

Paradigms Shifts in CMP

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CMPUG - Semicon West 2018

Paradigm Shifts in CMP

State of CMP

Market Inflections are driving CMP Growth and Complexity

Paradigm Shifts in CMP

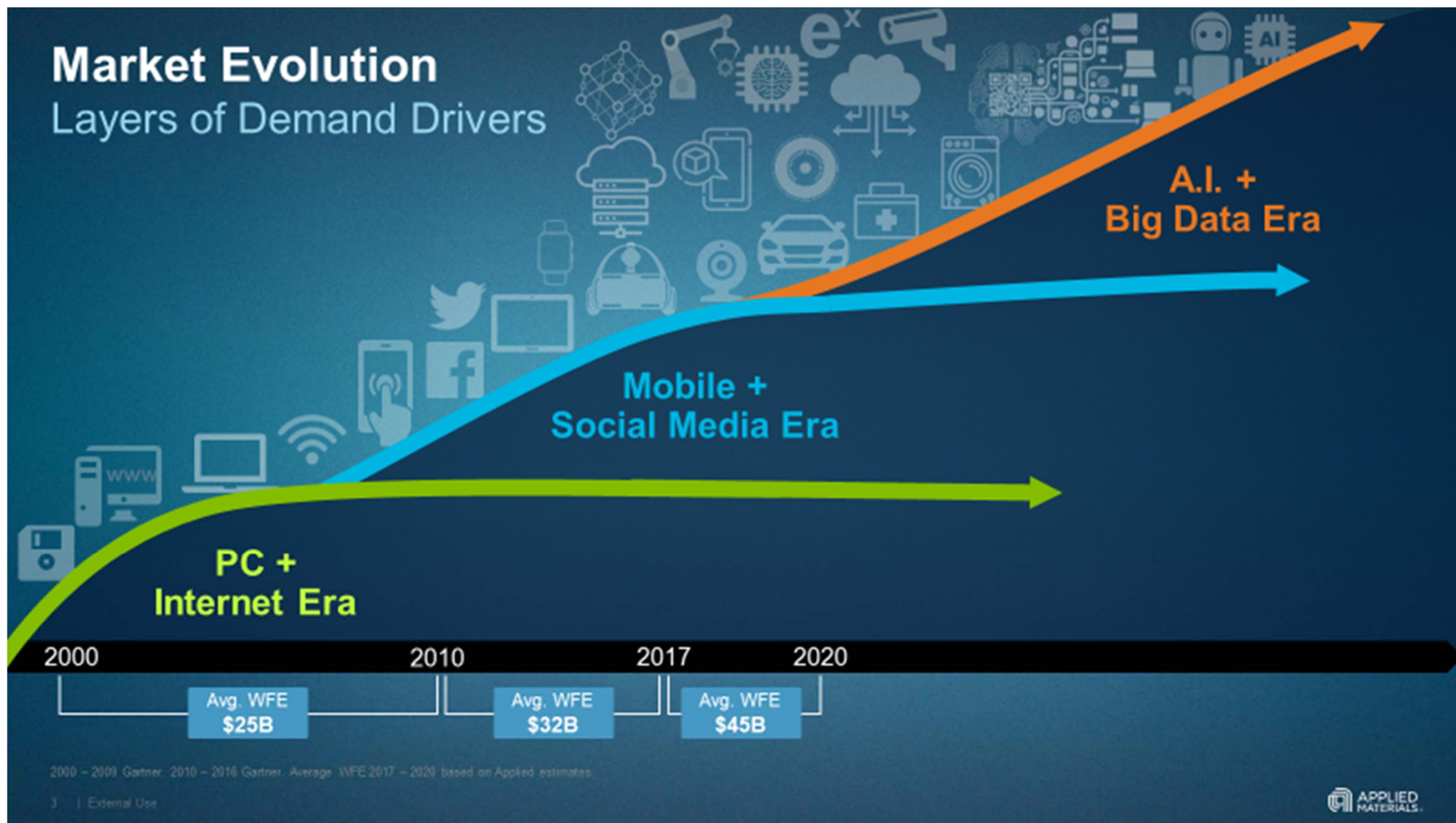
Strategies to address CMP Complexity

SMART CMP

Tailored CMP Pads

Market Evolution

Layers of Demand Drivers



Market Evolution

Layers of Demand Drivers

What's
happening
NOW

Mobile +
Social Media Era

A.I. +
Big Data Era

PC +
Internet Era

\$90B
2017 + 2018 WFE*

>\$4B
2017+2018 CMP*

2000 2010 2017 2020

Avg. WFE
\$25B

Avg. WFE
\$32B

Avg. WFE
\$45B

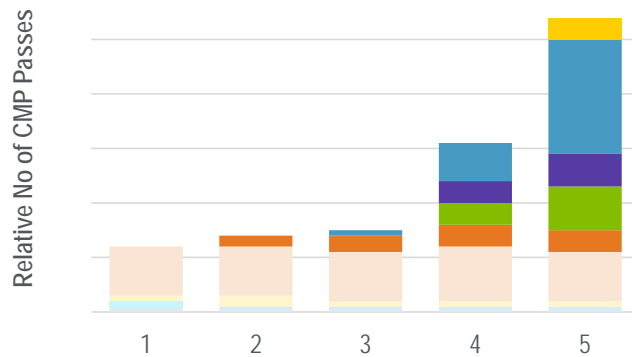
2000 – 2009: Gartner. 2010 – 2016: Gartner. Average WFE 2017 – 2020 based on Applied estimates.
* 2017 + 2018 WFE based on Applied estimates.

4 | External Use

APPLIED
MATERIALS

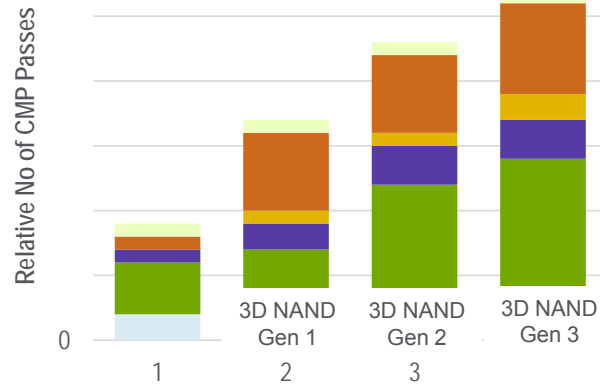
CMP Enabled Inflections

LOGIC



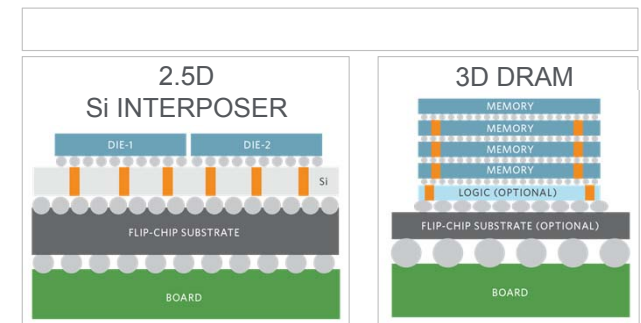
- 3D Transistor: FinFET
- Co contact & local interconnect
- 3D Multi Patterning
 - ▶ SA Gate Contact
- Large Die Form Factors
 - ▶ GPU

NAND



- 3D NAND
 - ▶ More W & oxide CMP
 - ▶ CMOS Under Array
 - ▶ Stacked Cells
 - ▶ Multi-Material Polish

ADVANCED PACKAGING



- Wafer Level Packaging
 - ▶ Image Sensors
 - ▶ Redistribution Layer (RDL)
 - ▶ Through Silicon Via (TSV)

Market Evolution

Layers of Demand

Entering a
NEW ERA
of growth

**A.I. +
Big Data Era**

**Mobile +
Social Media Era**

**PC +
Internet Era**

“A.I. related growth will boost
global GDP by \$16T by 2030”

– The Economist / PwC

“Data is to this century what oil
was to the last one: a driver of
growth and change”

– The Economist

2000

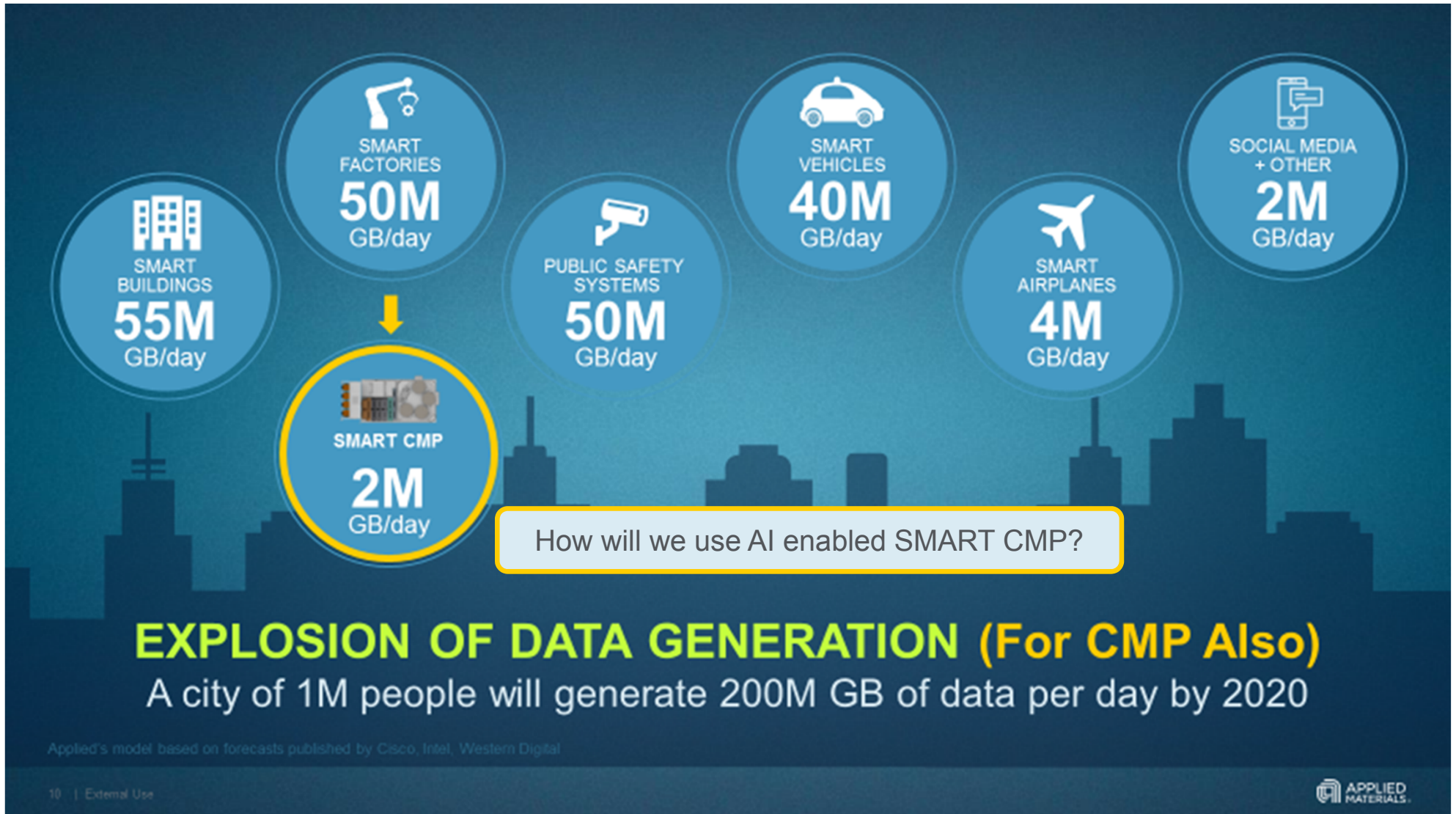
2010

2017

2020

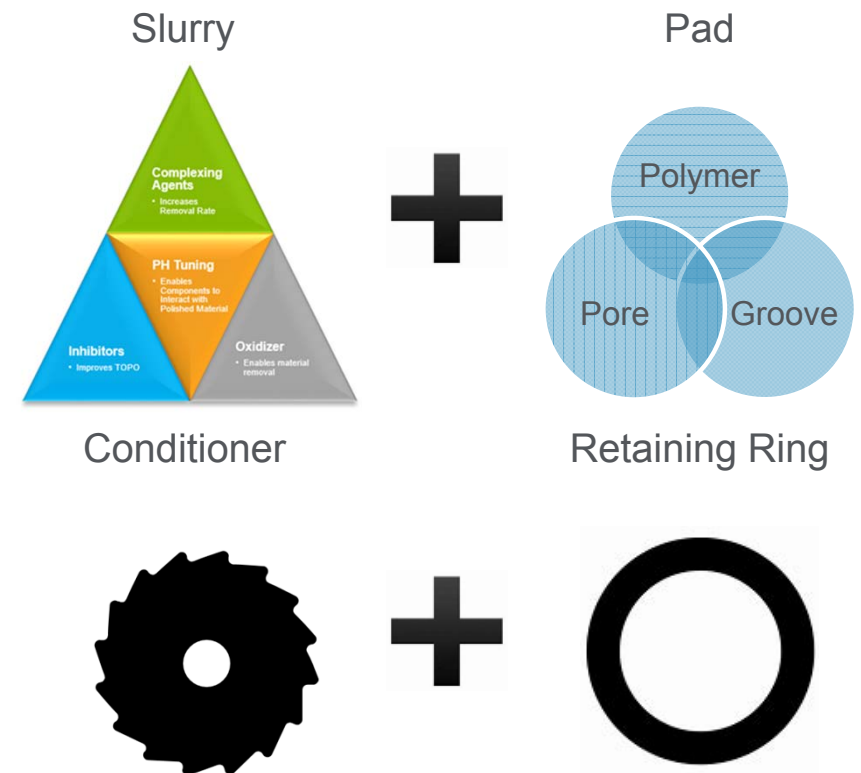
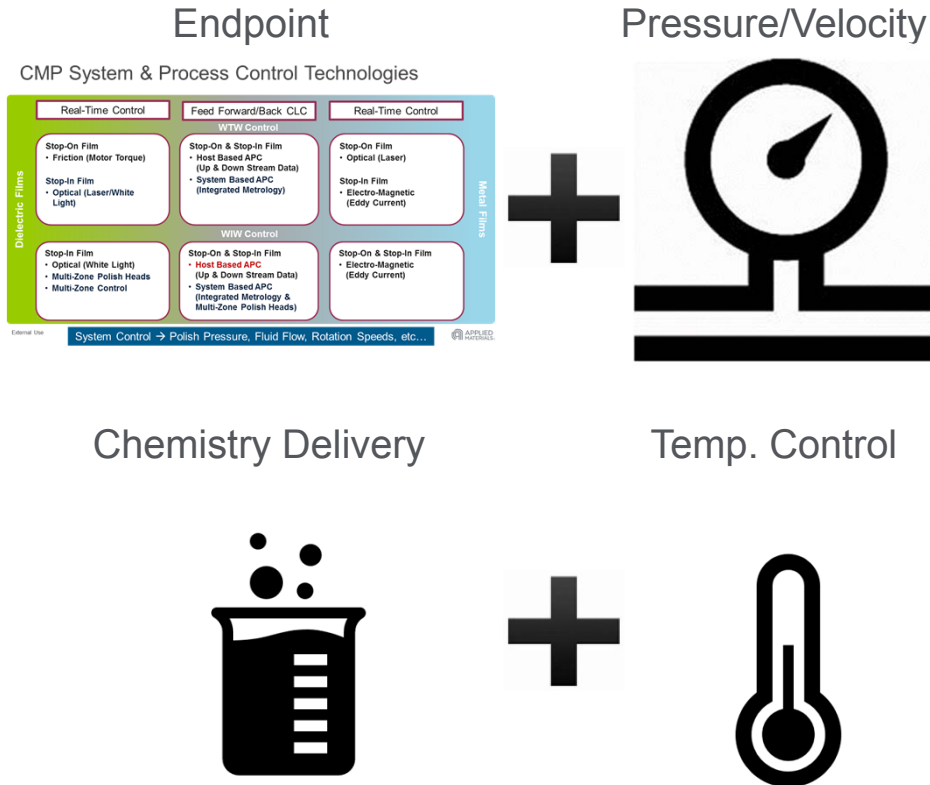
External Use

APPLIED
MATERIALS



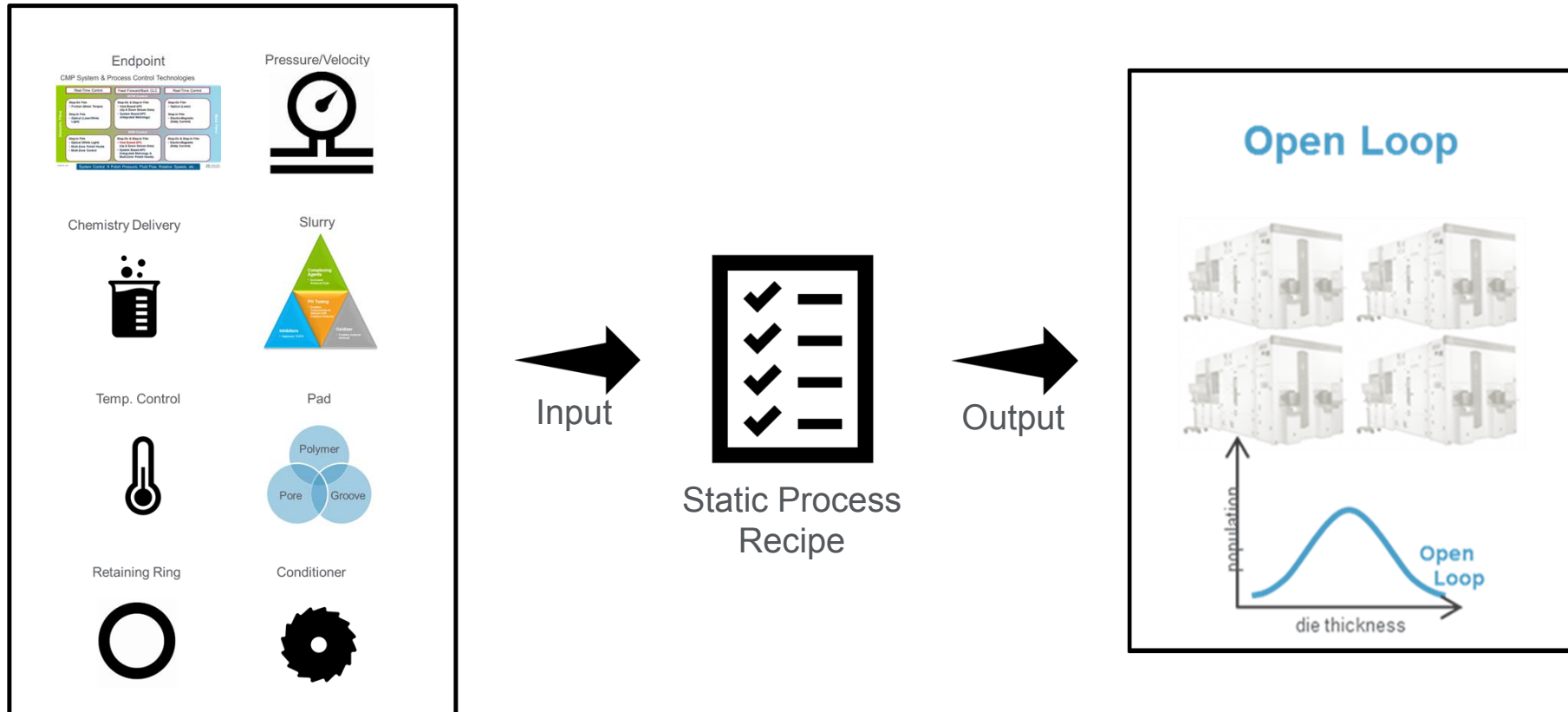
Hardware

Materials



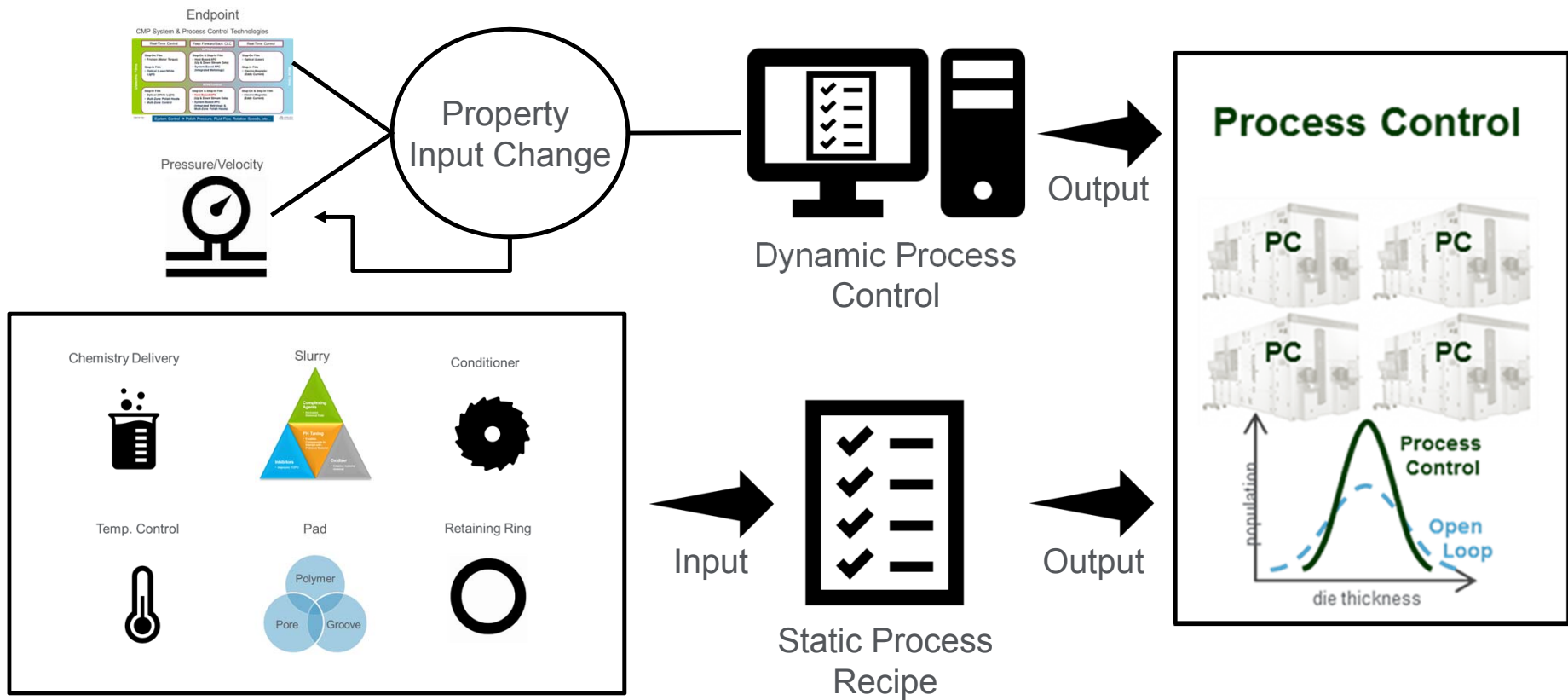
CMP Input Parameters.

Open Loop CMP



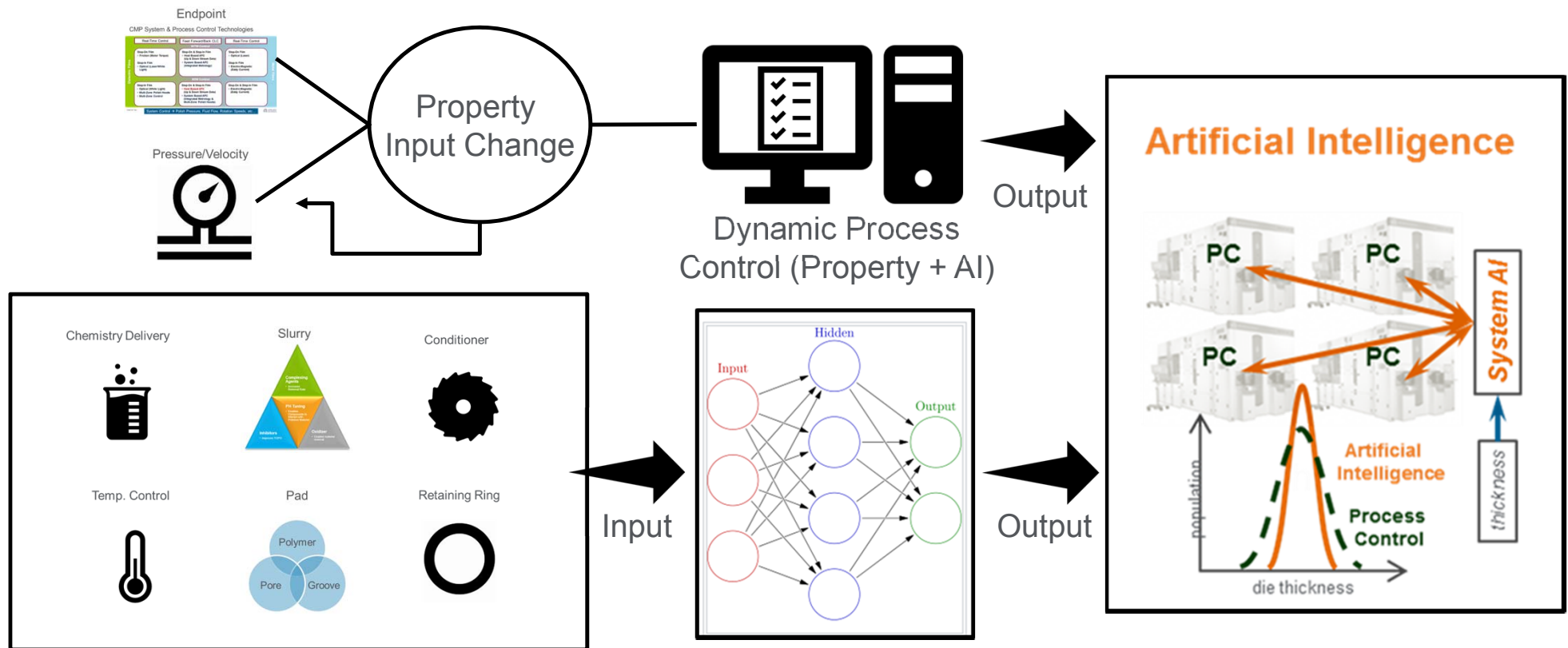
Stability achieved through reduced Input Parameter variability.

Process Controlled CMP



Performance improved through Dynamic Process Control of Input Parameters.

AI Augmented Process Controlled CMP



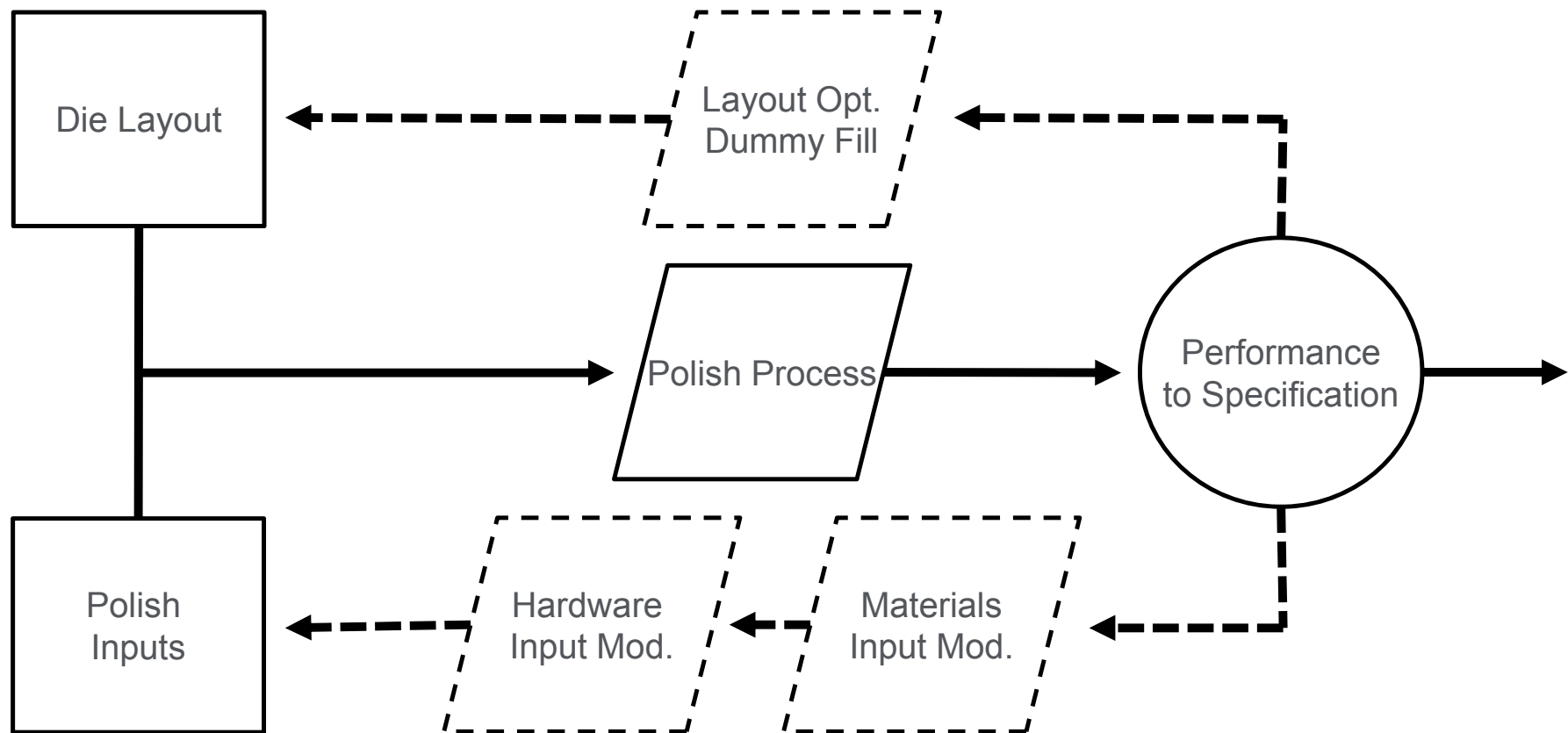
AI has the promise of optimizing output through the interpolation of multiple Input Parameters.

Warning with regards to AI Processing



Output success is a function of algorithm training.

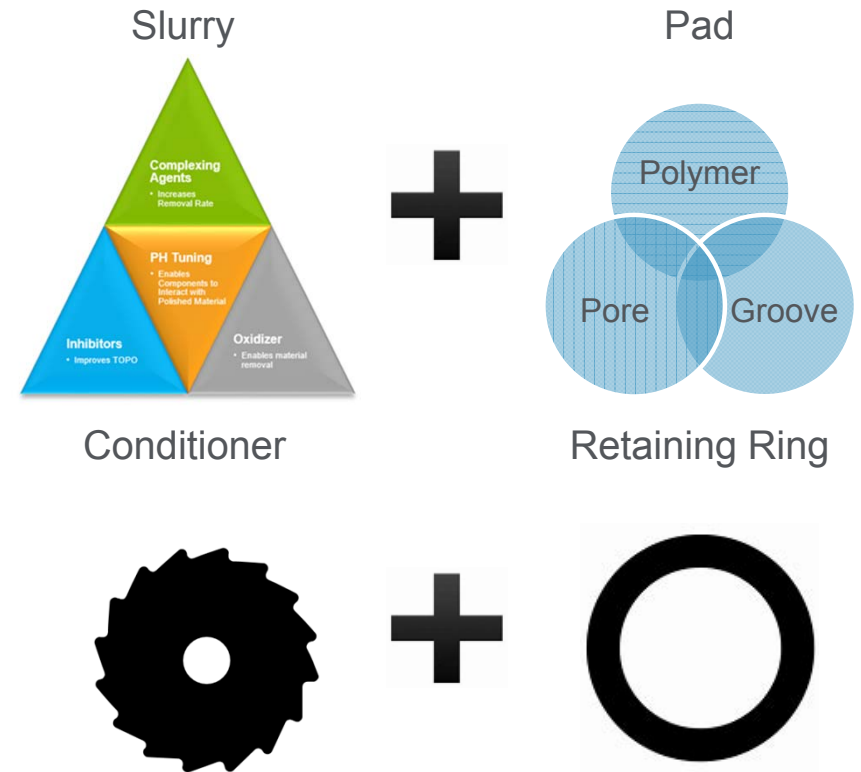
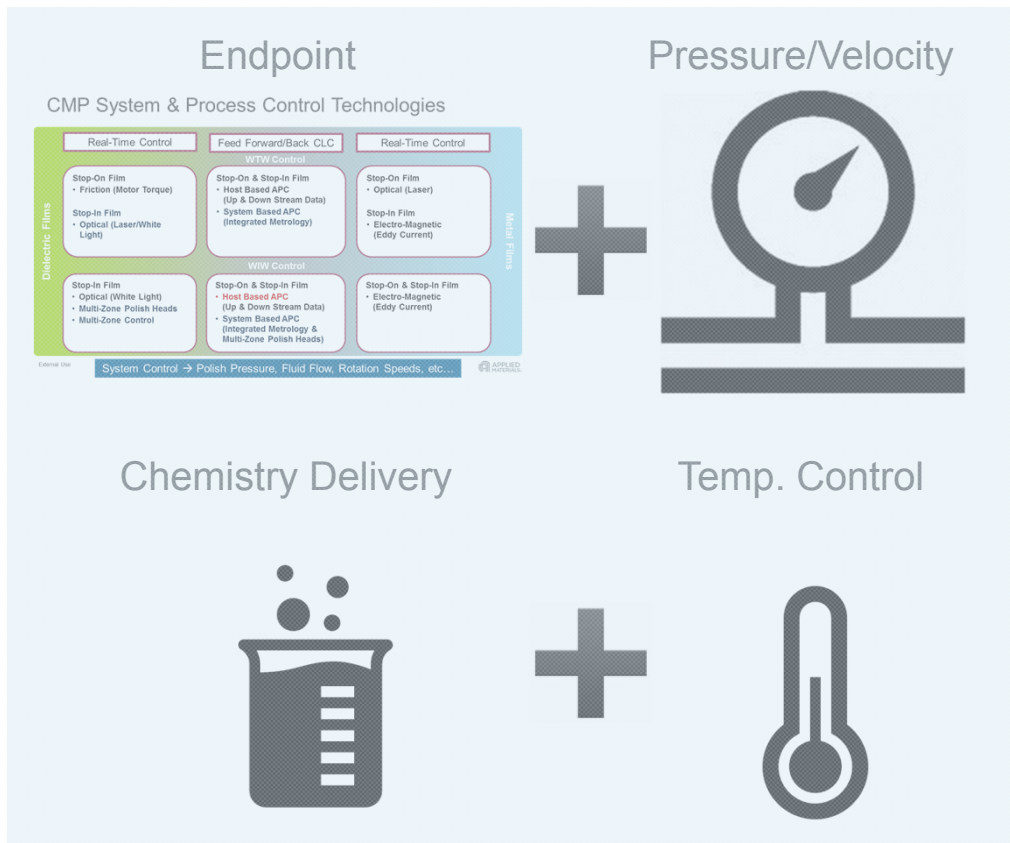
CMP Process Optimization



CMP Polish process versatility continues to enable new integration schemes.

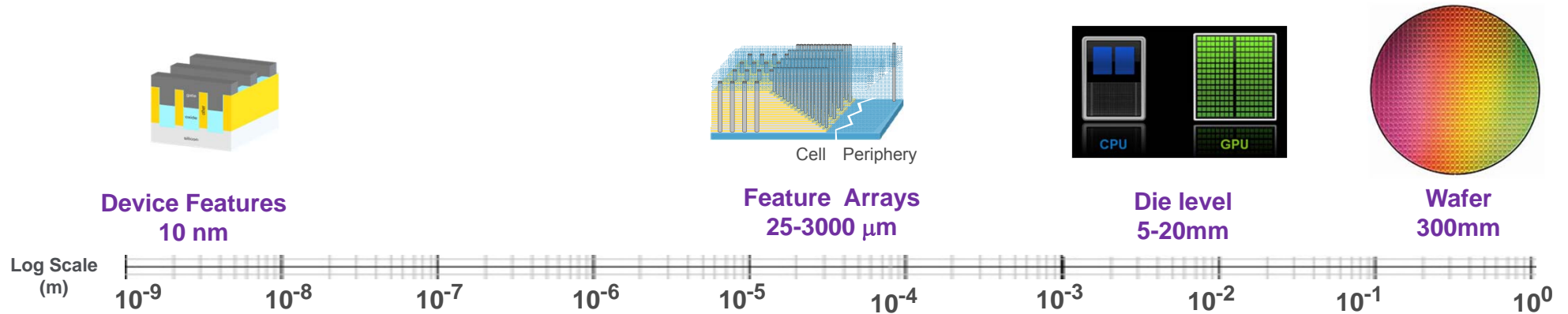
Hardware

Materials



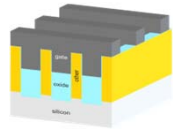
Each Process Input has a Structure/Property Model

CMP Pad Structure/Property Input Parameters

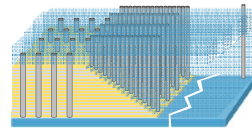


Critical Length Scales

CMP Pad Structure/Property Input Parameters

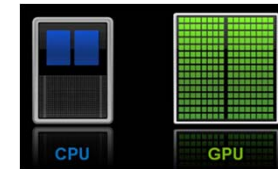


Device Features
10 nm

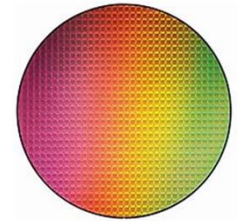


Cell Periphery

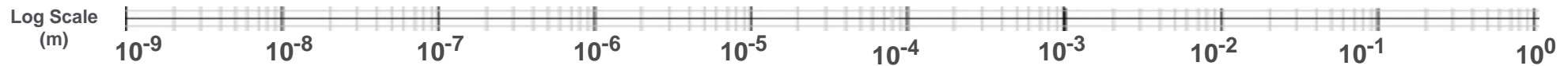
Feature Arrays
25-3000 μm



Die level
5-20mm



Wafer
300mm



Polymer Chains
50-100 nm

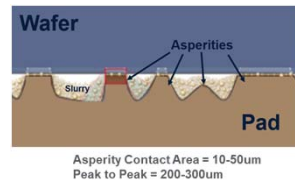
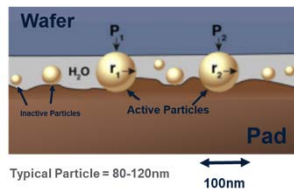
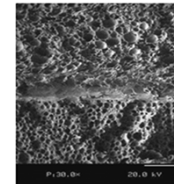
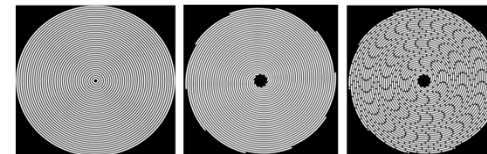
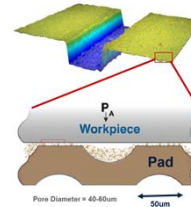
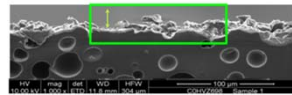
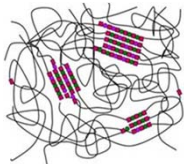
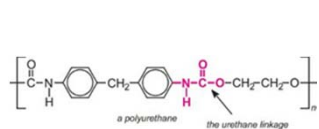
Polymer Domains
500-5000 nm

Pad Porosity
10-50 μm

Pad Groove
100-500 μm

Polish Element
0.5-3 mm

Pad Rebound
10-100 mm

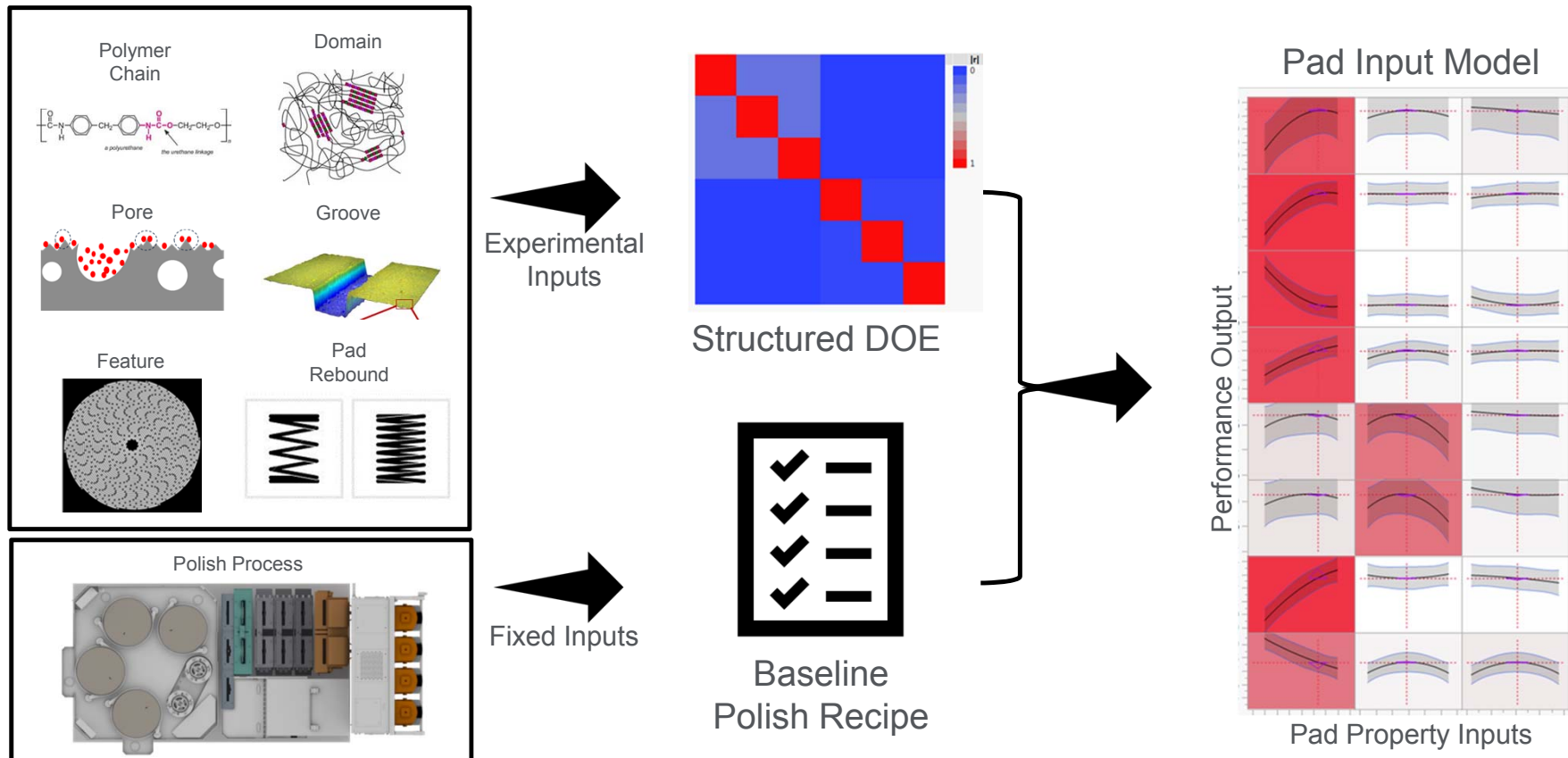


Structure/Property relationships can be deployed to design locally optimized CMP pads.

The diagram illustrates a systematic approach to optimizing pad properties for semiconductor polishing. It begins with defining **Experimental Inputs** (Polymer Chain and Domain) and **Fixed Inputs** (Pore, Groove, Feature, Pad Rebound, and Polish Process). These inputs are used to create a **Structured DOE** (Design of Experiments) matrix, which is then combined with a **Baseline Polish Recipe**. The resulting data is analyzed to produce **Performance Output**, which includes four key plots: **POLYMER FACTOR TO DEFECT**, **DOMAIN TO DEFECT**, **POLYMER FACTOR TO PLANARITY**, and **DOMAIN TO PLANARITY**. These plots show the relationship between various factors and the resulting pad properties, ultimately leading to the **Pad Property Inputs**.

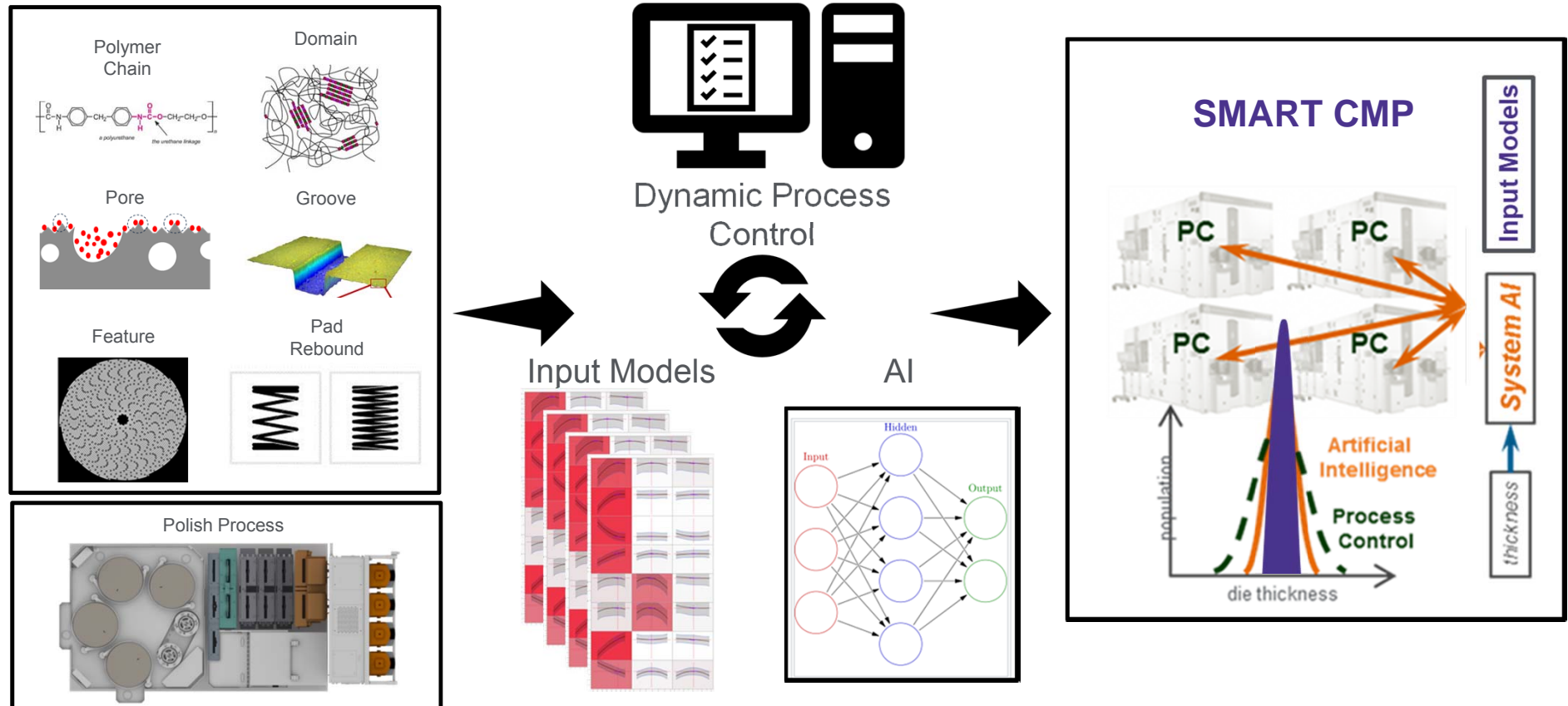
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CMP Pad Design Optimization



Rigorous Modeling efforts allow for targeted optimization of CMP Inputs and improvement to Die level Performance Outputs.

SMART CMP



SMART CMP: Input Parameter Model optimized AI deployed using Dynamic Process Control.

