Chamber Pressure Control

Yield Improvement Technology
For Semiconductor Etch
Applications

Presented by,

Martin Tollner
Snr Development Engineer
BOC Edwards (UK)

BOC EDWARDS

Introduction
Chamber Pressure Control

- Chamber Pressure Control (CPC) is an alternative to the traditional inlet throttle valve used for pressure control.

- Instead of varying the conductance between the chamber and pumping system the NEW method of CPC dynamically varies the performance of the turbo molecular pump to achieve the chamber pressure requirements of each process step.

- The CPC system uses a throttle valve located on the exhaust of the turbo molecular pump to collapse compression within the turbo pump and hence control the pressure in the process chamber.

- The first Chamber Pressure Control systems were evaluated on a LAM TCP9600SE Standalone Metal Etch Tool at a major European Fab.

CPC Key Benefits
Chamber Pressure Control

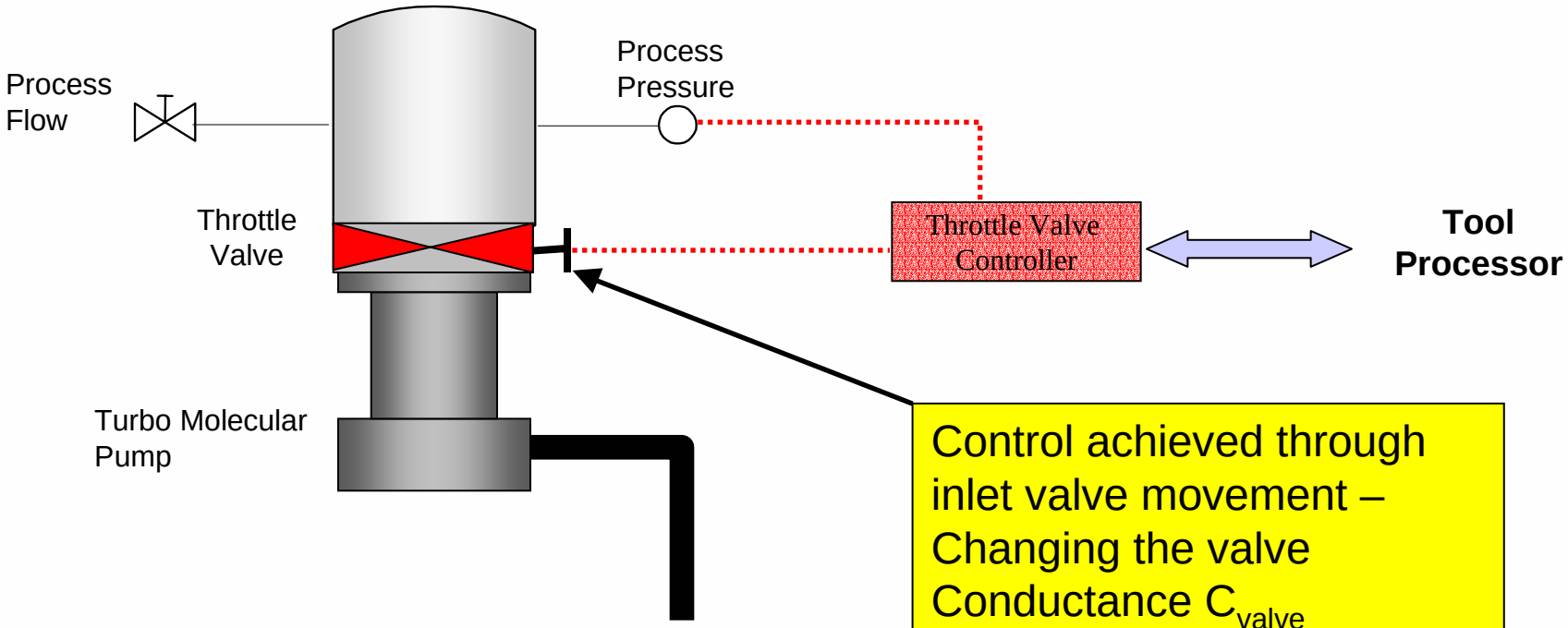
Extensive fab-based trials have demonstrated:

- **Particle Reduction**
  - -End User reported 1.5% yield improvement
- **Potential for improved etch trench geometries**
  - -Better laminar gas flow improves by-product pumping
- **Increased tool uptime**
  - -No throttle valve PM required
  - -No CPC valve PM required
- **Simple Installation**
  - -No change to cleanroom footprint
  - -No change to existing foreline and drypump arrangement.

BOC EDWARDS

Current Method of Pressure Control

Chamber Pressure Control



Control achieved through inlet valve movement – Changing the valve Conductance C_{valve}

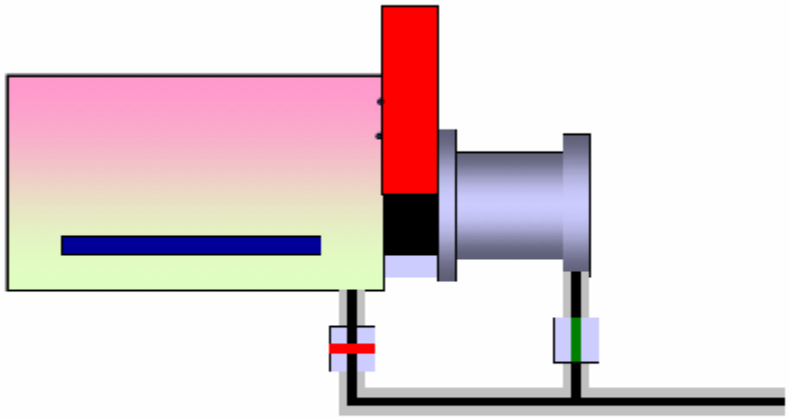
$$S_{eff} = \frac{1}{\frac{1}{S_{pump}} + \frac{1}{C_{Valve}}}$$

$$P = \frac{Q_{In}}{S_{eff}}$$

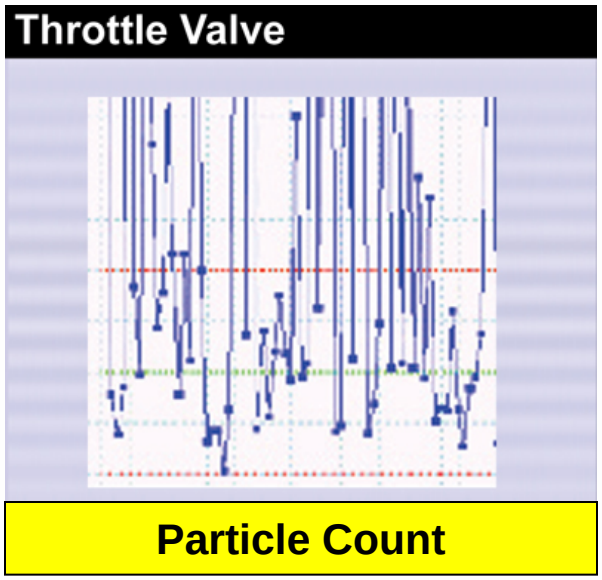
BOC EDWARDS

Problem with the Current Method

Chamber Pressure Control



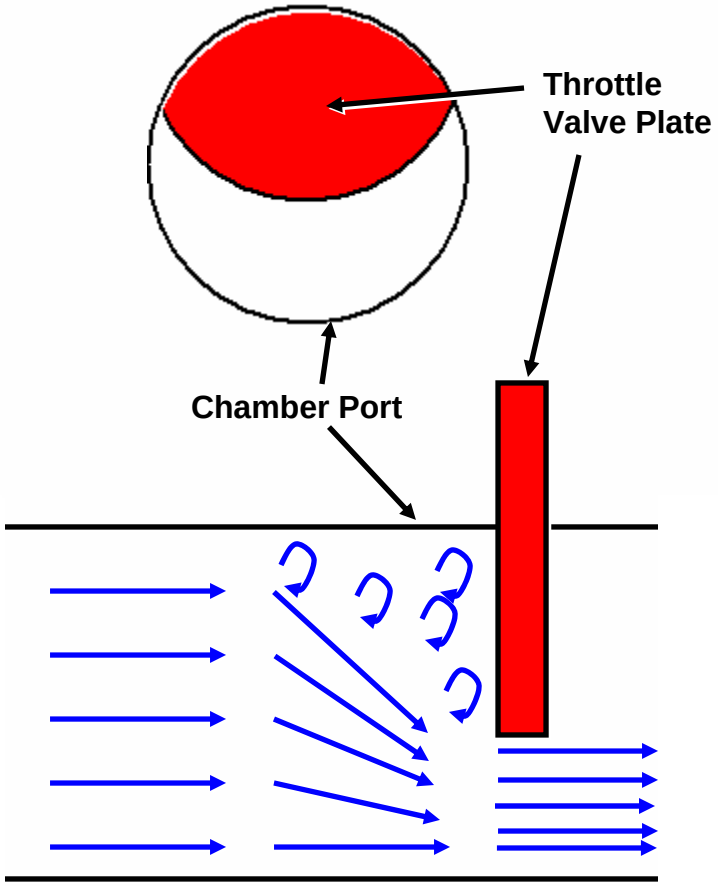
Rapid movement of Inlet valve may dislodge particulates condensed onto valve surface



- Significant and rapid inlet valve movement may be needed to control pressure in chamber particularly when plasma is struck
- This can be a source of particulate

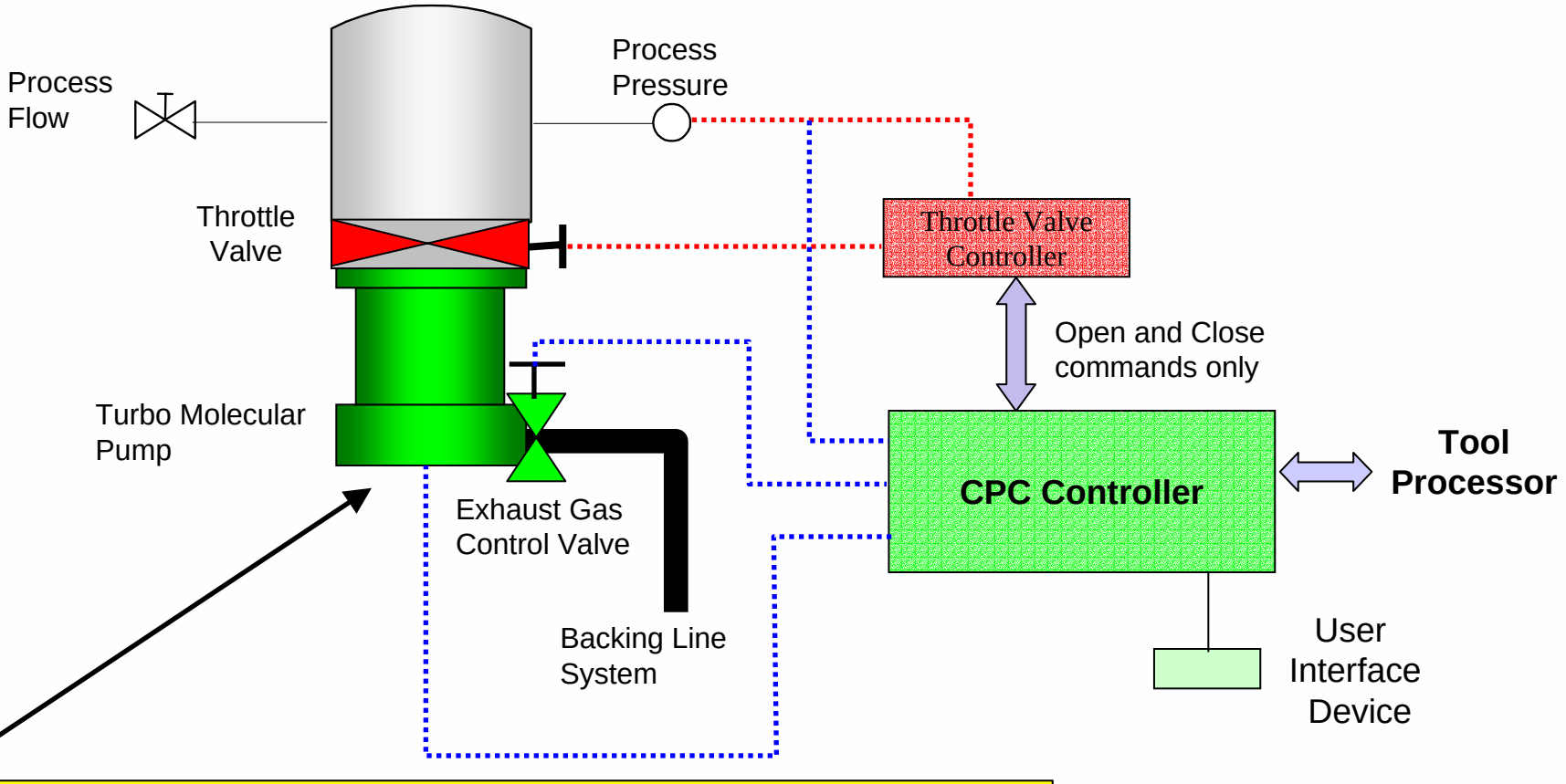
Problem with the Current Method
Chamber Pressure Control

- Due to the physical shape of the throttle valve, the throttle valve plate can cause,
  - **Non-symmetrical flow** through the chamber.
  - **Turbulent flow** in the chamber.



CPC Method of Pressure Control

Chamber Pressure Control



Control achieved through changing pumping performance

– Changing S_{pump}

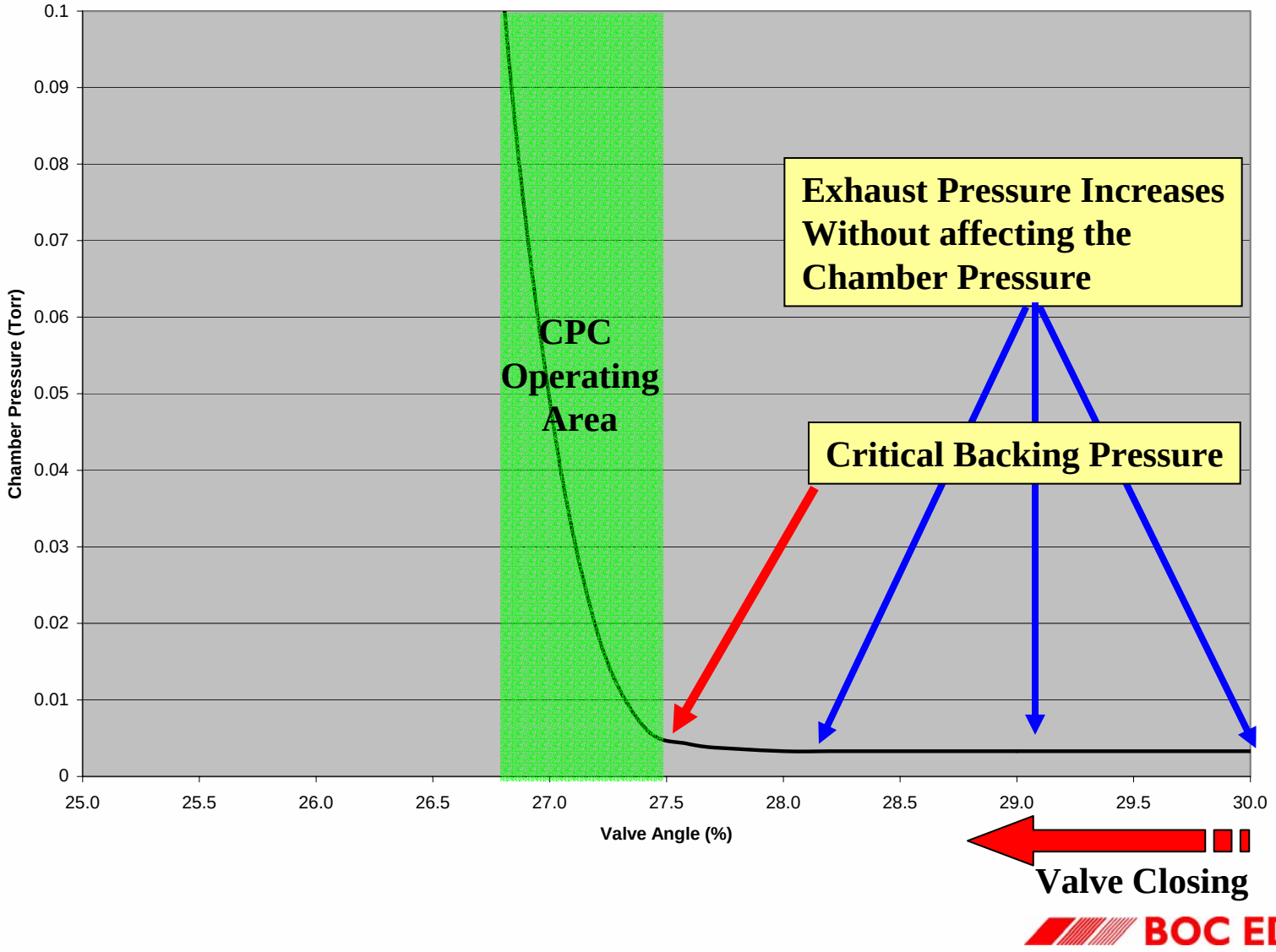
$$S_{eff} = \frac{1}{\frac{1}{S_{pump}} + \frac{1}{C_{Valve}}}$$

$$P = \frac{Q_{In}}{S_{eff}}$$

BOC EDWARDS

How Does CPC Work?

Chamber Pressure Control



BOC EDWARDS

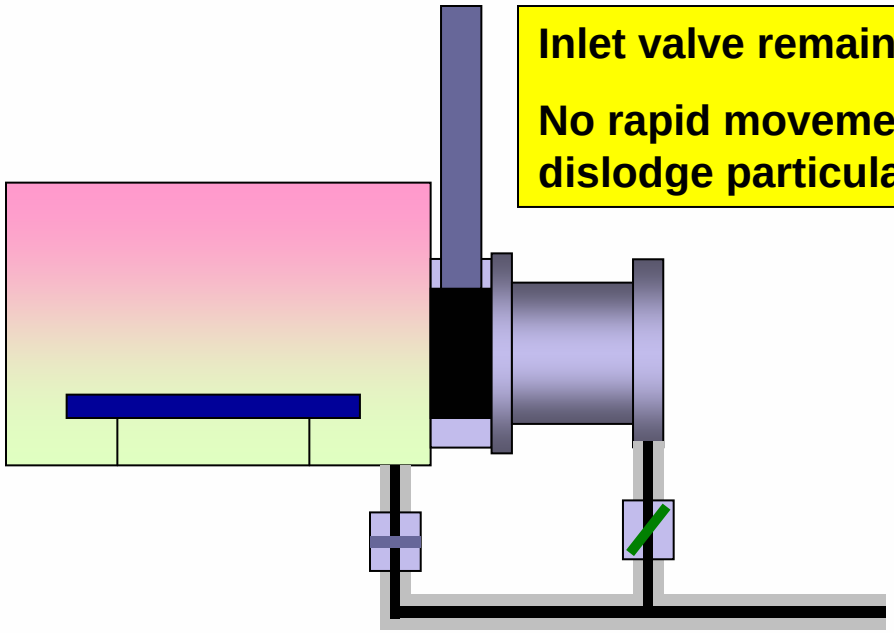
Turbo Molecular Pump Configuration
Chamber Pressure Control

- Standard BOC Edwards turbo molecular pumps are used, however the rotational speed is reduced to a fixed set value to ensure,
  - Turbo thermal stability during CPC operation
  - Exhaust pressures required do no cause process deposition issues.
- The reduction in turbo pump rotational speed allows for the CPC method to be used BUT decreases the pump performance of the system.
- To compensate for the performance loss a larger pump is selected when using the CPC method to obtain equivalent performance,

Current Pump Used	CPC Equivalent
1000l/s (STP-H1003C)	1300l/s (STP-A1303C)
1300l/s (STP-A1303C)	1600l/s (STP-A1603C)
1600l/s (STP-A1603C)	2200l/s (STP-F2203C)

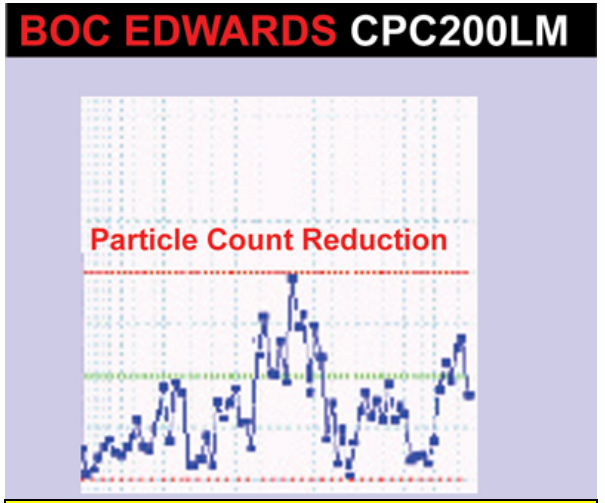
CPC Benefit – Particle Reduction

Chamber Pressure Control



Inlet valve remains open.

No rapid movement to dislodge particulate



Particle Count Reduced

Actual results from Beta site trial at major European fab

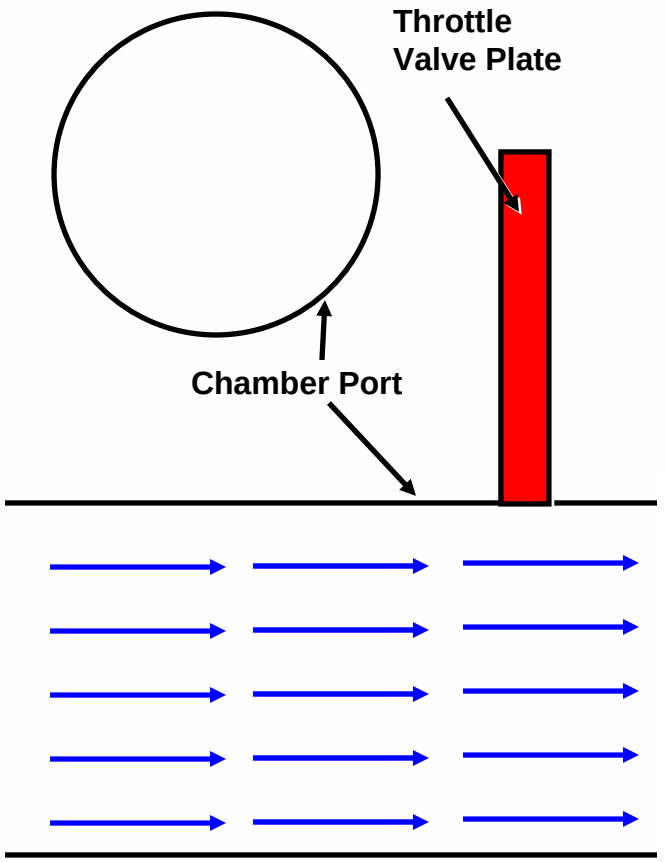
- When processing with CPC the inlet valve is fully open eliminating a source of particulate. Pressure control is achieved by controlling the performance of the turbo pump.

CPC Benefit - Improved Flow

Chamber Pressure Control

- With the throttle valve fully open the CPC method allows for,
  - **Better flow symmetry**
  - **Improved laminar flow**

- Results from CPC evaluations indicated **improvement in etch trench geometry**. Most likely due to a reduction in micro-loading as a result of improved laminar flow and by-product pumping.



CPC Benefit – Maintenance Reduction

Chamber Pressure Control

- Inlet Valve shown not to require routine maintenance
  - left in the open position during process
- CPC throttle valve shown not to require regular maintenance
  - CPC throttle valve thermally managed
  - System examined after 18 months of operation – relatively clean.
  - Turbo compression prevents particle back migration

Reduction in the occurrence of regular chamber maintenance by 38% **(based on CPC evaluation data)**

BOC EDWARDS

CPC Benefit – Ease of Installation
Chamber Pressure Control

Current System

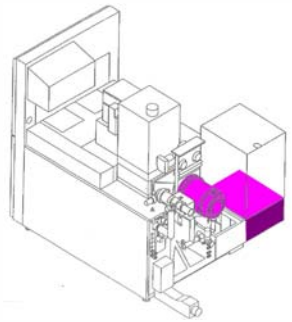
(Site Survey Required
To identify turbo pump, exhaust elbow and isolation valve configuration)

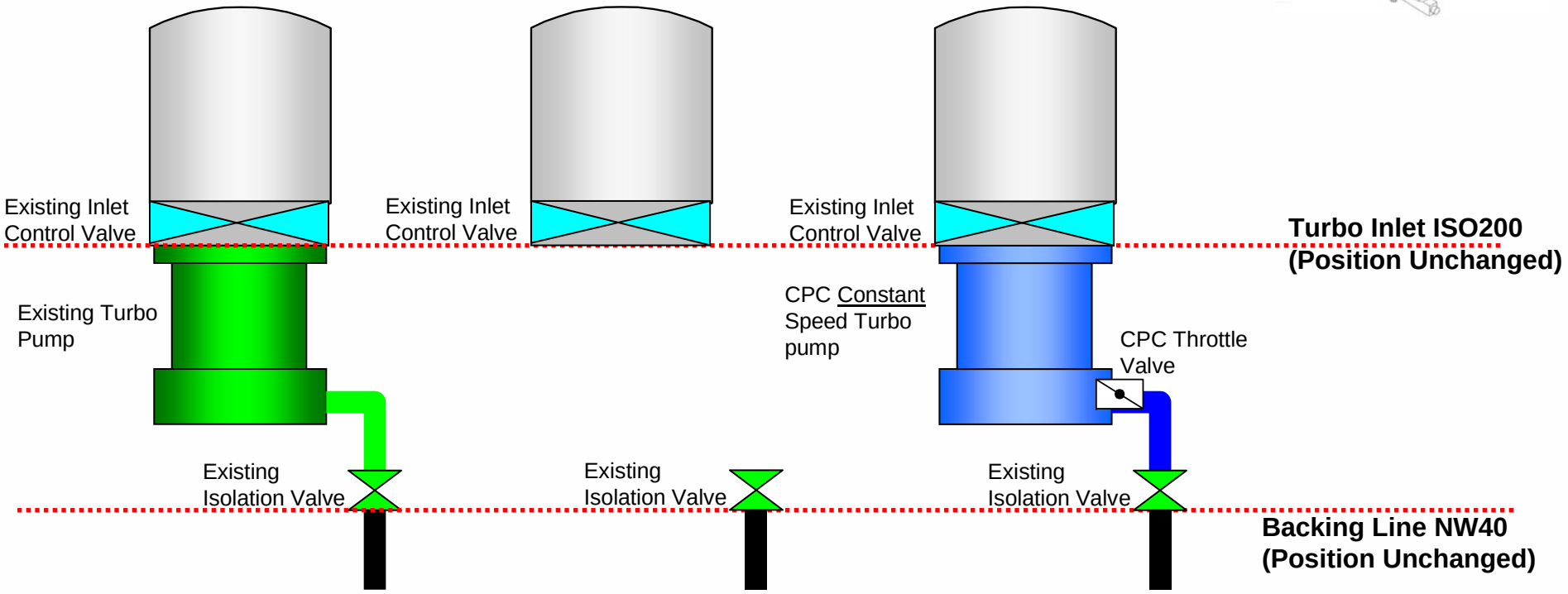
Remove Current System

(Turbo Pump and Exhaust Elbow)

CPC Installation

(Standard CPC installation kit
As per site survey results)





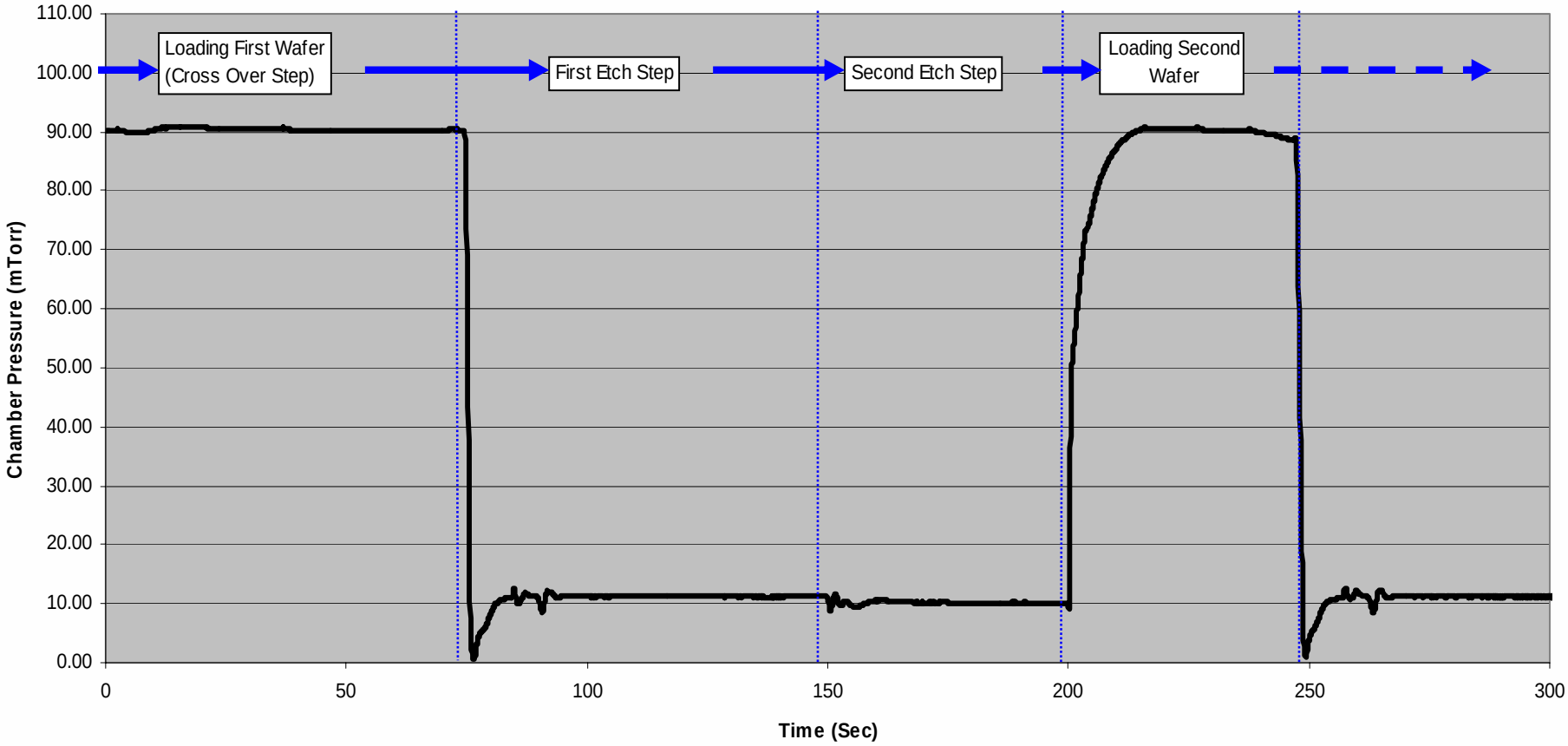
BOC EDWARDS

Process Cycle With CPC

Chamber Pressure Control

Metal Etch CPC System Pressure Response

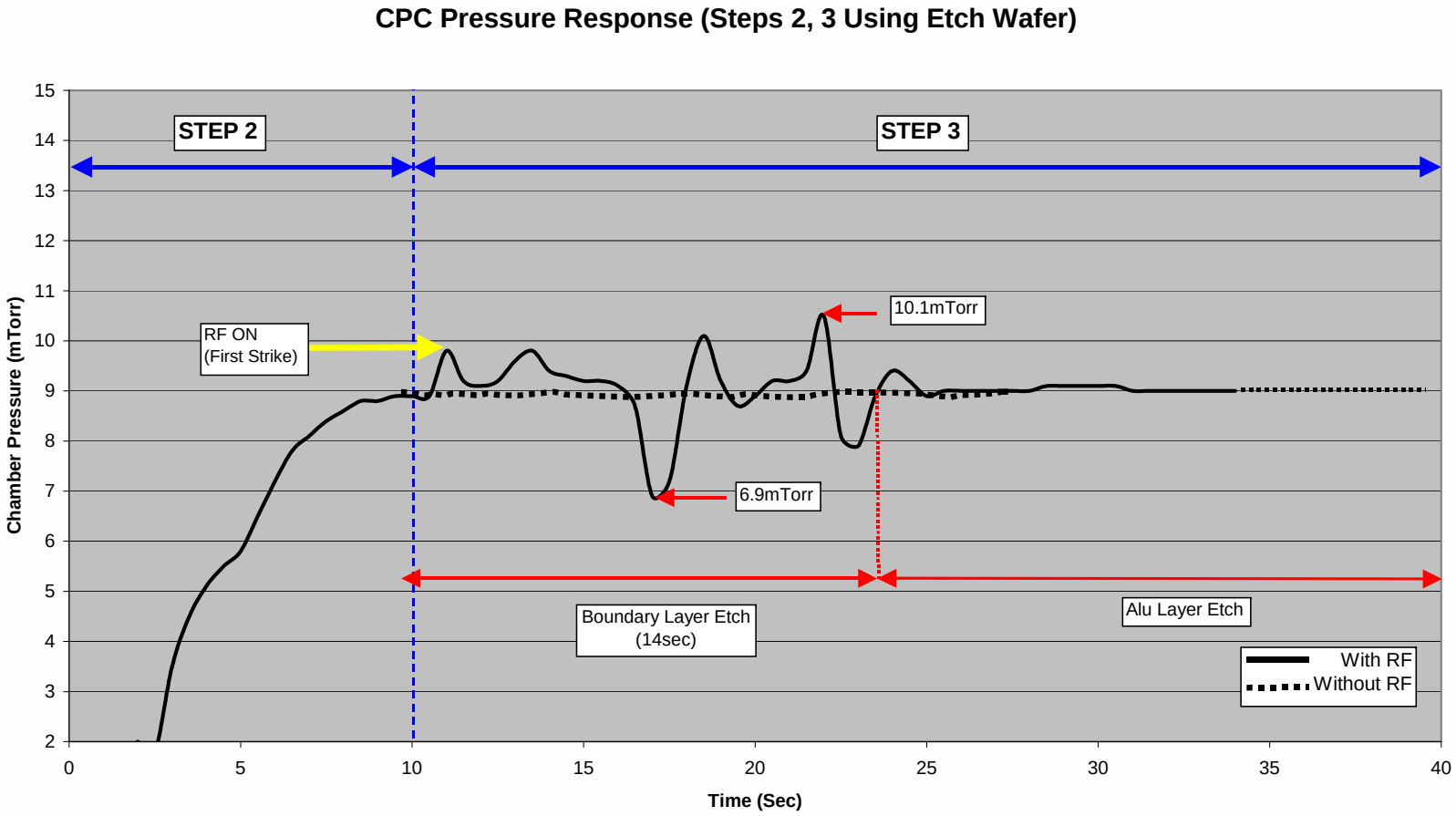
(Production Wafer)



BOC EDWARDS

CPC Response – Stability Step

Chamber Pressure Control

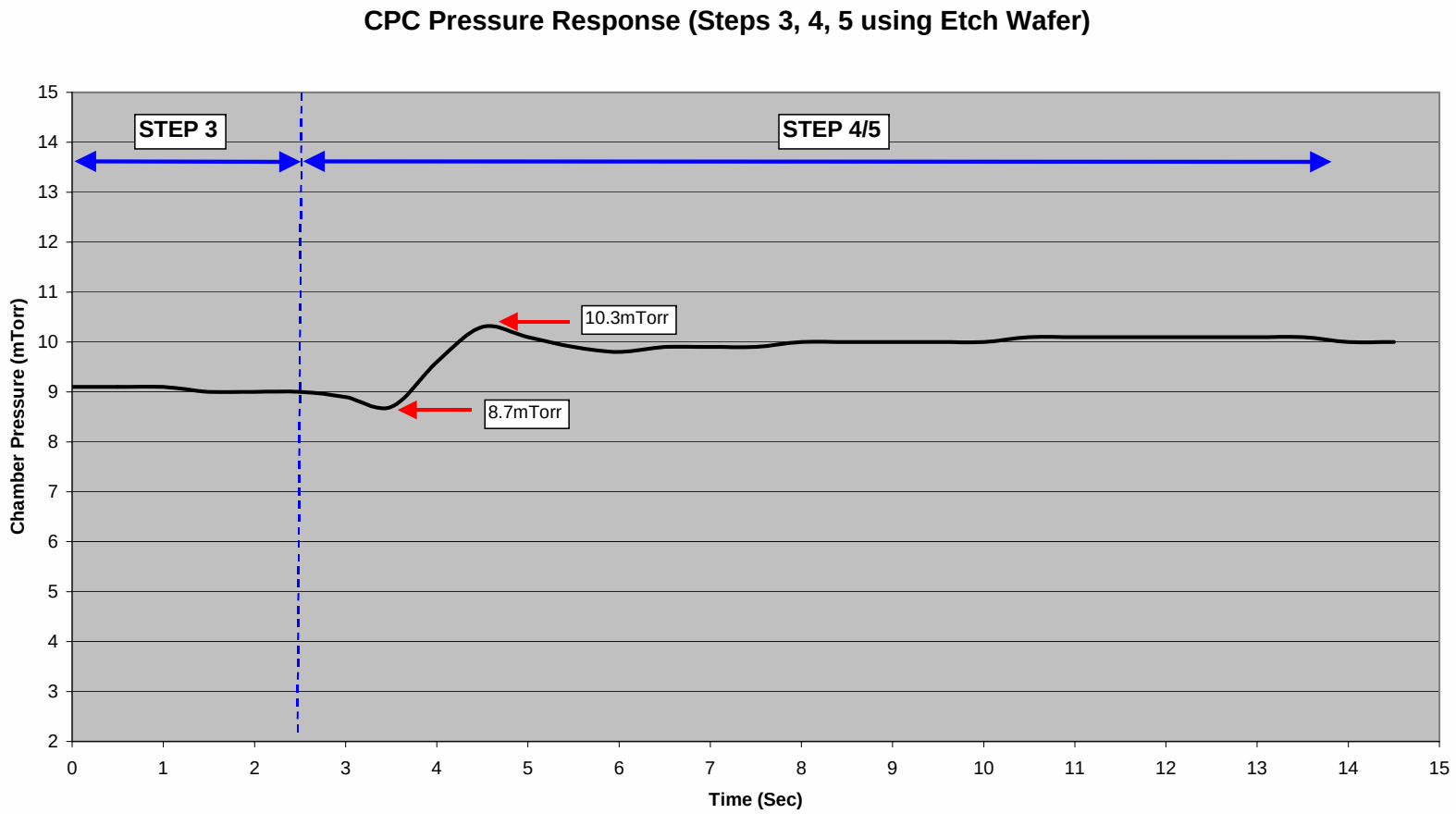


9mTorr stabilisation and etch step

BOC EDWARDS

CPC Response – Transition Step

Chamber Pressure Control



9mTorr to 10mTorr transition step

BOC EDWARDS

CPC Response Characteristics

Chamber Pressure Control

Reduced with faster valve option (Oxide/Poly Etch Requirement)

	CPC System	Requirement
Response Time (Base to Set Point)	**< 5 sec**	< 15 sec
Stability During Aluminium Etch	< 2% of set point	< 5% of set point
Stability During Boundary Layer Etch	< 22% of set point	< 25% of set point
Stability Between Pressure Set Points	< 13% of set point	< 25% of set point
Time Between Pressure Set Points	< 3 sec	< 3 sec
Plasma Strike Recovery Time	< 2 sec	< 2 sec

CPC Field Results

Chamber Pressure Control

The process results available from the following CPC systems installed on LAM TCP9600SE Standalone metal etch tools

	Alpha Site (0-8months) (Tool 7)	Current System (6 months) (Tool 7)
Area	5	5
Sum	35	50
NDD/PL	7.2	10.5
OCC	9	30

	Alpha Site (8-18months) (Tool 7)	Beta Site (0-10months) (Tool 9)	Current Average (10 months) (15 tools)
Area	2.5	2.6	3.9
Sum	22	24	45
NDD/PL	4.5	4.7	5.6
OCC	9	6	26

Area = Number particles > 1µm
Sum = Number particle > 0.2 µm
NDD/PL = number of defects/plate
OCC = Number of times tool had to be shutdown

BOC EDWARDS

Summary
Chamber Pressure Control

- The CPC method has demonstrated,
  - Similar if not better pressure control response characteristics as the current method.
  - A reduction in the number of defects and hence increase in overall yield (~1.5%) due to reduced particulate contamination.
  - An improvement in laminar flow and flow symmetry through the chamber.
  - A reduction in preventative maintenance required.