Analysis and Prediction of Polish Profiling

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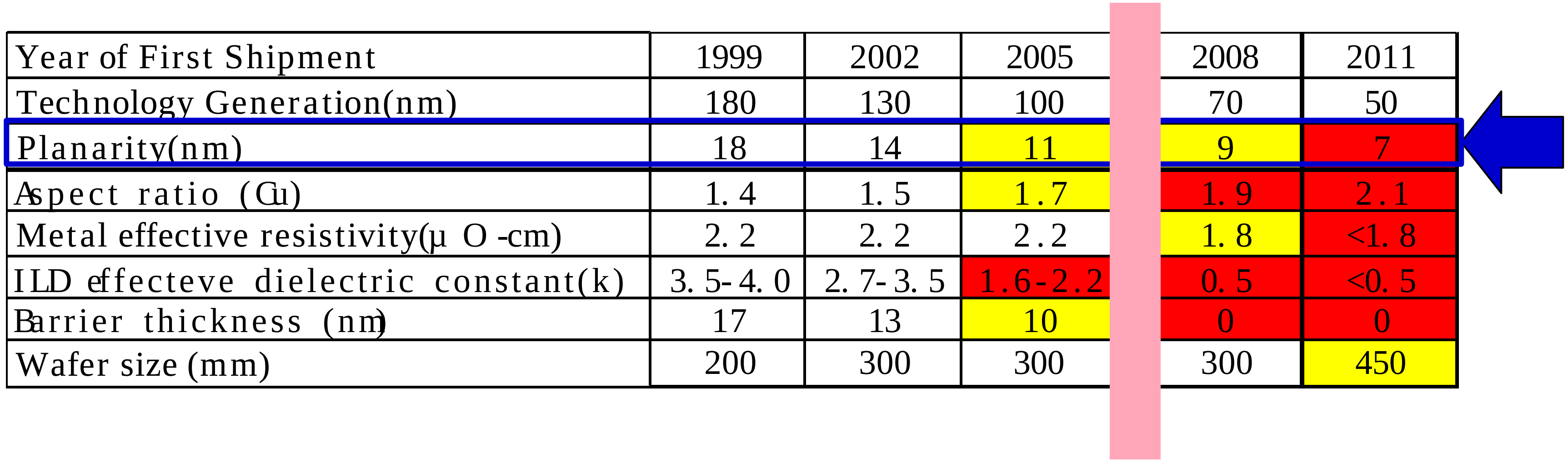
What is the Message From ITRS ?



Year of First Shipment	1999	2002	2005	2008	2011
Technology Generation(nm)	180	130	100	70	50
Planarity(nm)	18	14	11	9	7
Aspect ratio (Cu)	1.4	1.5	1.7	1.9	2.1
Metal effective resistivity(μ O -cm)	2.2	2.2	2.2	1.8	<1.8
ILD effecteve dielectric constant(k)	3.5-4.0	2.7-3.5	1.6-2.2	0.5	<0.5
Barrier thickness (nm)	17	13	10	0	0
Wafer size (mm)	200	300	300	300	450

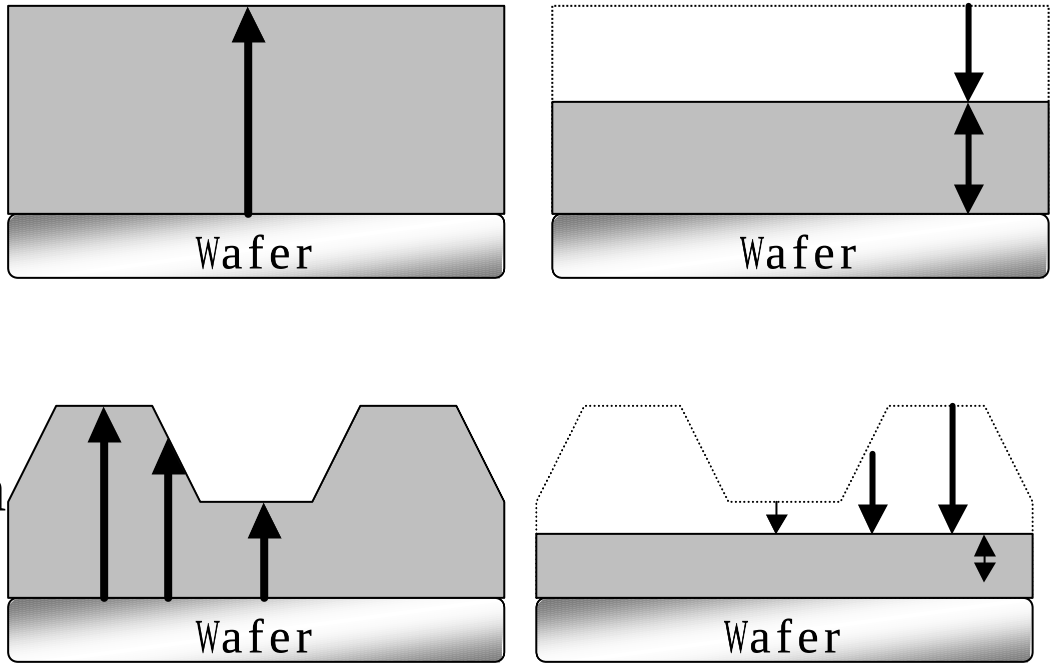
Brick Wall

The "super planarity" requirement by ITRS demands that *ALL* CMP tools must have

"Pro-Active" Profile Control

What is “Pro-Active Profile Control”?

Proactive (pro ak’tiv), *adj.* Serving to prepare for, intervene in, or control an expected occurrence or situation



Uniform deposition

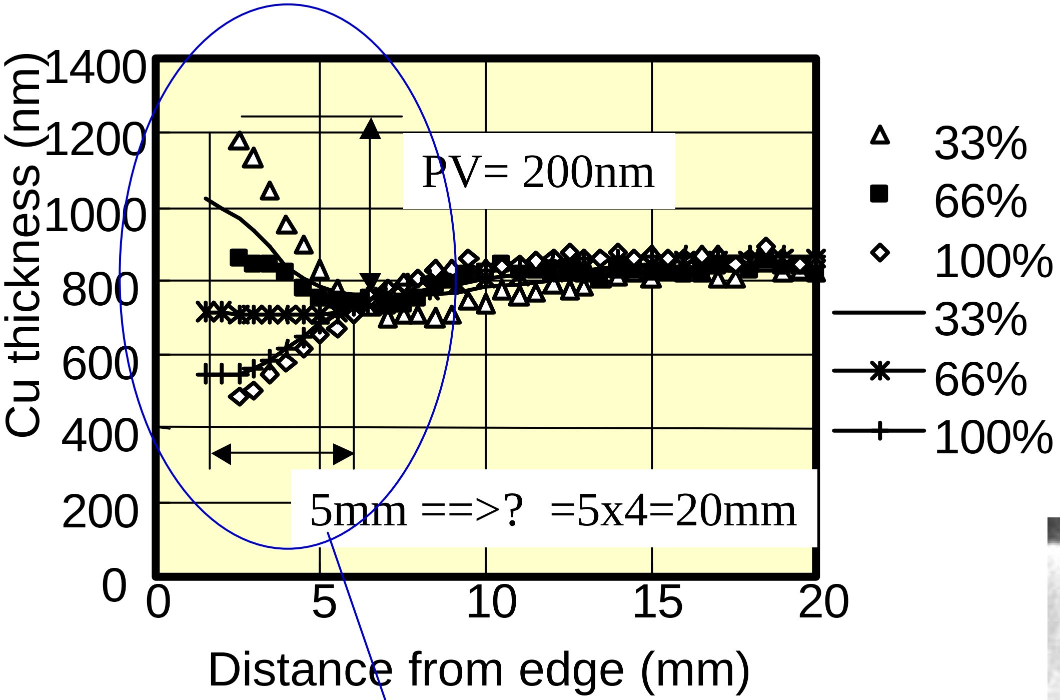
Uniform polish

Non-uniform deposition

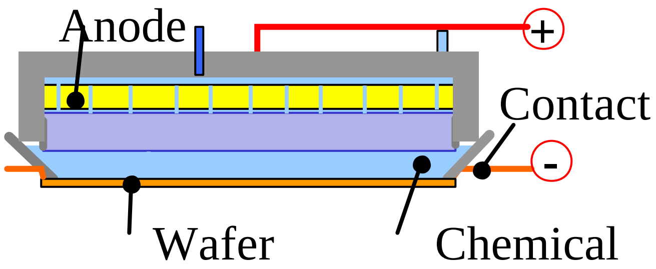
Non-uniform polish

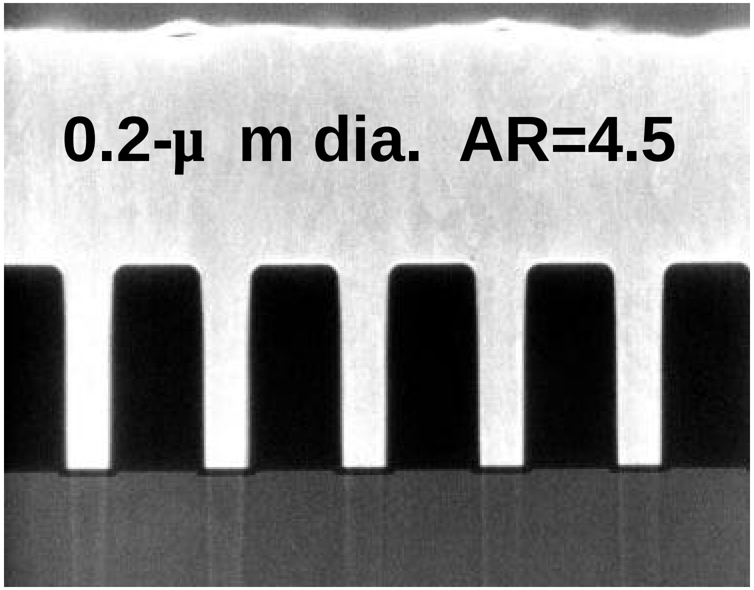
Pro-Active profile control is the ability to produce uniform polish profiles regardless of the incoming wafer deposition profile.

Examples of Six Different Cu Deposition Profiles

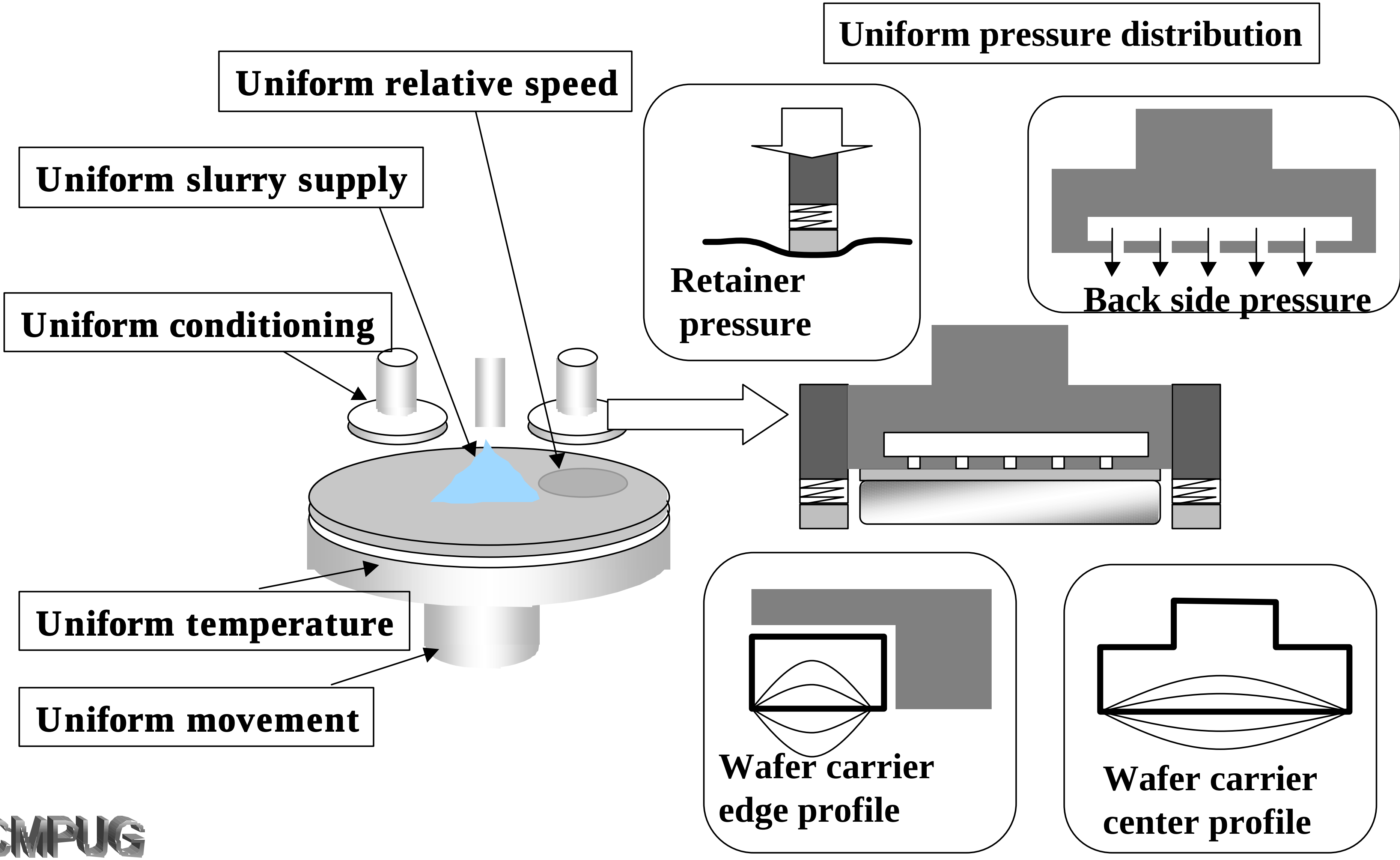


Edge Pro-profile control is required.





Several Methods to Improve CMP Performance



Uniform pressure distribution

Uniform relative speed

Uniform slurry supply

Uniform conditioning

Retainer pressure

Back side pressure

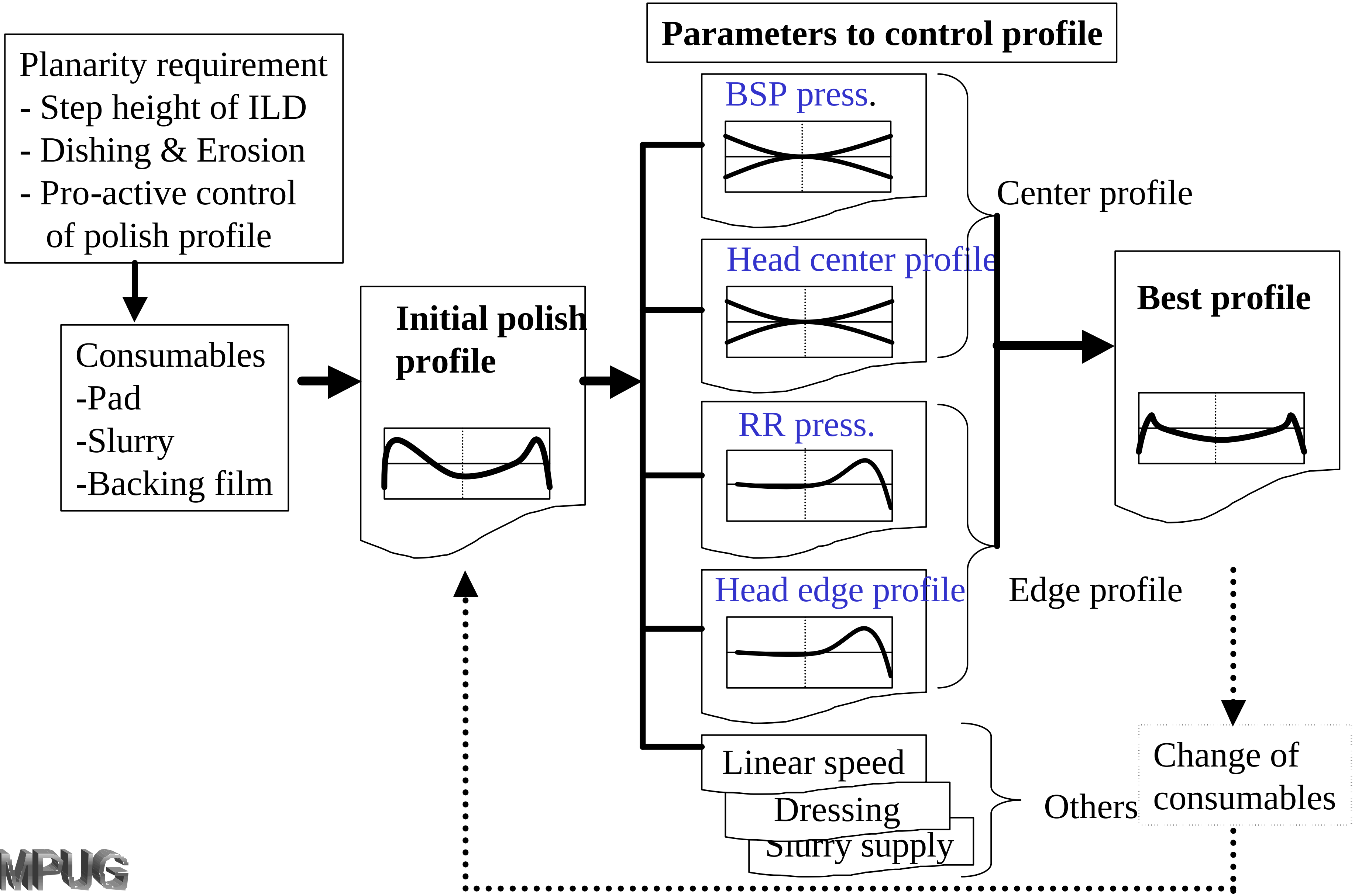
Uniform temperature

Uniform movement

Wafer carrier edge profile

Wafer carrier center profile

Pro-Active Profile Control for CLC & APC



Planarity requirement
- Step height of ILD
- Dishing & Erosion
- Pro-active control of polish profile

Consumables
-Pad
-Slurry
-Backing film

Initial polish profile

Parameters to control profile

BSP press.

Head center profile

RR press.

Head edge profile

Linear speed

Dressing

Slurry supply

Center profile

Edge profile

Others

Best profile

Change of consumables

Basic Calculation Equations

A Polish profile is predicted by the following equation, based on Preston's equation;

$q\ (r) = k_0\ (r)\ k_1\ (r) k_2\ (r)\ k_3\ (r)\ k_4\ (r)\ p\ (r)\ v\ (r)$

where,

$q\ (r)$: Polish quantity
$k_0\ (r)$: Basic proportional co-efficient
$k_1\ (r)$: Back-side pressure co-efficient
$k_2\ (r)$: Retainer-ring pressure co-efficient
$k_3\ (r)$: Head center-profile co-efficient
$k_4\ (r)$: Head edge profile co-efficient

$p\ (r)$:Pressure on polished wafer
$v\ (r)$:Linear velocity

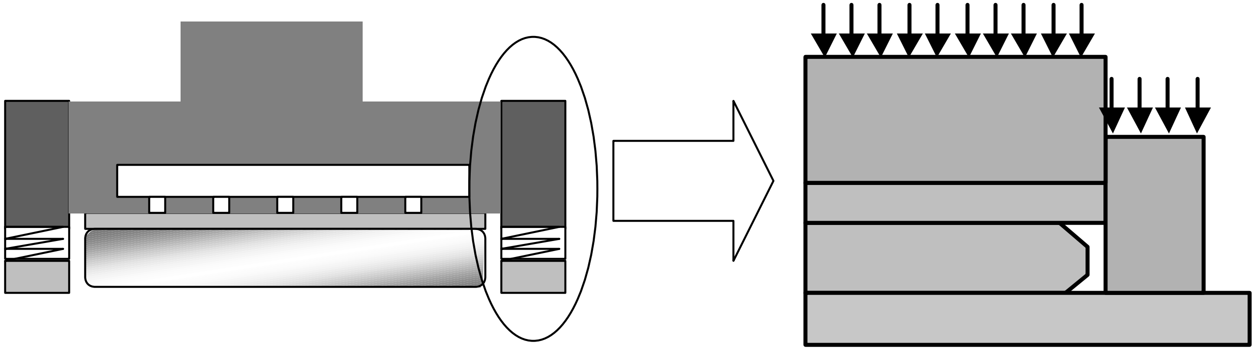
Conditions for Analysis

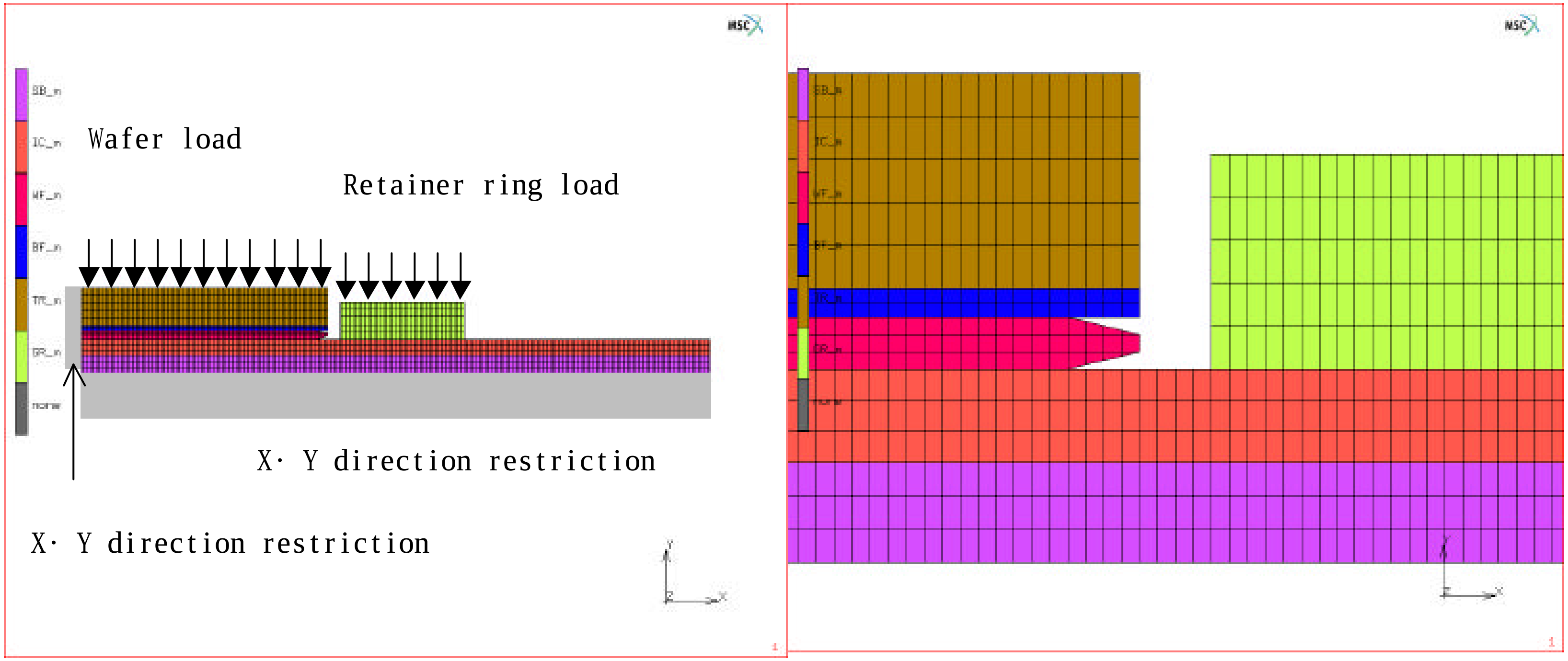
The analysis is performed under the following consumable set and experimental conditions:

Slurry :SS25
Pad :IC1000/Suba 400
Backing film :NF200
Speed Carrier/Table :30/30 rpm
Carrier force :500 g/cm^2
Retainer-ring force :0-700 g/cm^2
ILD :TEOS

$V\ (r)=V\ (0)=0.5$ m/sec
$v(r)=V\ (r)/V\ (0)=1$
$q\ (r)=k\ _0(r)$ Basic
$q\ '(r)=k\ _0(r)?k\ _1\ (r)?k\ _2\ (r)?k\ _3\ (r)$ ***Improved***

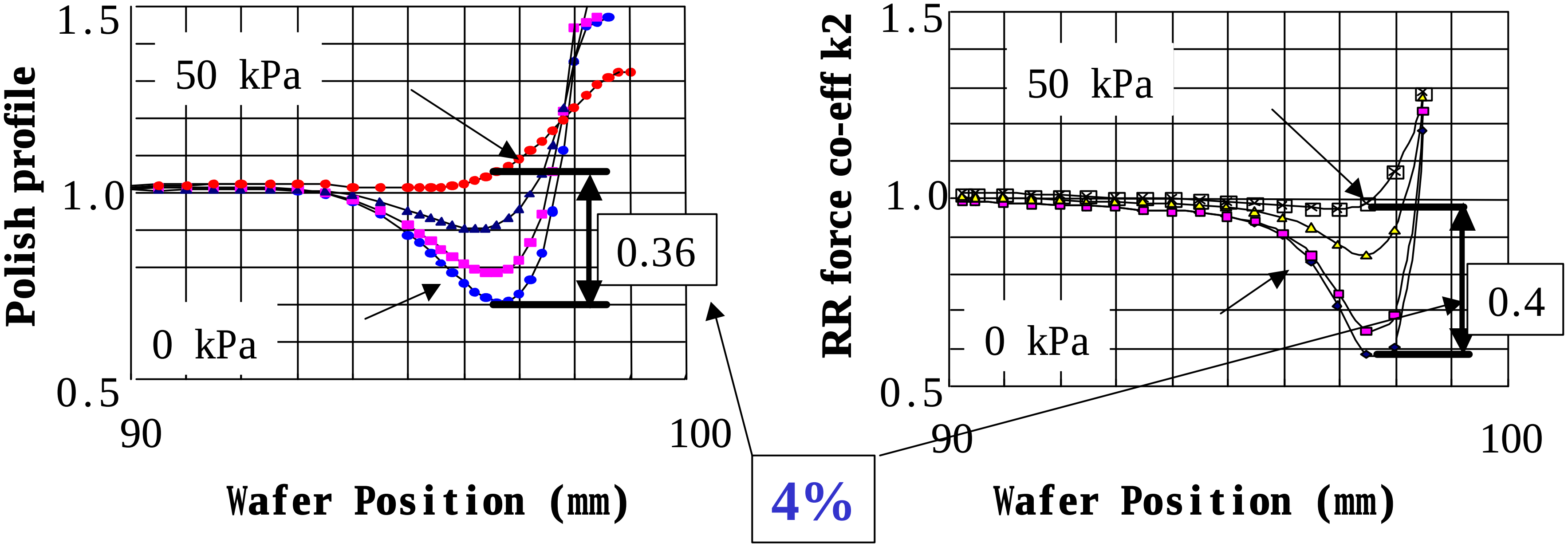
Effect of Retainer Ring Force





FEM Mesh drawing

Effect of Retainer Ring Force



Experimental

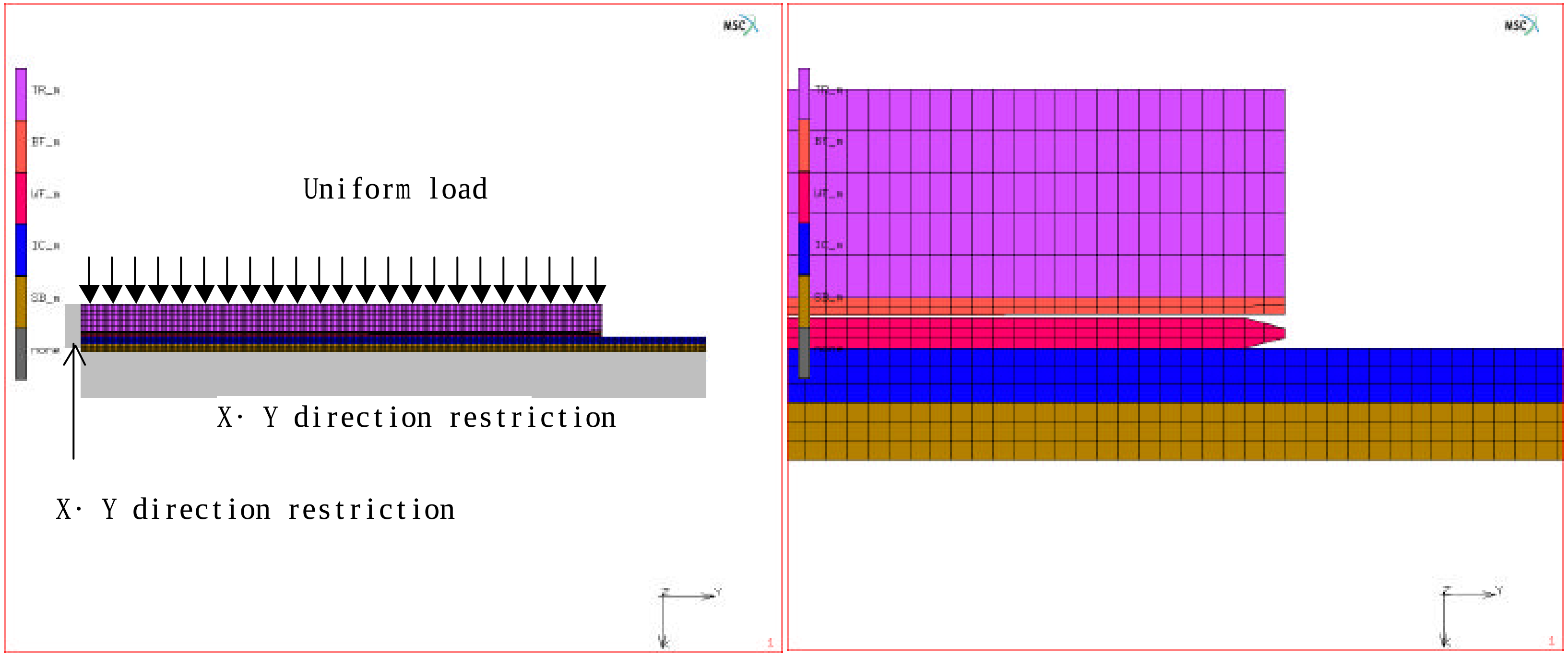
FEM analysis

FEM analysis follows the same trend as experiment

Effect of Head Center Profiles

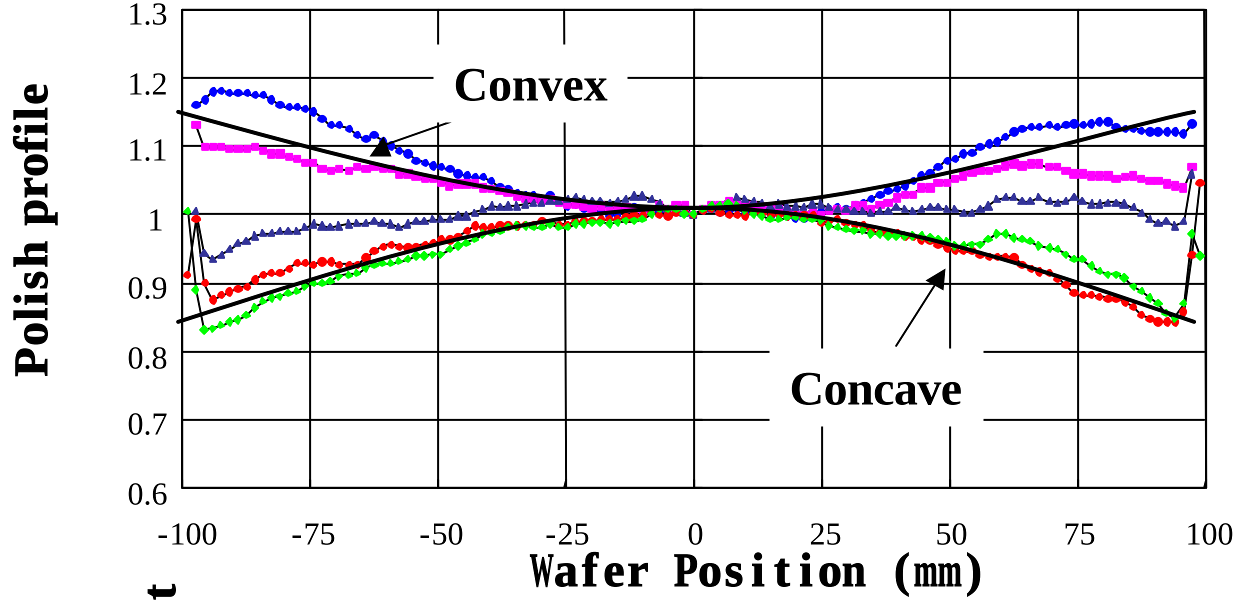
Convex

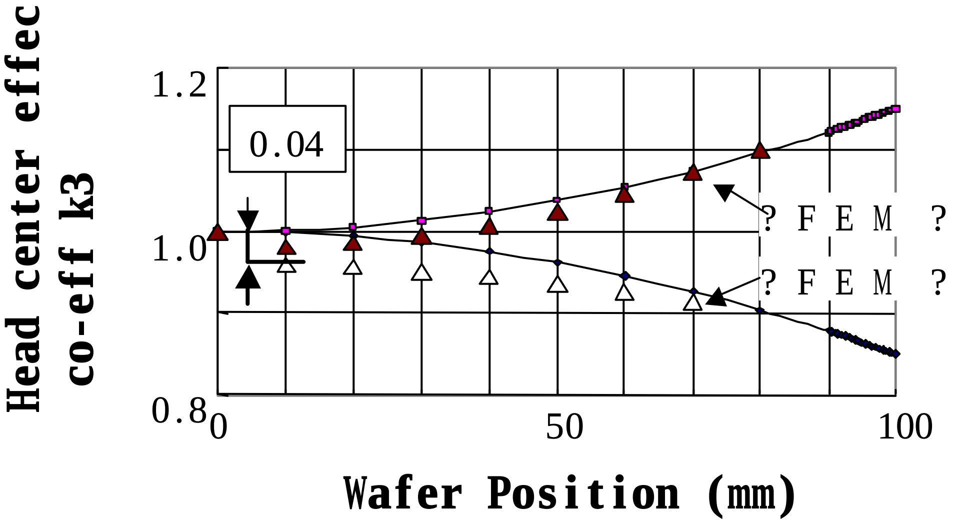
Concave



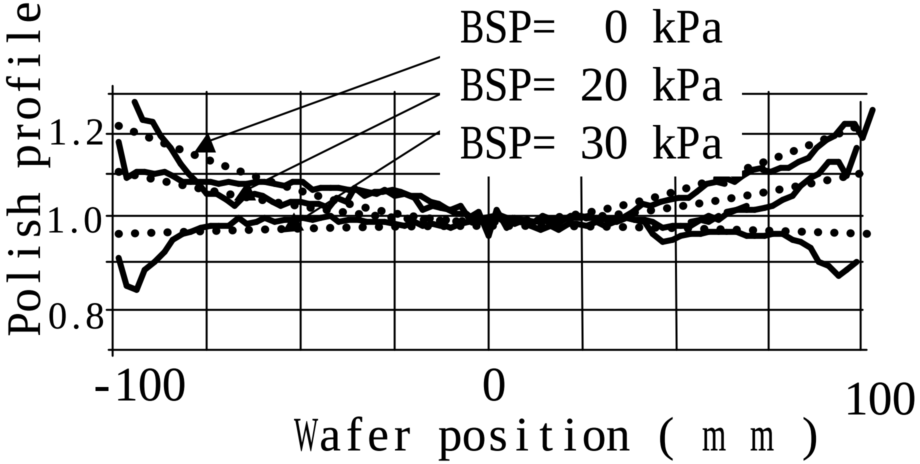
FEM Mesh drawing

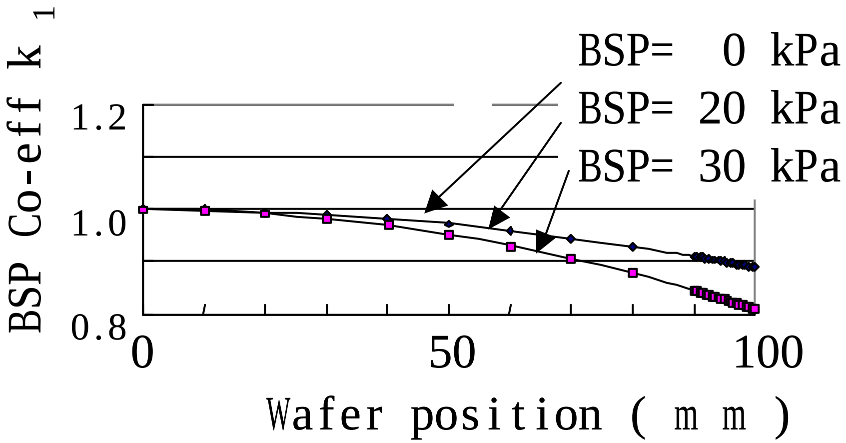
Effect of Head Center Profiles

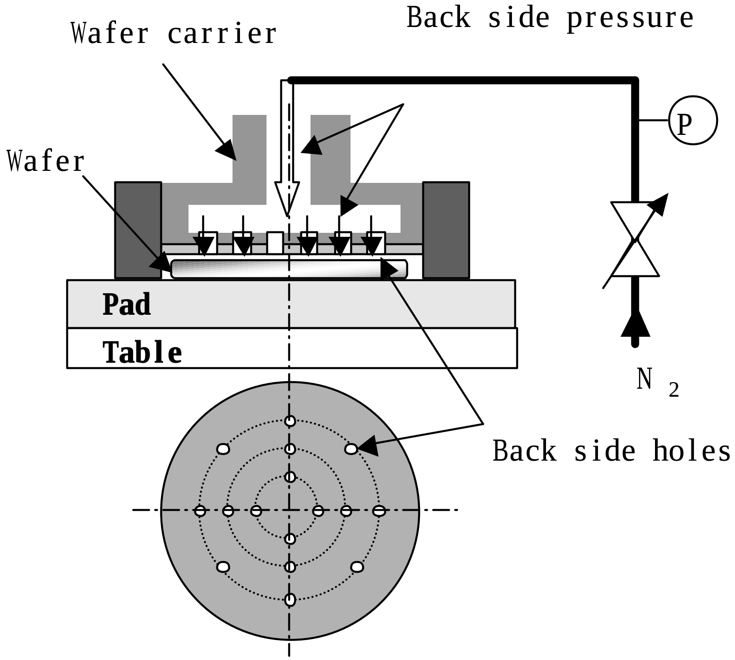




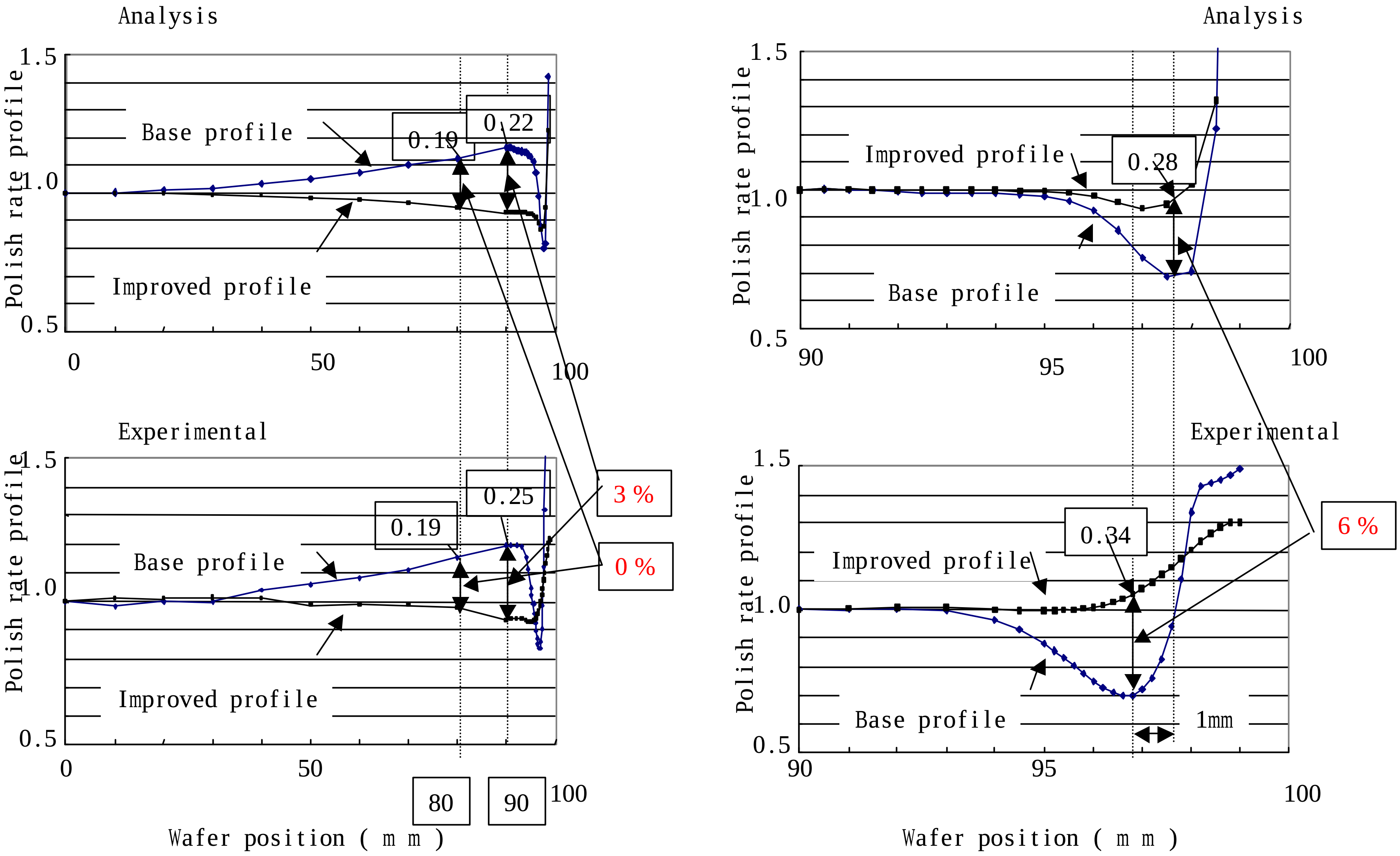
Effect of Back Side Pressure







Comparison of Analysis and Experimental Data



CONCLUSION

1. **Back-side effect co-efficient k_1 has been obtained by experiment.**
2. **Retainer-ring force effect co-efficient k_2 has been obtained by FEM analysis and has been confirmed to be highly predictable.**
3. **Carrier center-profile effect co-efficient k_3 has been obtained by FEM analysis and confirmed to be highly predictable.**
4. **Carrier-edge profile effect co-efficient k_4 has been obtained by experiment.**
5. **The analysis and presented example shows that the model is acceptable for predicting polish profiles.**
6. **This type of analysis will be useful for automated CMP closed-loop control.**