

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($\mu\Omega$ -cm)	2.2	2.2	2.2	1.8	<1.8
ILD effective 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

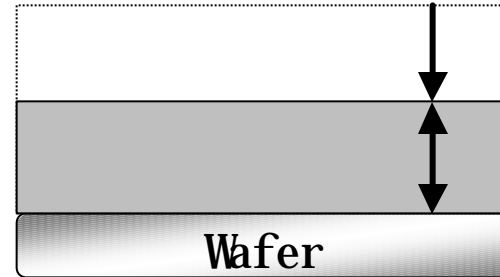
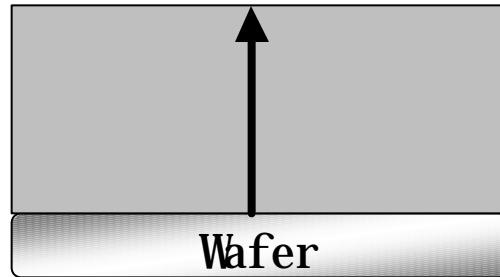
The “super planarity” requirement by ITRS demands that *ALL* CMP tools must have

“Pro-Active” Profile Control

What is “Pro-Active Profile Control”?

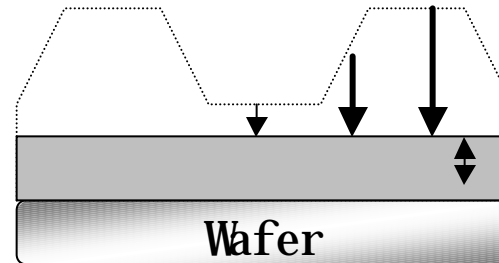
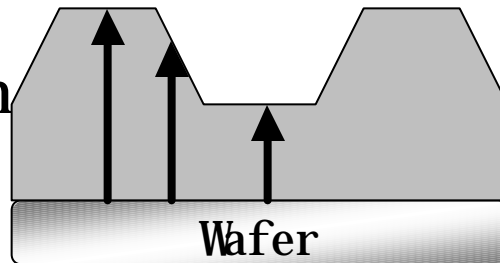
Proactive (pro ak'tiv), *adj.* Serving to prepare for, intervene in, or control an expected occurrence or situation

Uniform
deposition



Uniform
polish

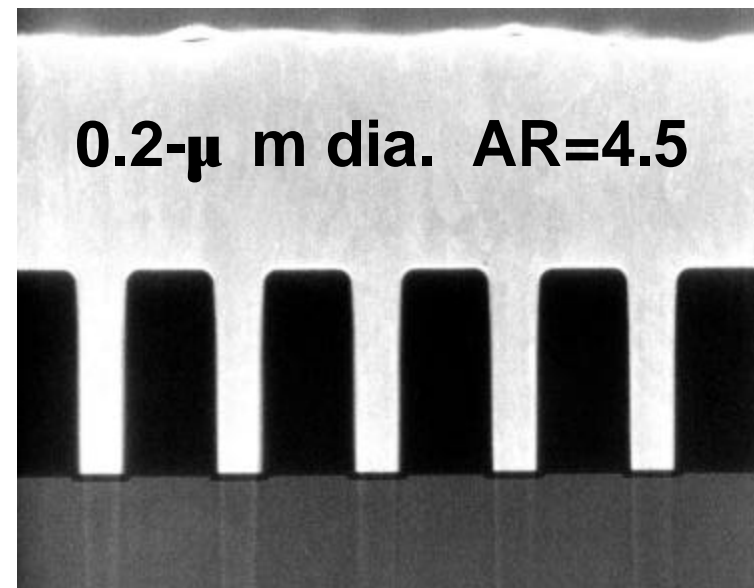
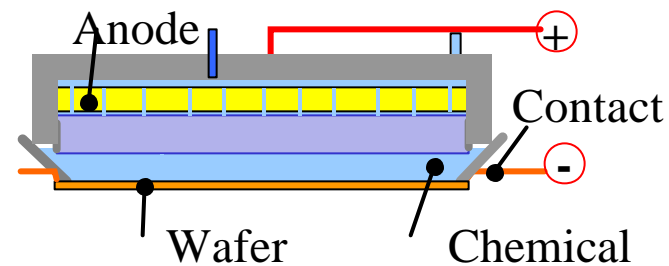
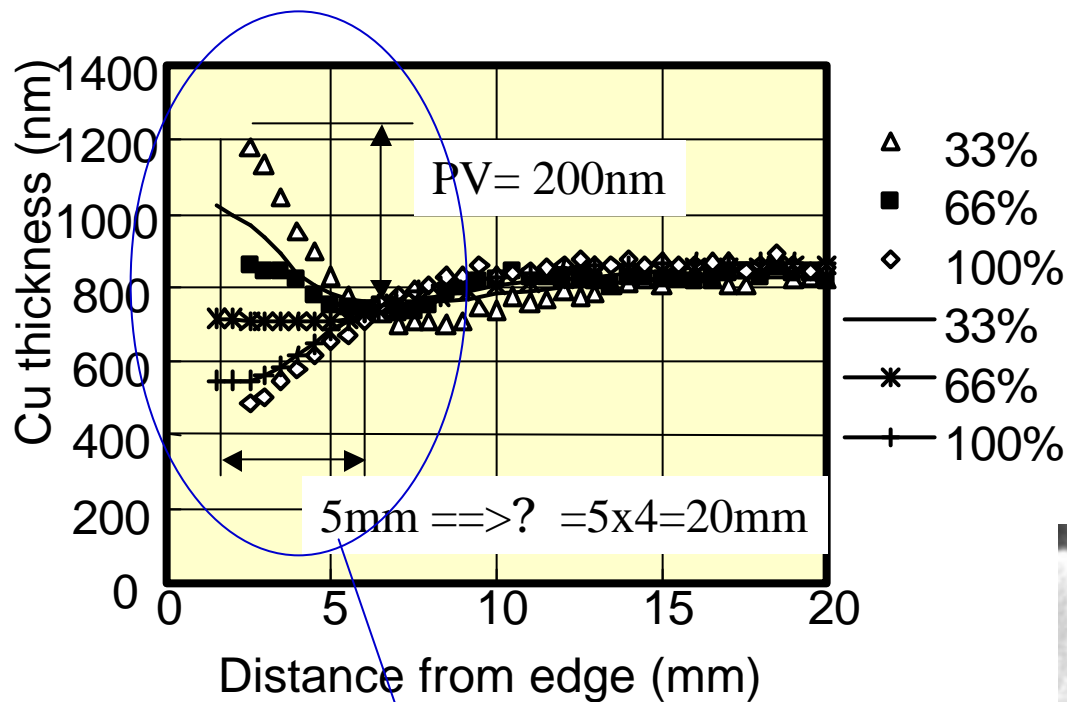
Non-uniform
deposition



Non-uniform
polish

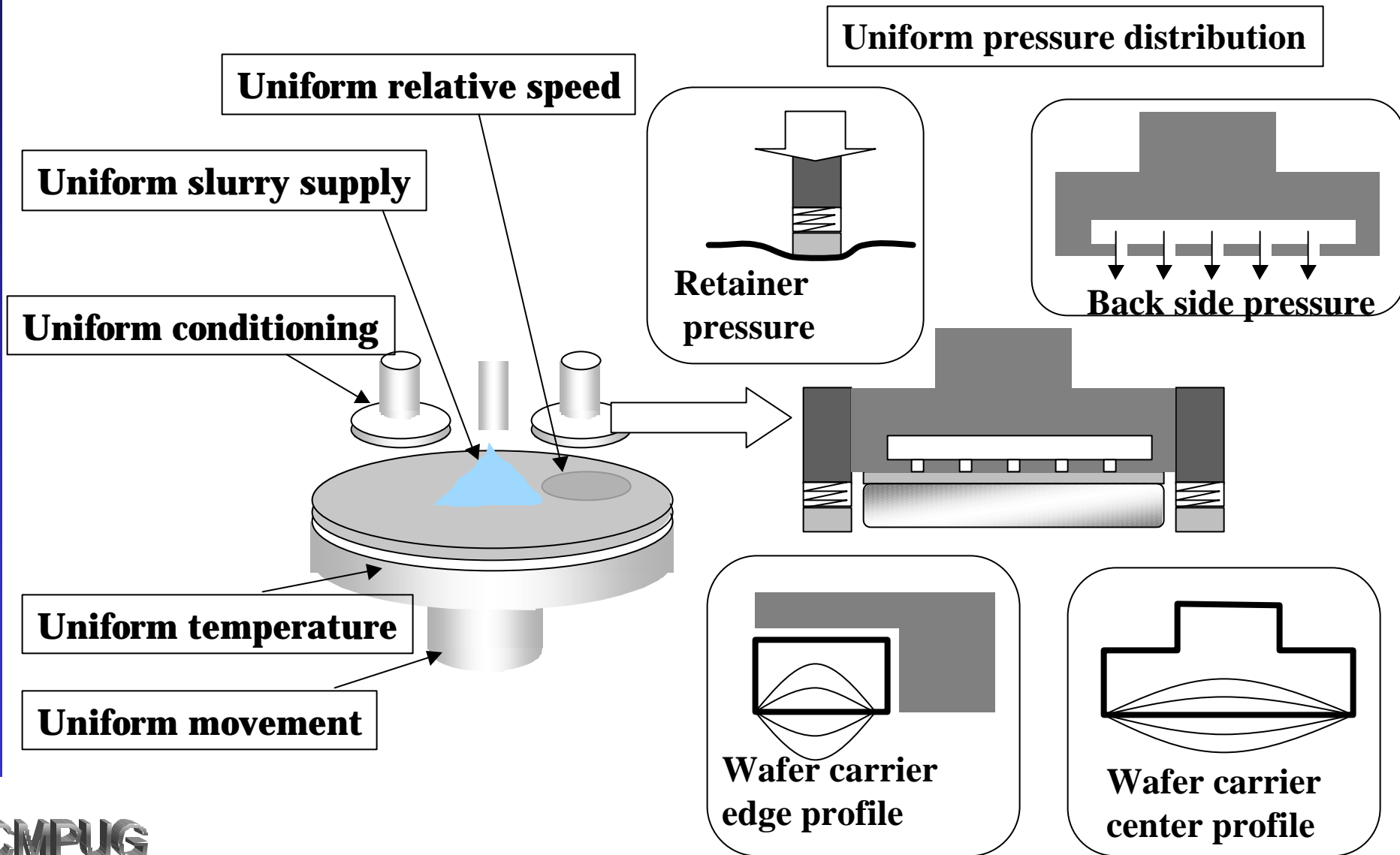
Pro-Active profile control is the ability to produce uniform polish profiles regardless of the incoming wafer deposition profile.

Examples of Six Different Cu Deposition Profiles

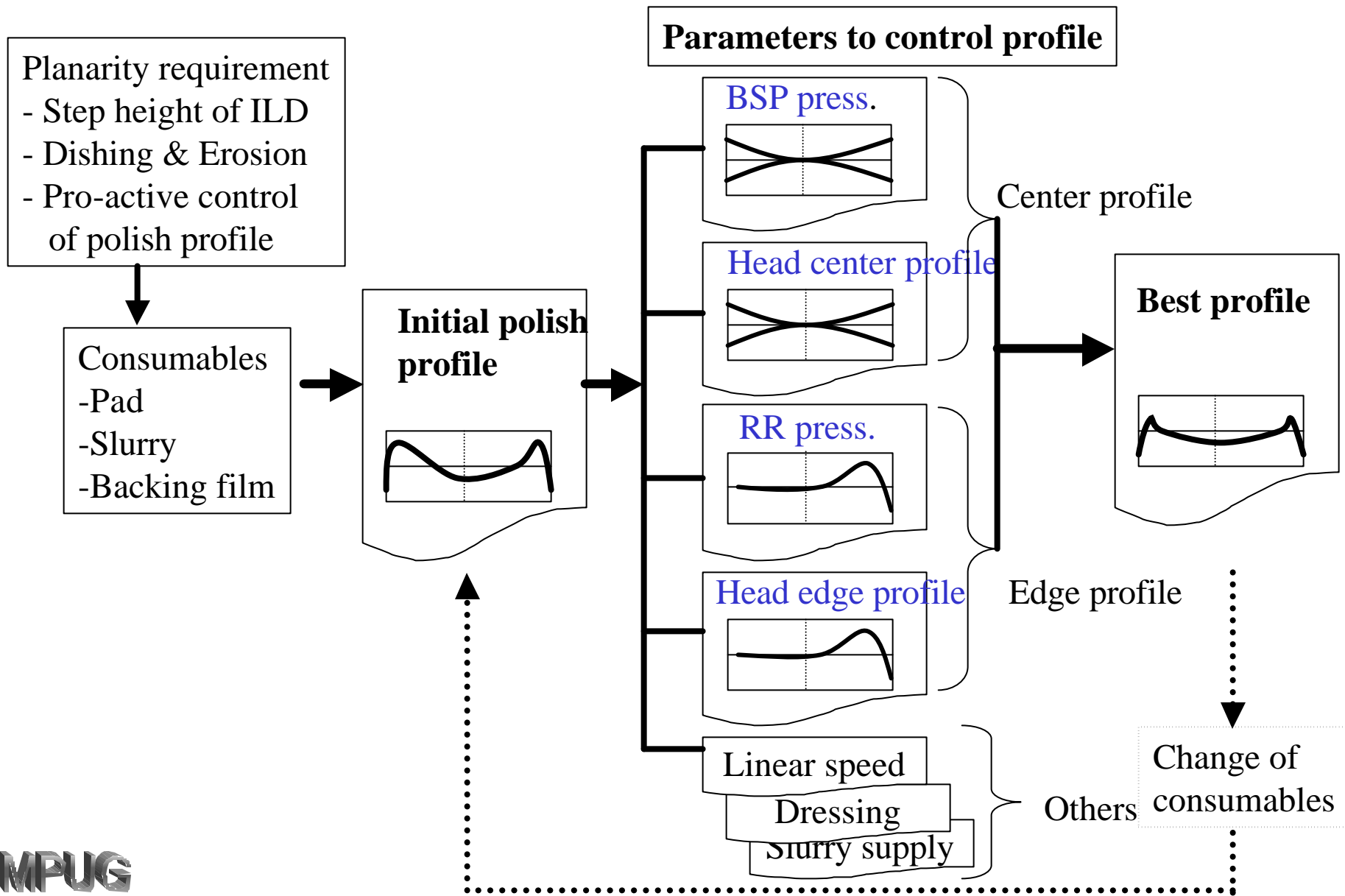


Edge Pro-profile control is required.

Several Methods to Improve CMP Performance



Pro-Active Profile Control for CLC & APC



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

$$V(r) = V(0) = 0.5 \text{ m/sec}$$

$$v(r) = V(r)/V(0) = 1$$

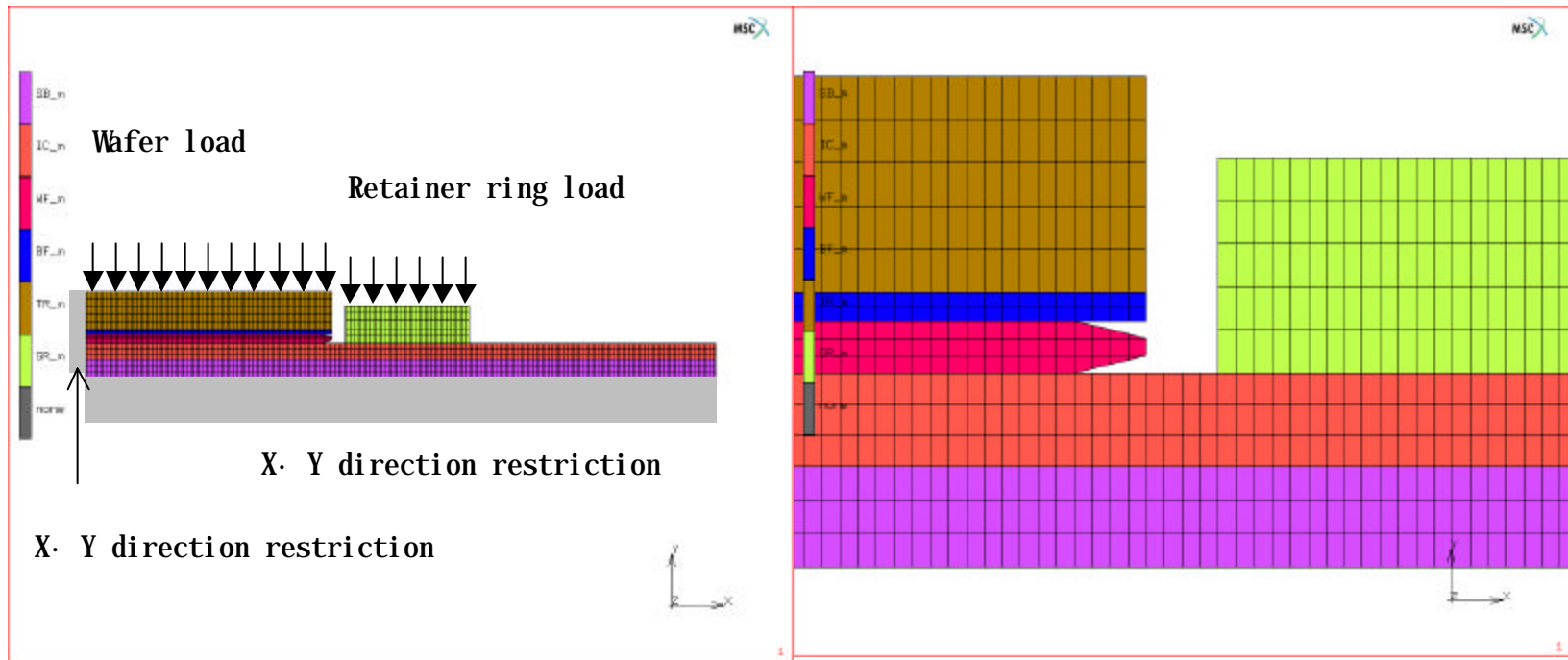
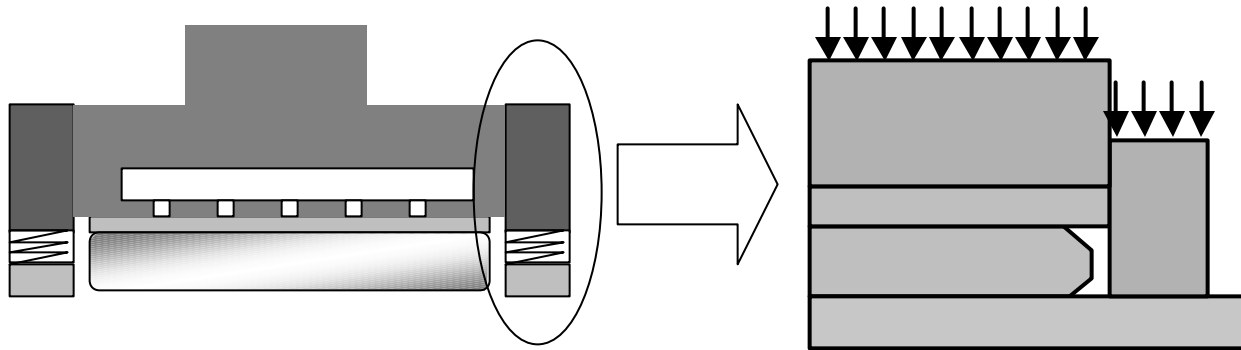
$$q(r) = k_0(r)$$

$$q'(r) = k_0(r) ? k_1(r) ? k_2(r) ? k_3(r)$$

Basic

Improved

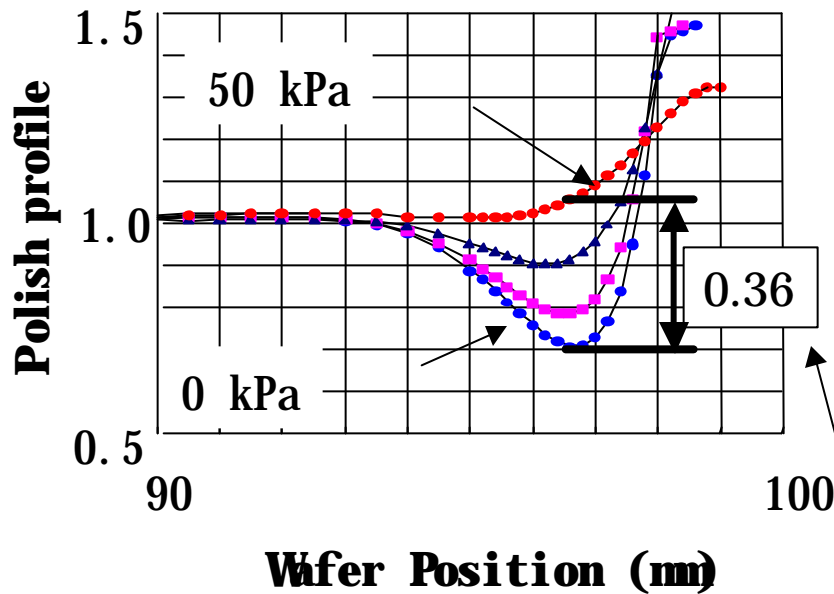
Effect of Retainer Ring Force



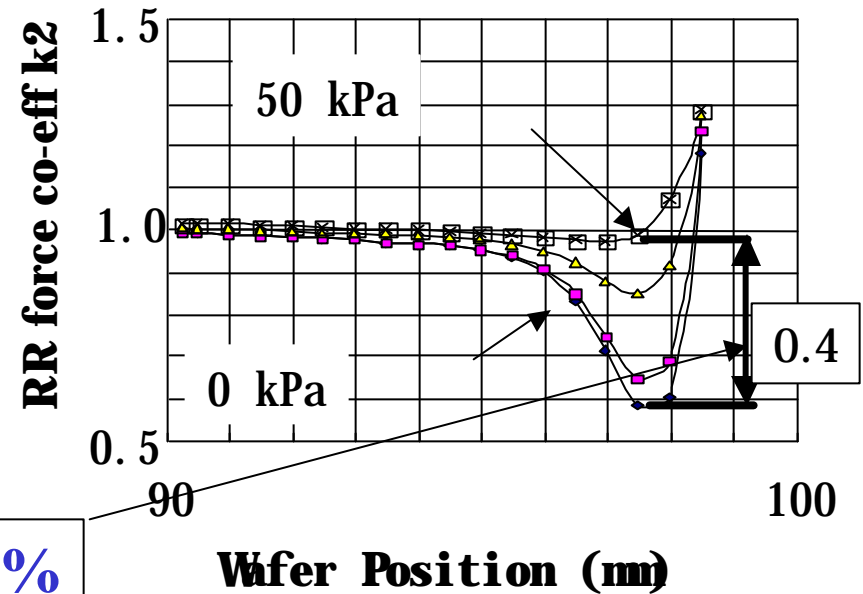
FEM Mesh drawing

Effect of Retainer Ring Force

Experimental



FEM analysis



FEM analysis follows the same trend as experiment

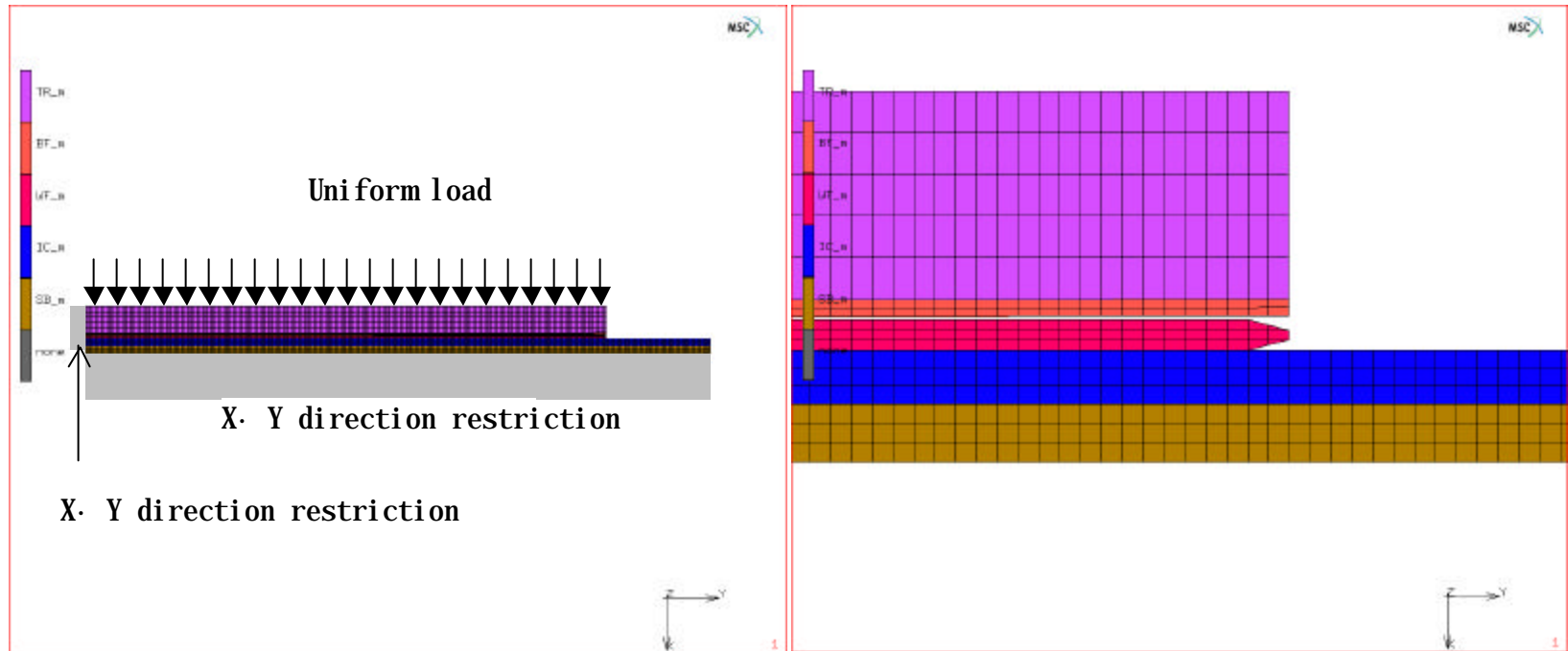
Effect of Head Center Profiles



Convex

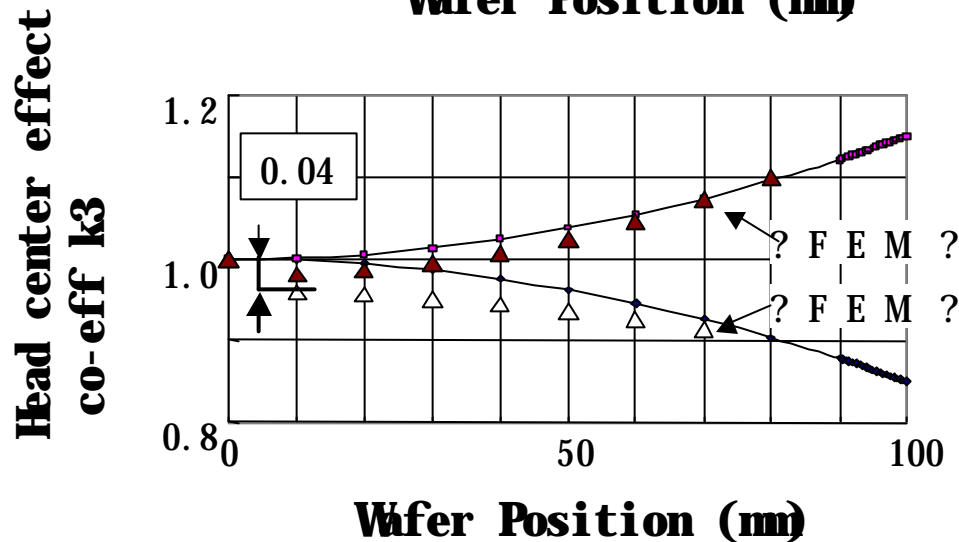
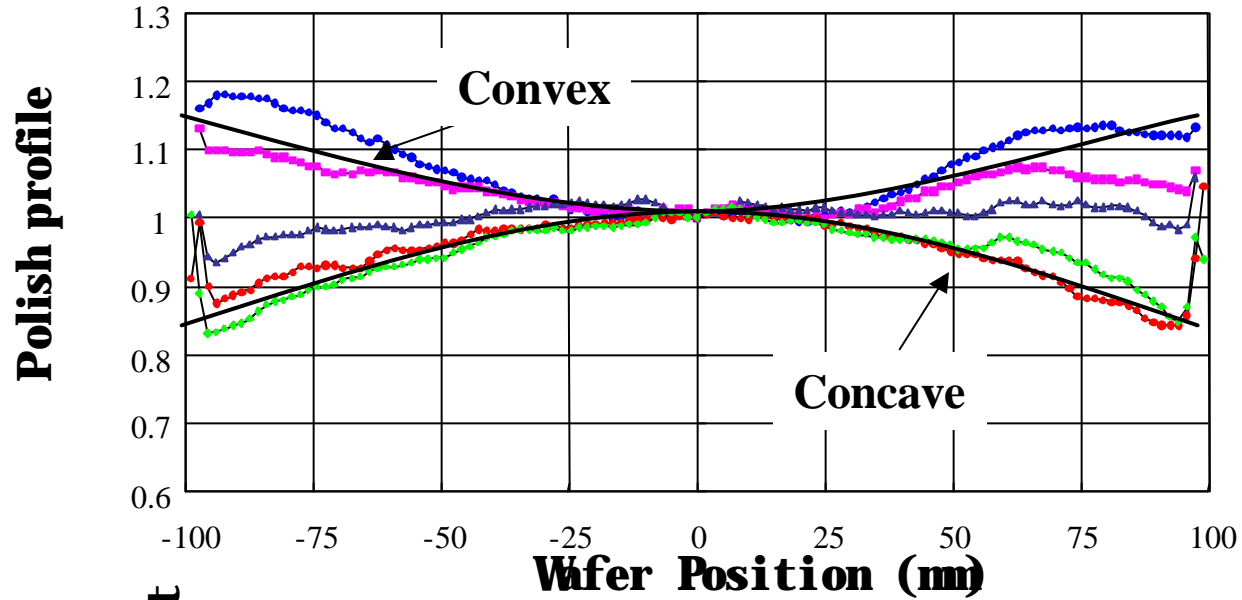


Concave

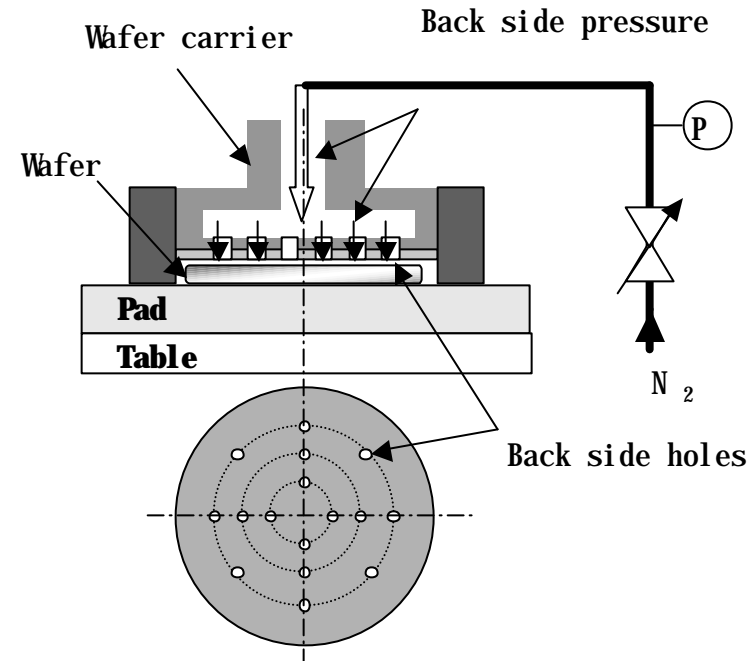
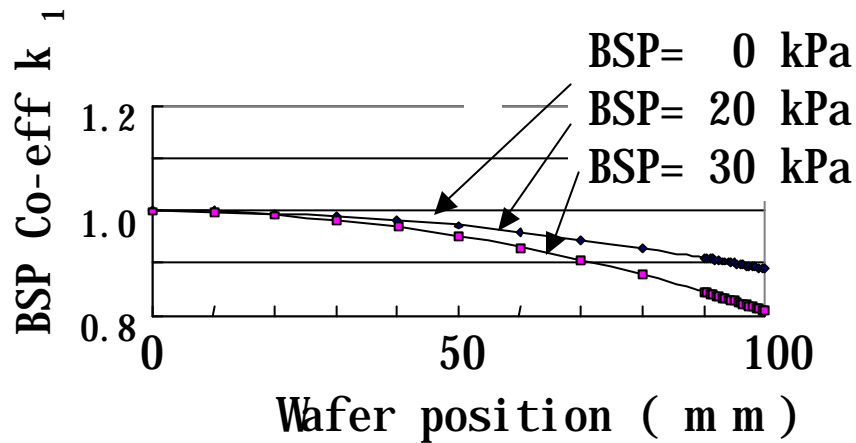
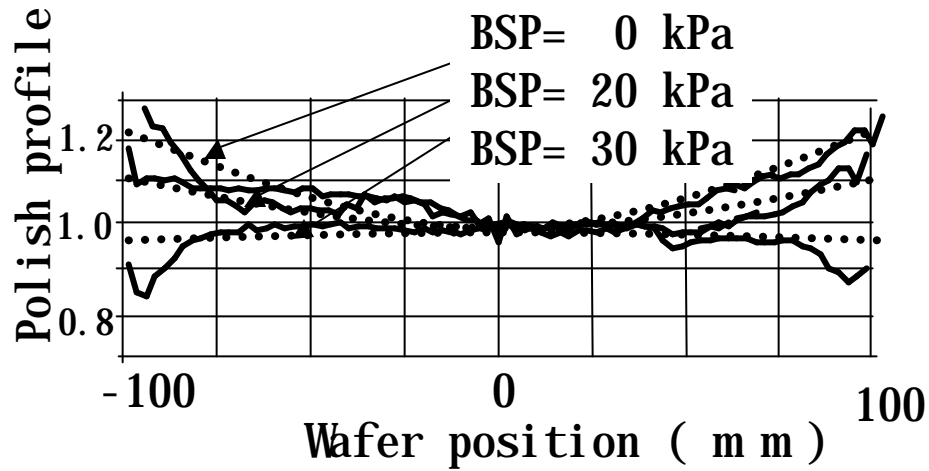


FEM Mesh drawing

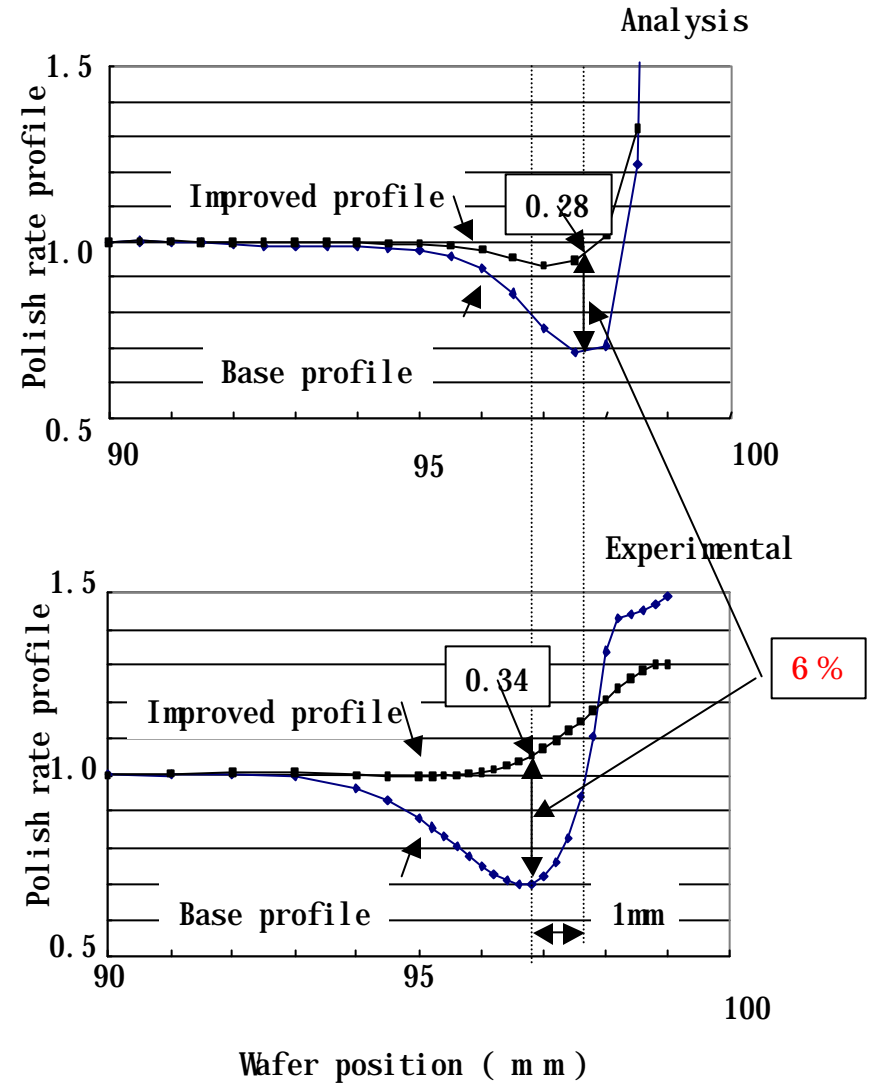
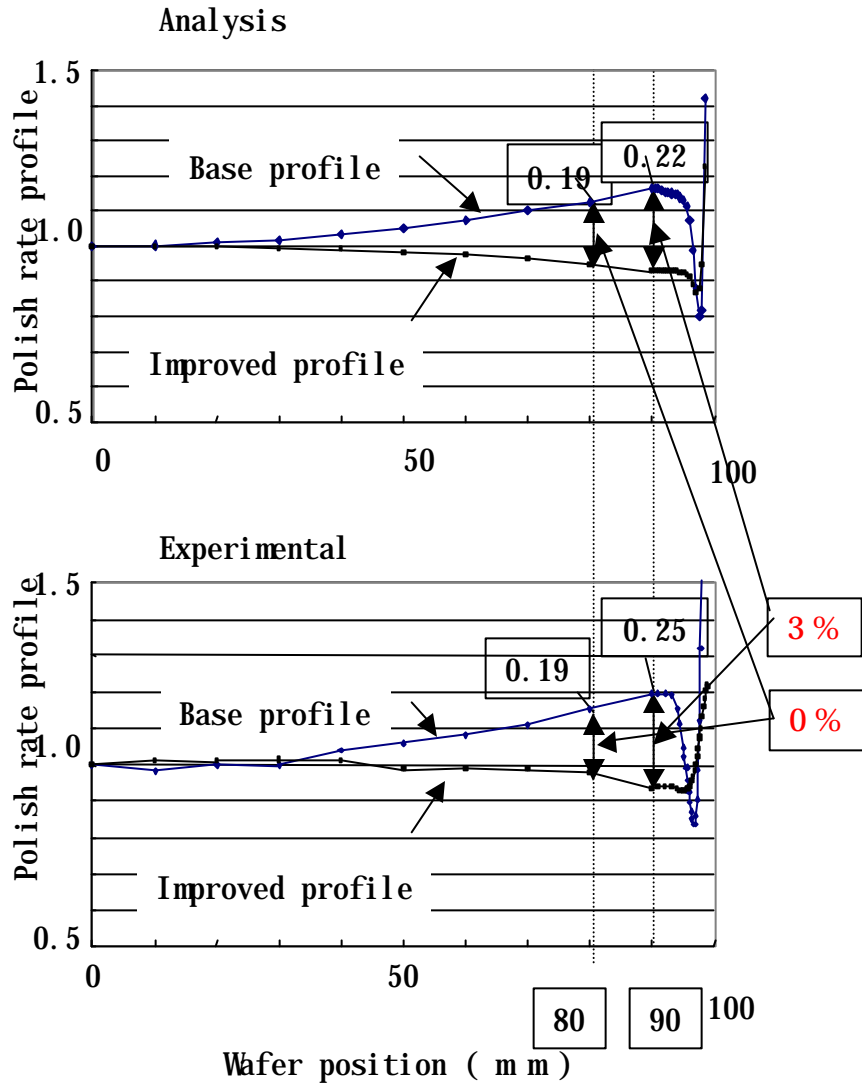
Effect of Head Center Profiles



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.**