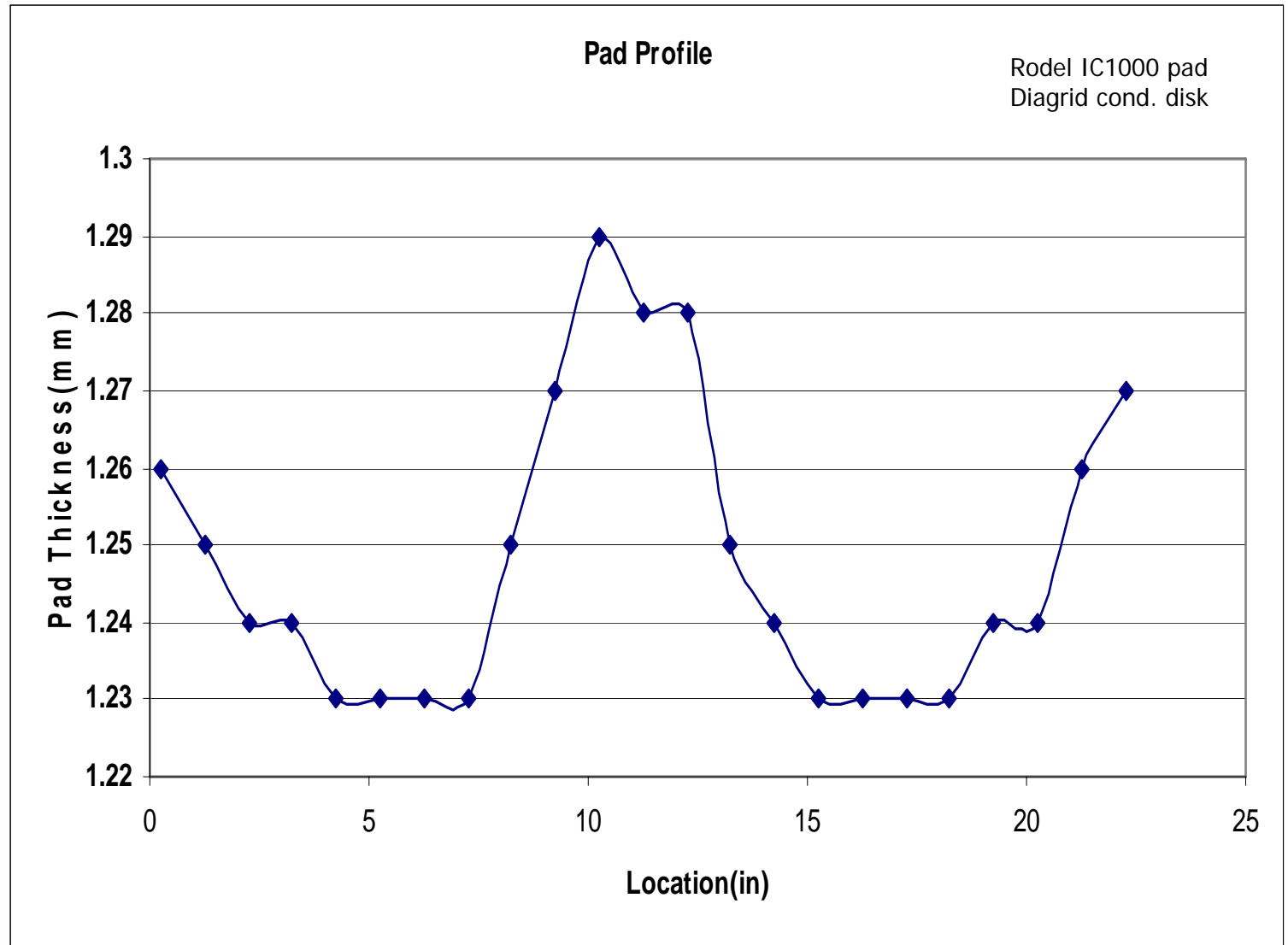
- **Phase 3: Characterize pad wear and compare impact of hardware differences**

Using data from the above trials, settings were chosen to compare an extended run on the SteadySweep™ to the standard APP-1000 pad conditioner at its normal operating pressure. Extended runs were simulated with a series of filler wafers and rate monitor wafers separated by hour-long periods of pad conditioning in DI water.

Roughly parabolic profile with equal timed segments.

Total 4 hours conditioning

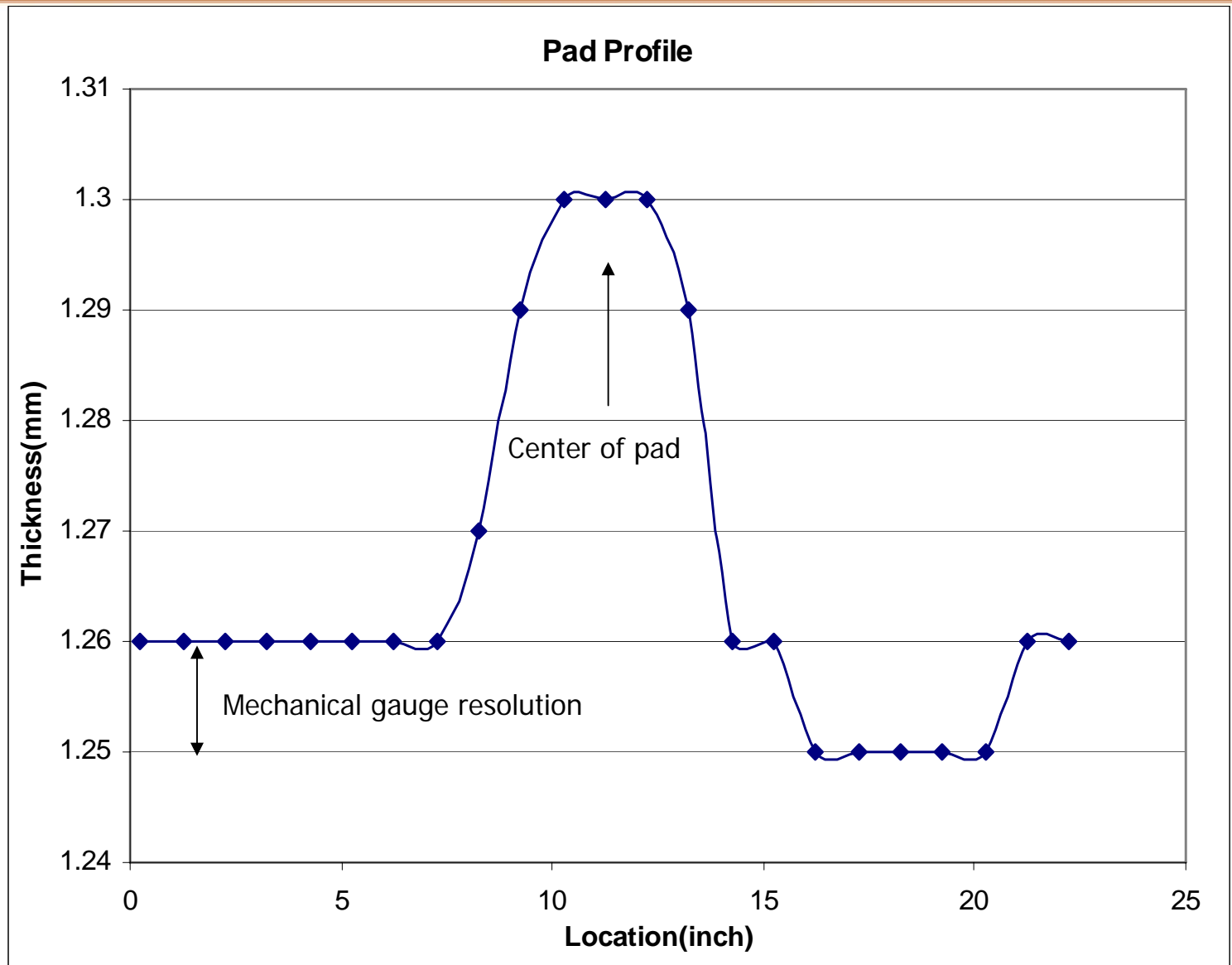
Rodel IC1000 pad  
Diagrid cond. disk



Much flatter profile with weighted segments.

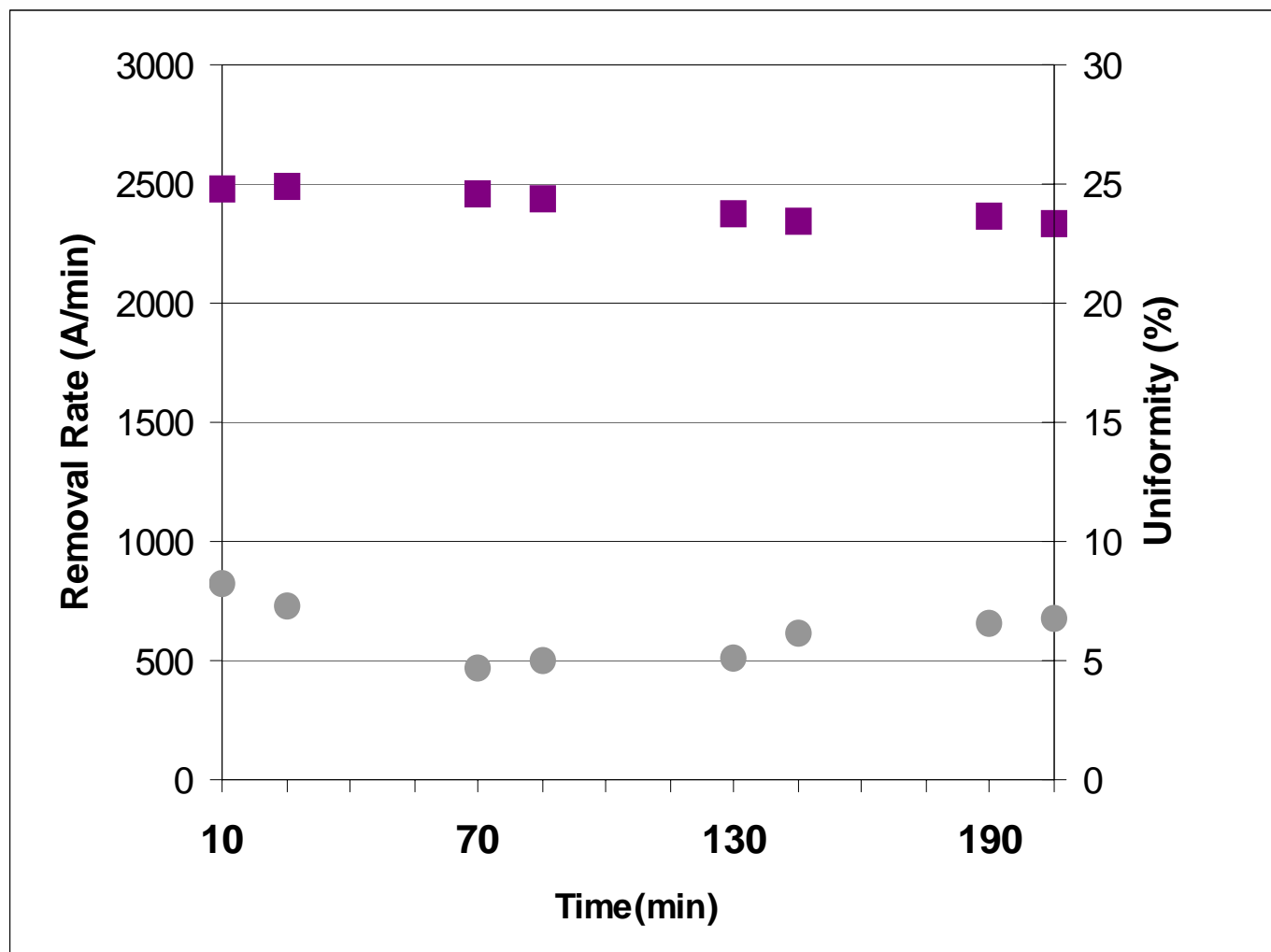
Total 4 hours conditioning

Rodel IC1000 pad  
Diagrid cond. disk



Alternating sequence of 1-hour conditioning periods followed by a series of filler wafers and rate monitor wafers to assess process stability during extended wear.

Pad stack: IC1000 perf on Suba IV  
 Slurry: Cabot SS-12  
 DF = 7psi, Platen speed = 40 rpm  
 Diagrid conditioning disk, in-situ

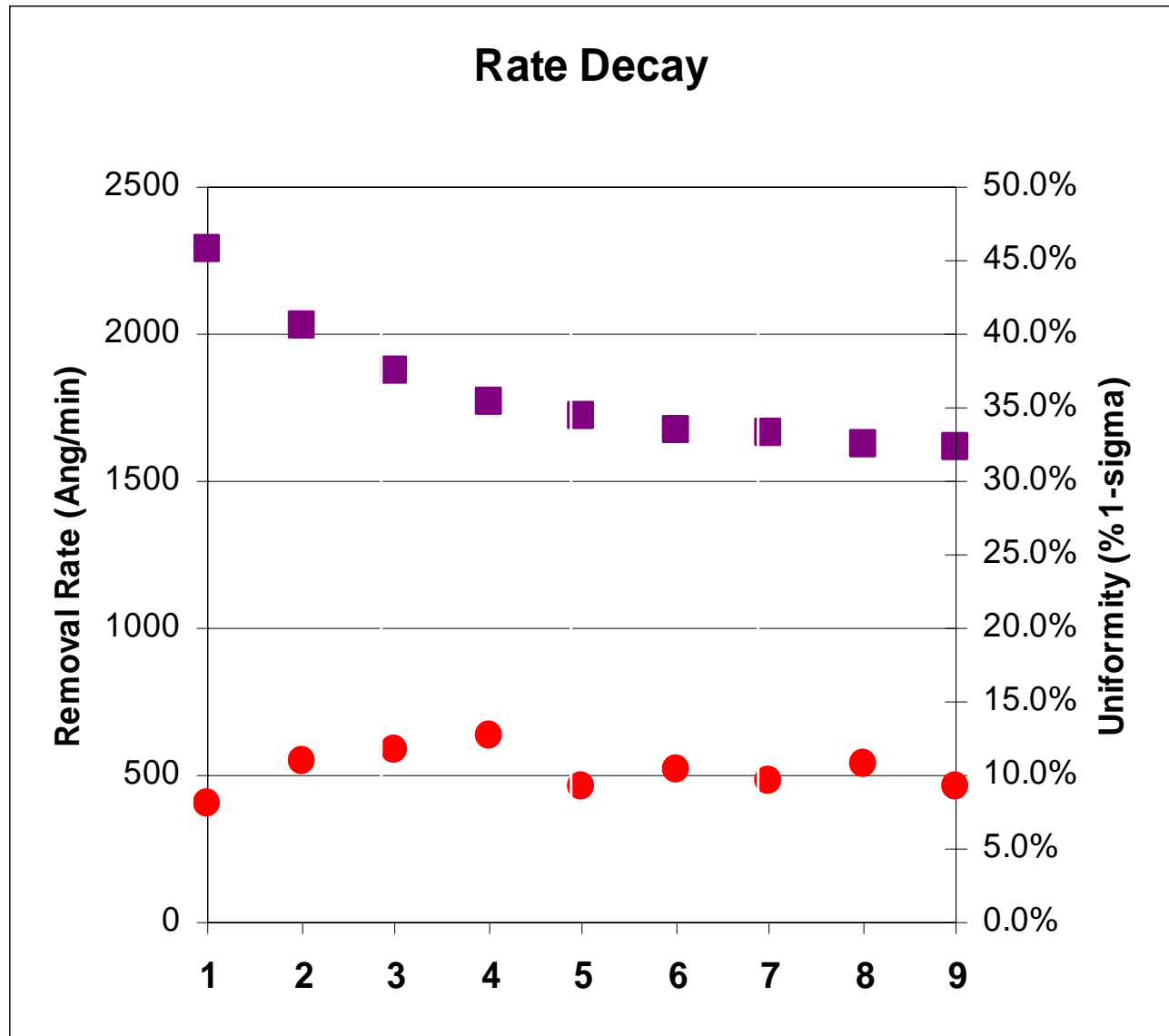


- As expected, we were able to optimize the settings across each of ten segments in the full conditioning sweep to achieve a relatively flat cut profile as a function of pad wear.
- Wafer-level process results show stable rate and uniformity at a nominal conditioning force of 10 lbs.

NEXT PHASE: RESPONSE AS A FUNCTION OF APPLIED FORCE

Wafers polished for 60 sec each after pad conditioning was stopped.

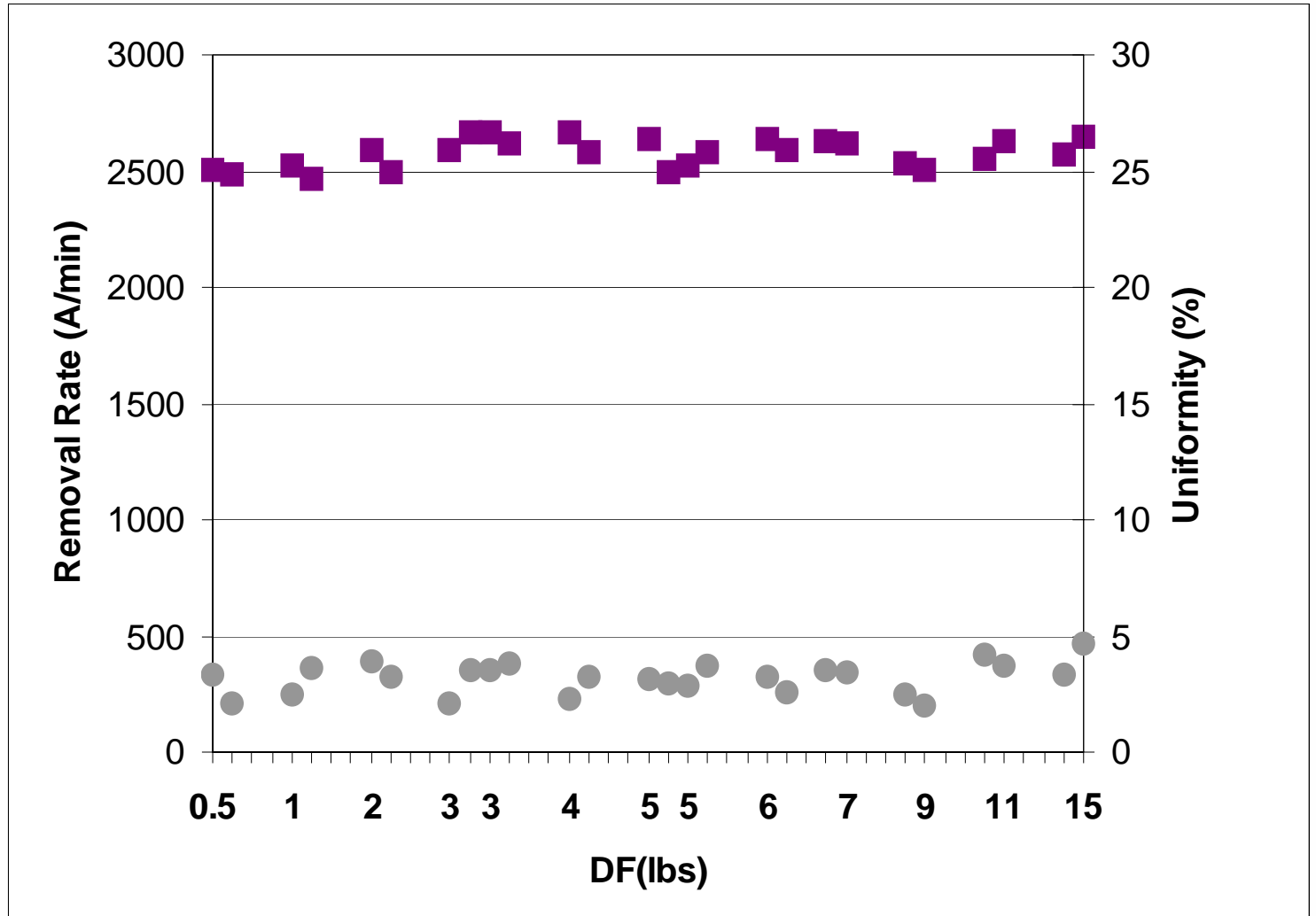
Process was first stabilized with standard breakin and in-situ pad conditioning.



Multiple runs

Consistent rate and uniformity

Very slight drop in rate at applied forces of 1 lb and 0.5 lb.



Pad stack: IC1000 perf on Suba IV  
 Slurry: Cabot SS-12  
 DF = 7psi, Platen speed = 40 rpm  
 Diagrid conditioning disk, in-situ  
 SteadySweep™ Conditioner

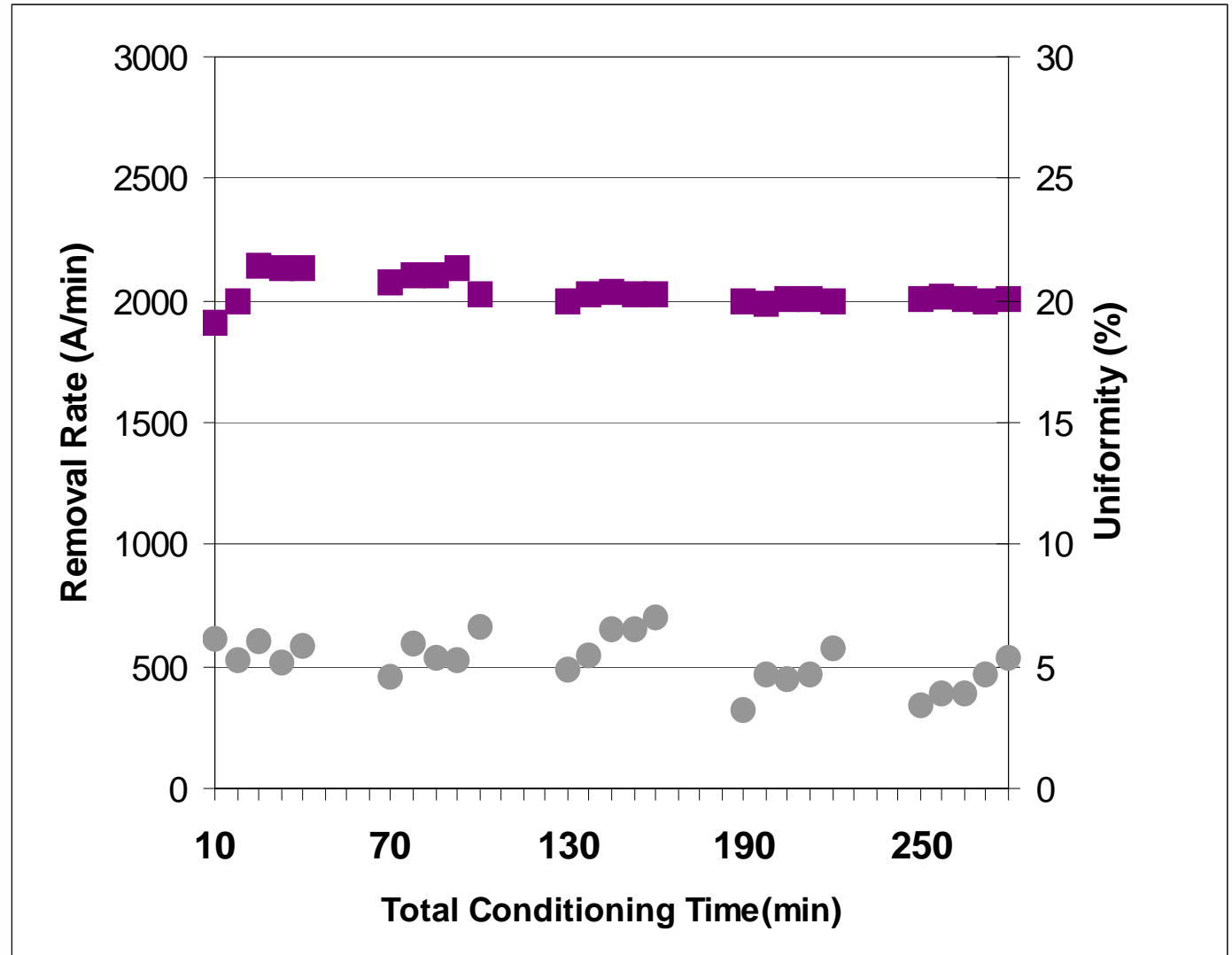
- Rate decay following discontinuation of pad conditioning clearly shows that no conditioning leads to at least 30% drop in removal rate.
- Stable rate across the full range of conditioning force implies that even 2 lbs of force from the SteadySweep™ provides sufficient conditioning to maintain a consistent pad surface texture.
  - This is in contrast to conventional systems where conditioning force is generally set to 7 lbs or higher to maintain process consistency.

NEXT PHASE: EXTENDED RUN COMPARISONS

# CMP FastForward™ IPEC 472 Extended Run

Standard process with APP1000 conditioner at 8 lbs.

Slight decay through 4 hr run.

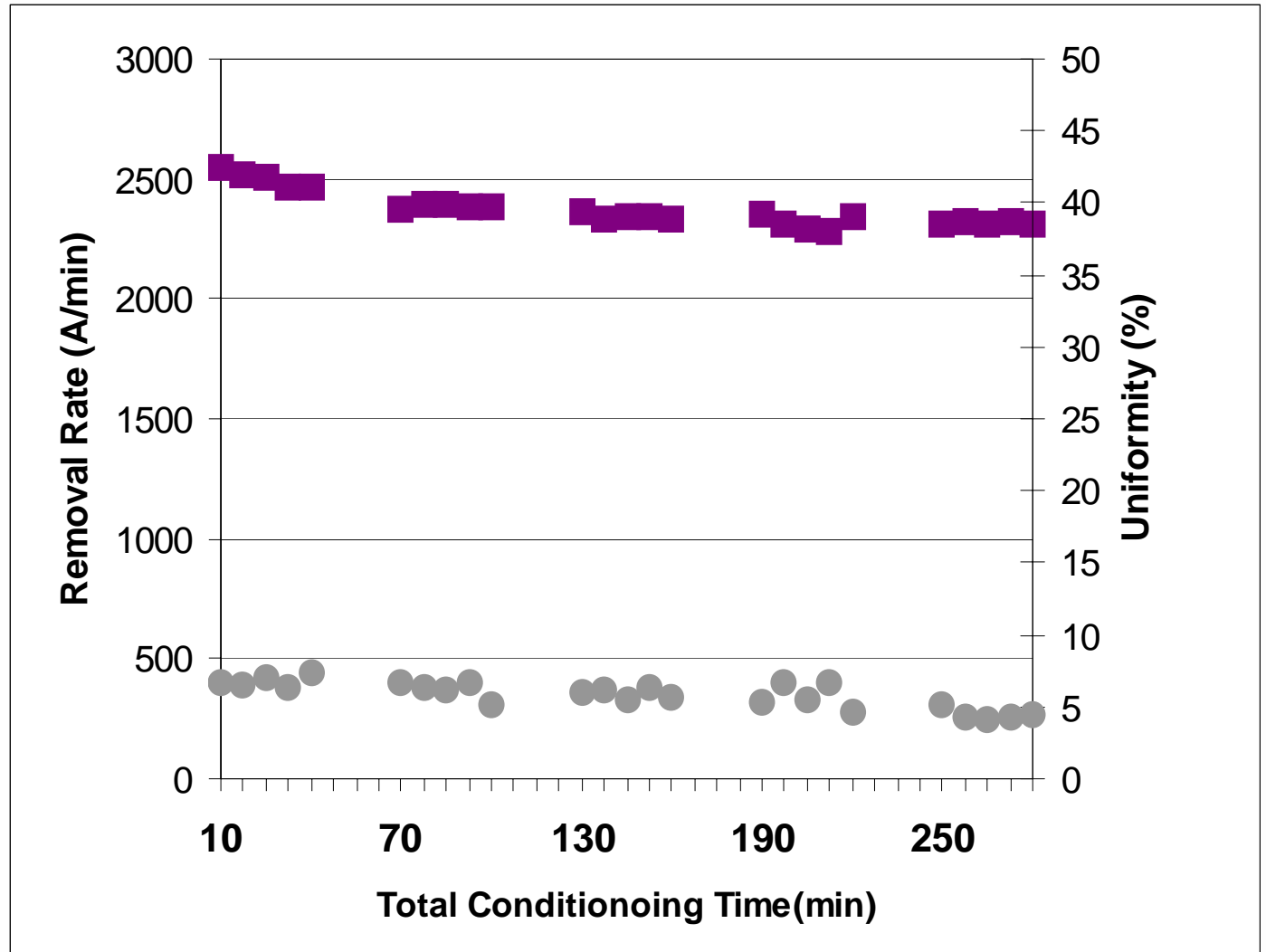


Pad stack: IC1000 perf on Suba IV  
Slurry: Cabot SS-12  
DF = 7psi, Platen speed = 40 rpm  
Diagrid conditioning disk, in-situ  
APP1000 conditioning arm (OEM)

Standard process with SteadySweep™ at 4 lbs (with exact same carrier and conditioning disk).

Slight decay through 4 hr run.

Similar process repeatability at slightly higher rate.

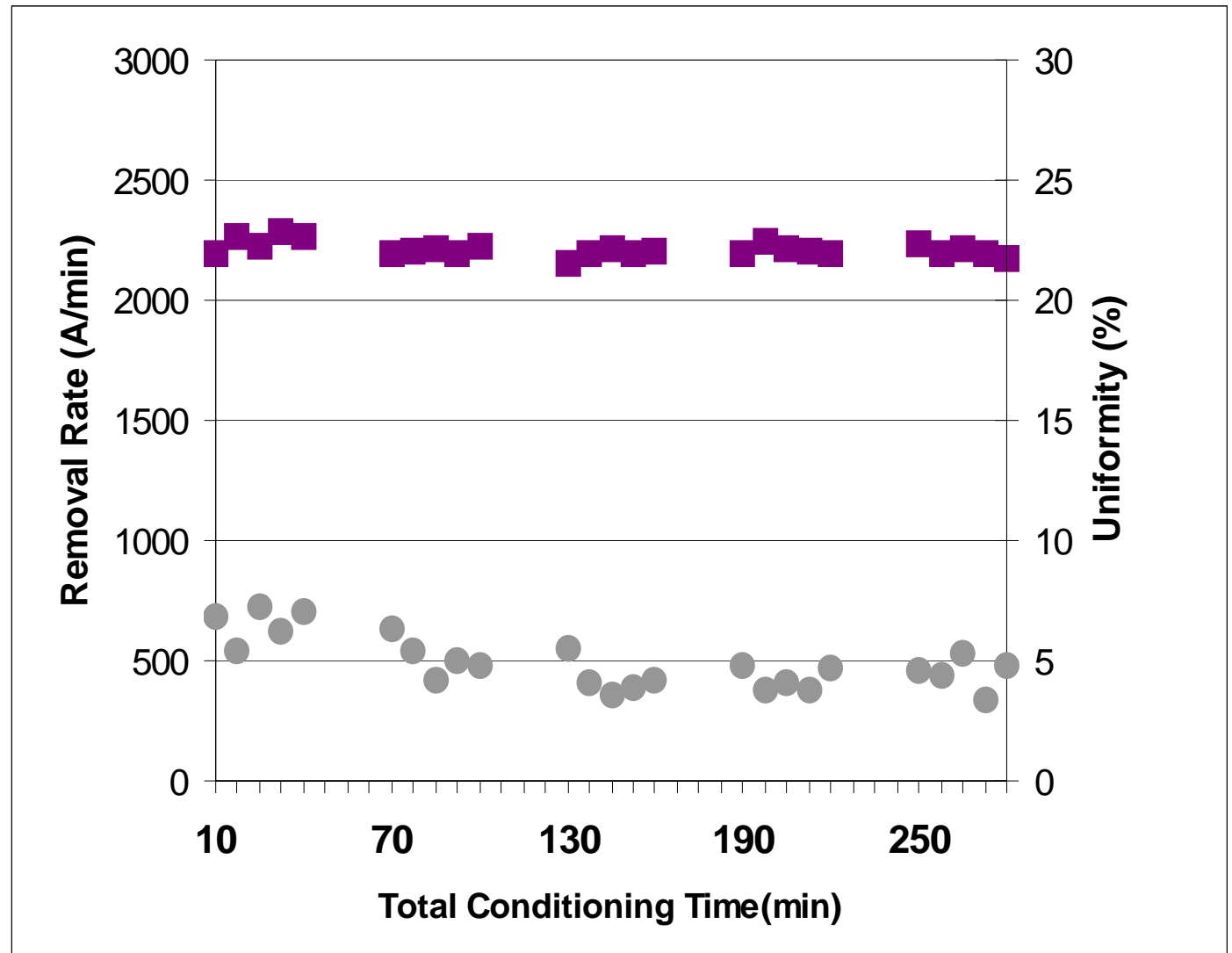


Pad stack: IC1000 perf on Suba IV  
 Slurry: Cabot SS-12  
 DF = 7psi, Platen speed = 40 rpm  
 Diagrid conditioning disk, in-situ  
 SteadySweep™ conditioning arm

Standard process with SteadySweep™ at 2 lbs (with exact same carrier and conditioning disk).

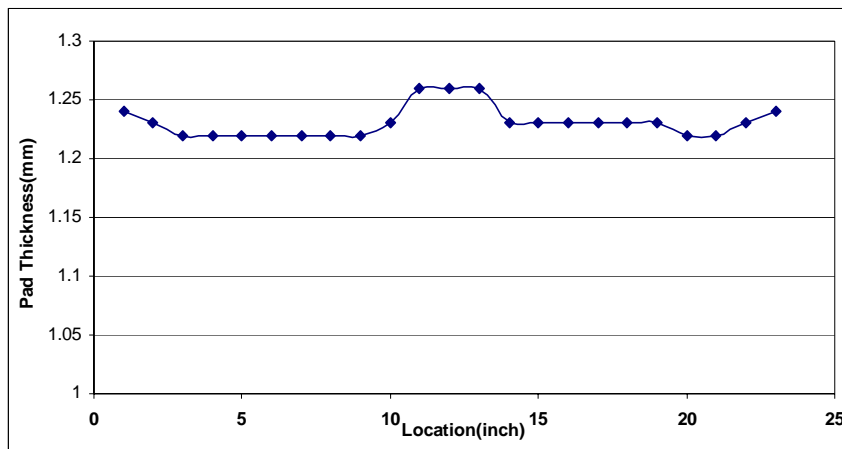
Near zero decay through 4 hr run.

Excellent process repeatability at slightly higher rate.



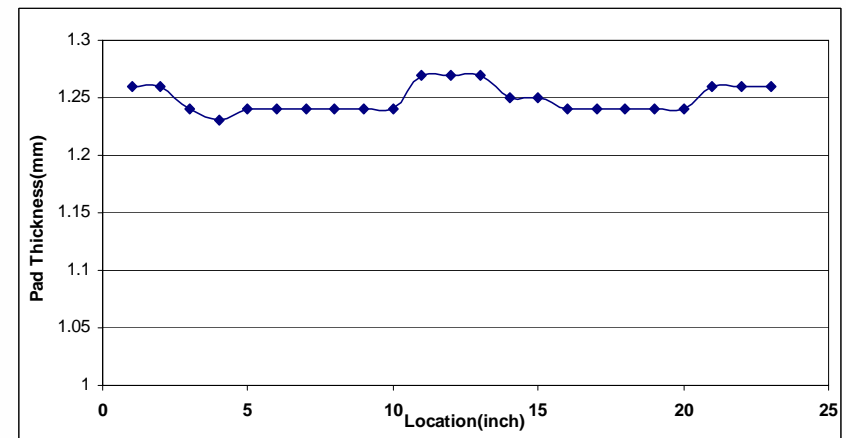
Pad stack: IC1000 perf on Suba IV  
 Slurry: Cabot SS-12  
 DF = 7psi, Platen speed = 40 rpm  
 Diagrid conditioning disk, in-situ  
 SteadySweep™ conditioning arm

Potential extension of pad life by at least 15% and equal or better process repeatability at the same time!



Reasonably flat pad cut profile

**Avg pad wear = 0.04 mm**  
(center of wafer track)



Reasonably flat pad cut profile

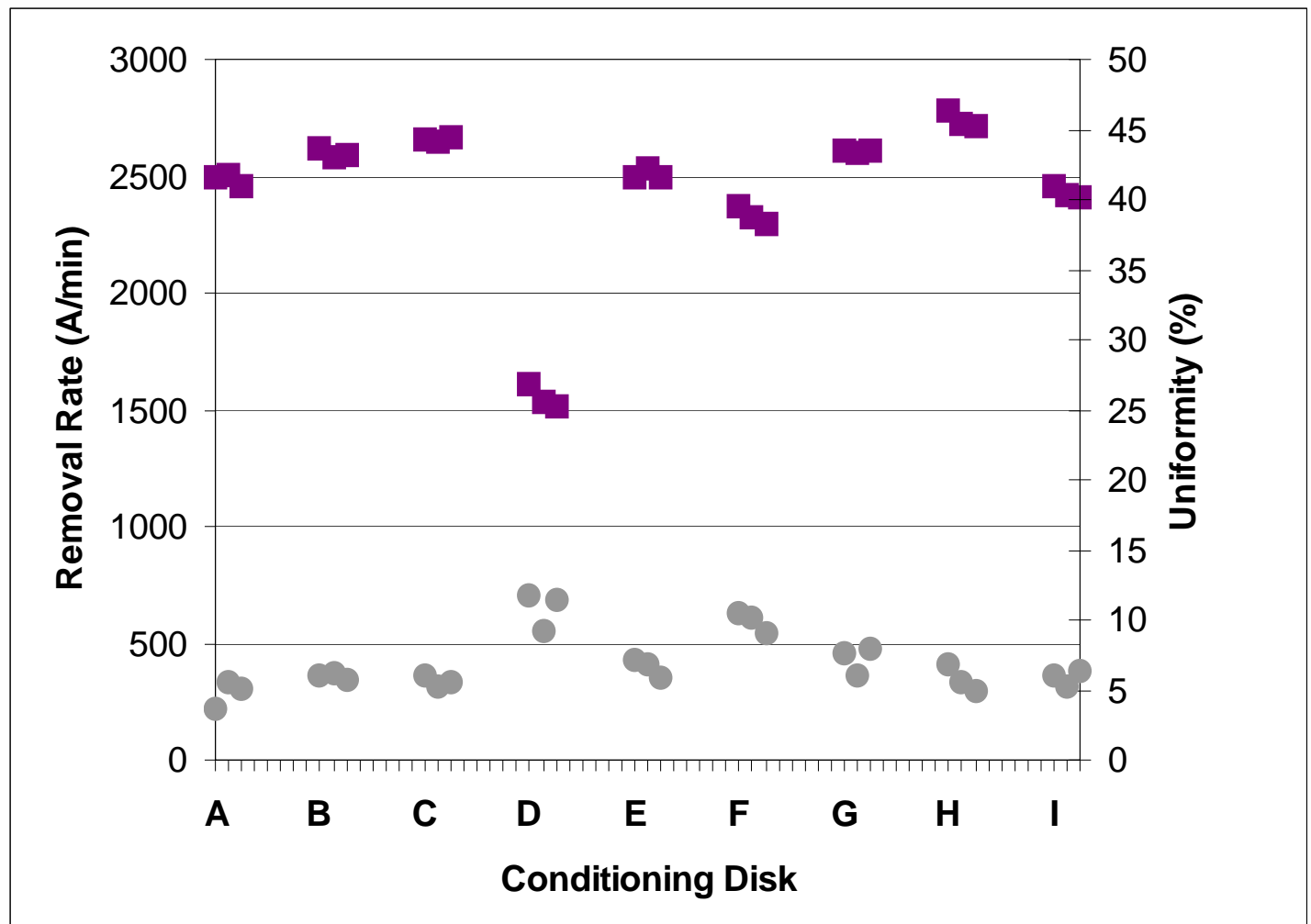
**Avg pad wear = 0.03 mm**  
(center of wafer track)

- Slight rate decay across the first portion of new pad life is normal with most rotational processes as is observed in both early runs.
- Slight differences in removal rate are likely due to an unintentional offset in the physical location of the polishing track during process. (This was adjusted in for the 2<sup>nd</sup> extended run.)
- Stable process results are obtained at substantially lower conditioning force using the SteadySweep™ conditioning arm.
  - Conservative estimate of 15% longer pad life.
  - Enables processes that may require extremely low conditioning force.

SteadySweep™ arm using most major brands of conditioning disks in back-to-back trial.

All tests performed on the SAME IC1000 pad.

Expt conditions:  
 4 lbs applied force  
 15 min breakin  
 10 min filler wafers  
 3 rate wafers  
 Repeat for next disk



- Optimization of sweep segmentation was successful at achieving a flat pad cut profile across at least 4 hours of conditioning time.
- Uniform pressure throughout the conditioning sweep allows consistent process results across a wide range of applied pressures.
- Extended run experiments confirm that the uniform pressure achieved with a SteadySweep™ conditioning arm gives a stable process at much lower applied force than typically required.
- Multiple disk comparisons show differences among various types of disks, but uniform conditioning pressure can give repeatable results with nearly any of the disks currently available.
- Several SteadySweep™ systems are already in the field and continue to demonstrate improvements in process results.

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