FULL WAFER CONTACT BREAKTHROUGH WITH ULTRA - HIGH PIN COUNT

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Overview

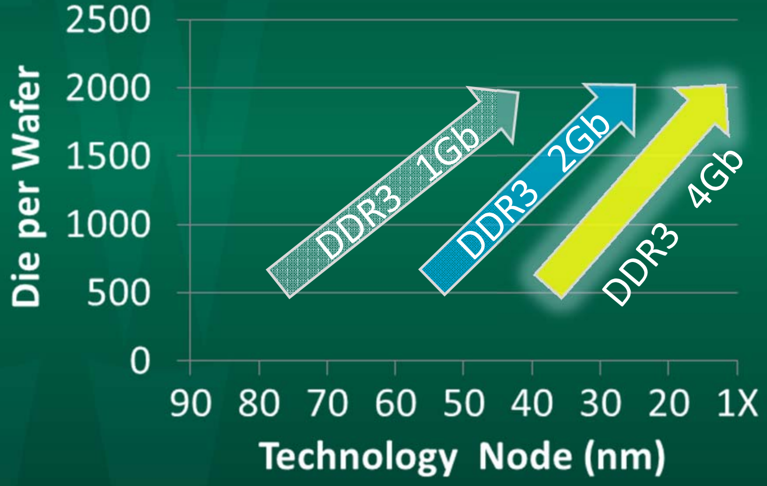
- Background
- Current Technology
- VPCS (Vacuum Probe Contact System)
  - VPCS + MEMS Probe
  - Design Considerations
- Probe card Architecture
- 1TD Contact Procedure
- Results
- Summary
- Next step

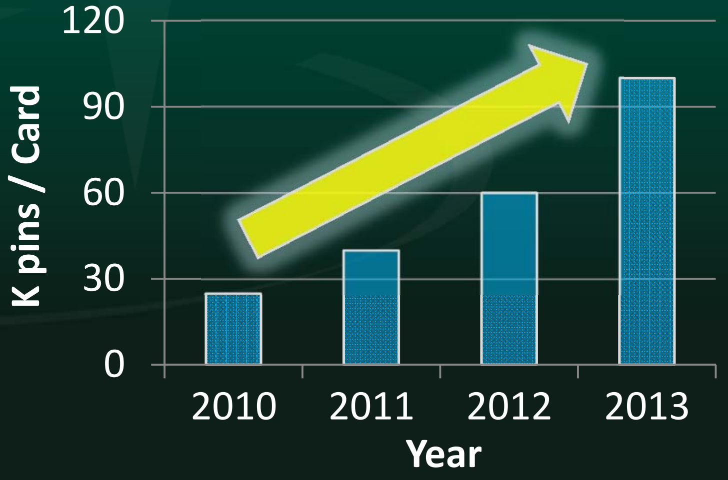
Background

- **450mm wafer is coming**
  - Increasing the number of die per wafer
  - Strong requirement to reduce test cost

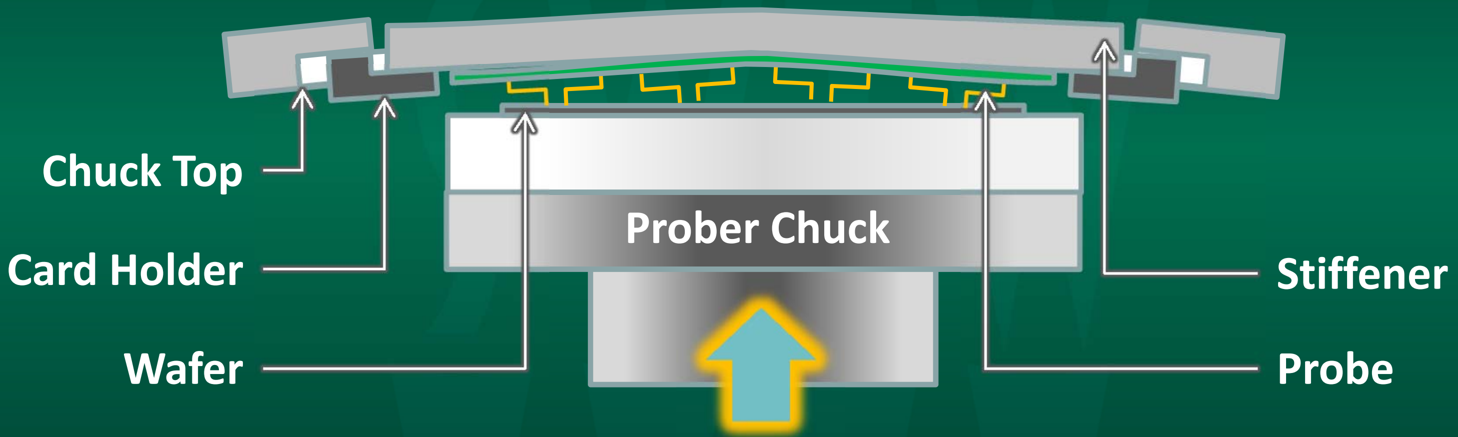
  → 1 TD test is needed

- **Requirement for 1TD test**
  - Ultra high pin count probe card & prober are needed for 450mm wafer
  - Utilize current probe card technology
    - Existing contactor
    - Similar specification to contact (force, scrub, overdrive, etc…)





Current Technology



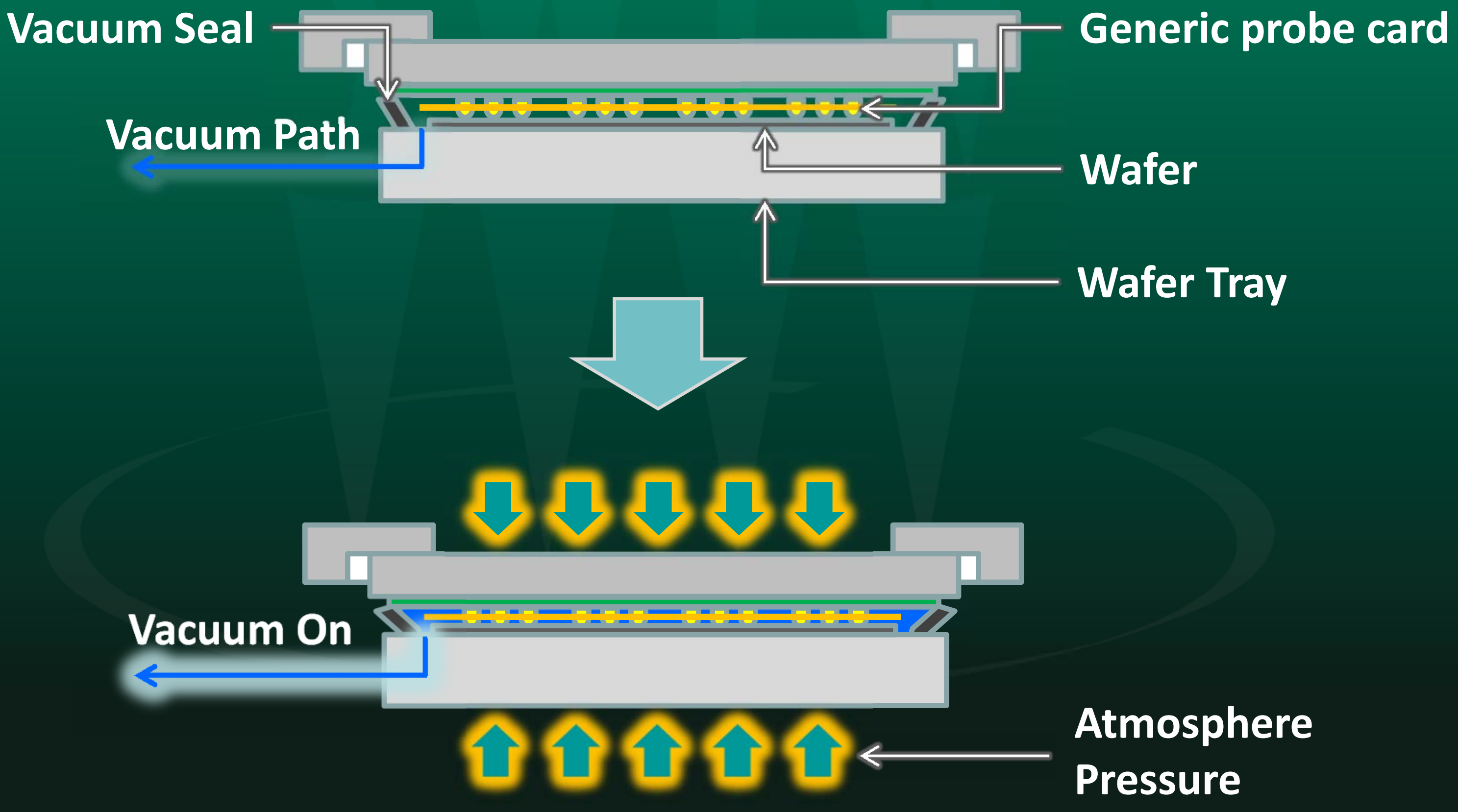
- **Ultra high contact force reaches as much as 1 ton**

•1 ton is needed, 5gF x 200K pins at 450mm wafer
  - High stiffness for prober and probe card would be needed
    - ➢ Prevent deformation
    - ➢ Maintain planarity

→ **It would be heavier, bigger, more expensive!**

VPCS “Vacuum Probe Contact System”

- Initial Concept and Architecture



Advantage of VPCS + MEMS probe

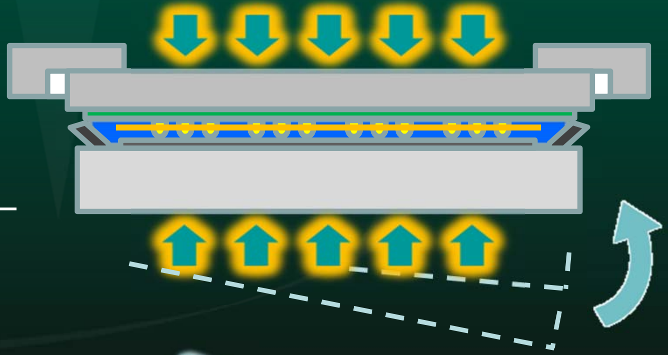
Advantages of VPCS

- Easily obtained uniform and high contact force
  - 300mm wafer 576kgF, max 120K pin
  - 450mm wafer 1,297kgF, max 260K pin

    *-80kPa, 5gf/pin

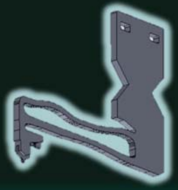
- Because pressure is uniformly distributed over the tester and the wafer sides, a high stiffness structure is not required for prober and card

- Easy coplanarity control
  - Wafer tray fit to probe card



Advantages of MEMS Probe

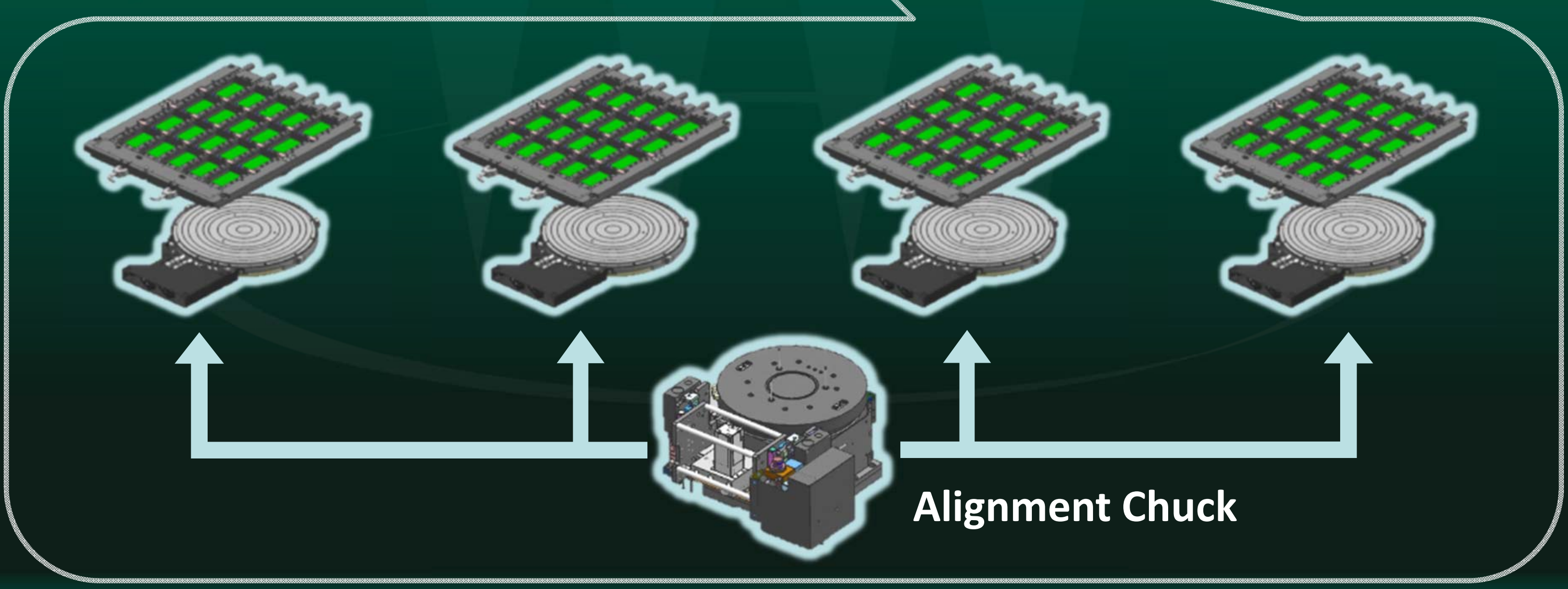
- Proven technology
  - High repeatability & manufacturing productivity



HA5100CELL (Equipped with VPCS)

All-in-one test solution

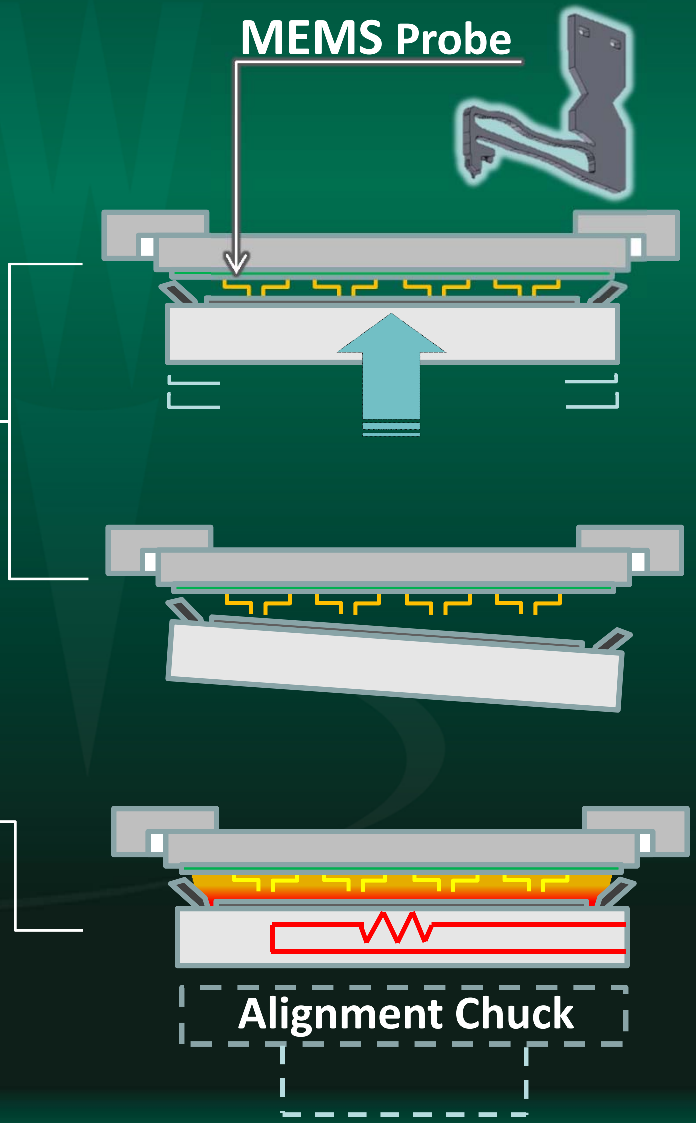
- Combines a tester and prober
- 4 wafer parallel test solution



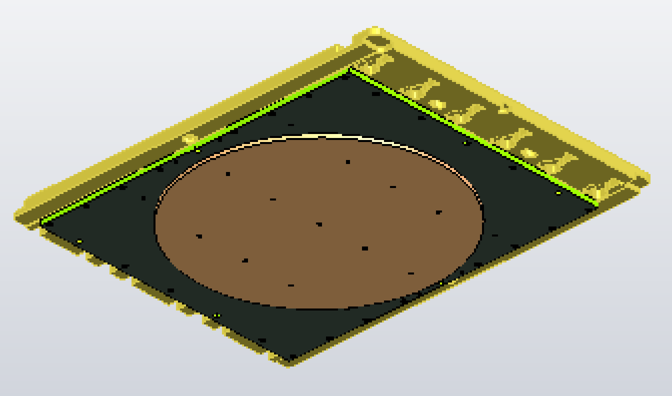
Alignment Chuck

Design Considerations

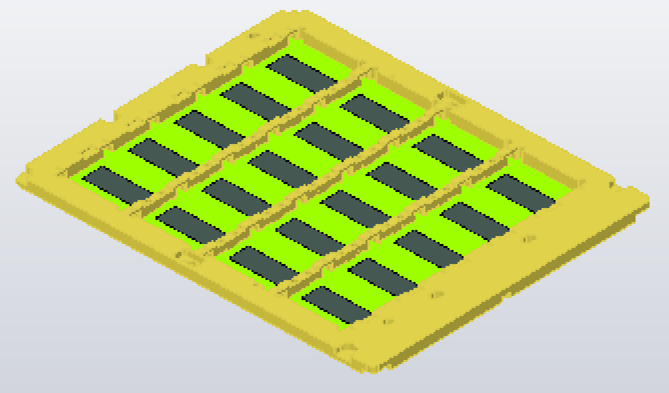
- **Vacuum-tight Control**
  - Need structure to keep it vacuum-tight
- **Overdrive & Tilt Control**
  - MEMS probe needs OD control
  - Need probe protection
  - Need structure to maintain parallelism
- **Preheat control w/o alignment chuck**
  - Before probes touch, need Hi T/Lo T preheat control



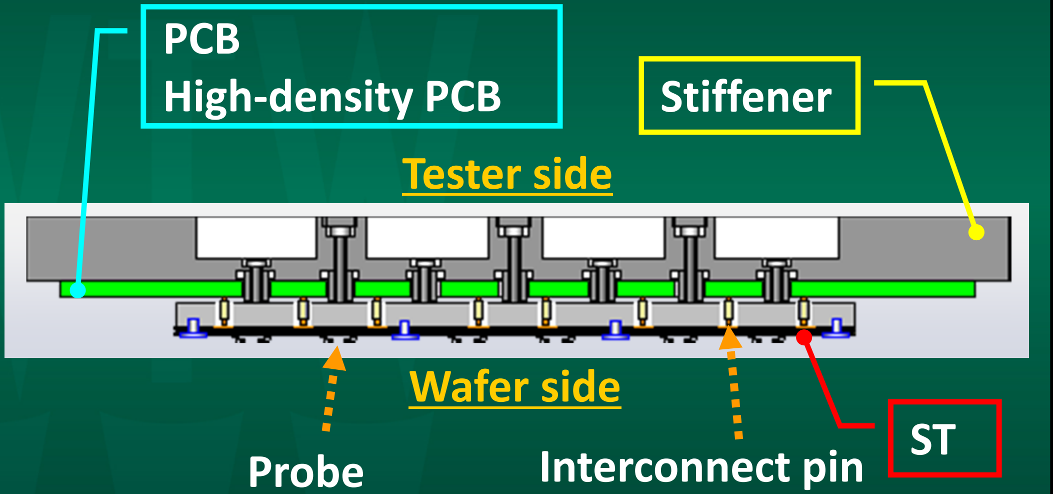
VPCS Compliant MC* Structure Outline

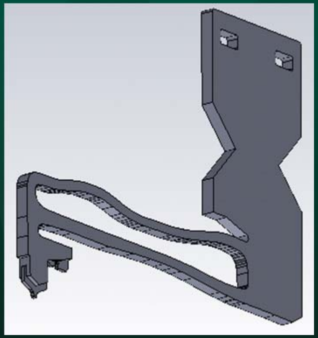


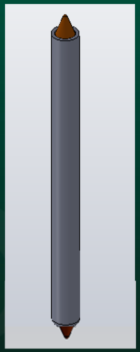
Wafer side view of probe card



Tester side view of probe card







Probe
- *MEMS-probe*
- *Low probe force*
- *Stable probe contact*

IC-Pin
- *Low load*
- *Long stroke*
- *Stable contact*

*JEM MEMS probe card

Wafer Tray Docking Issues

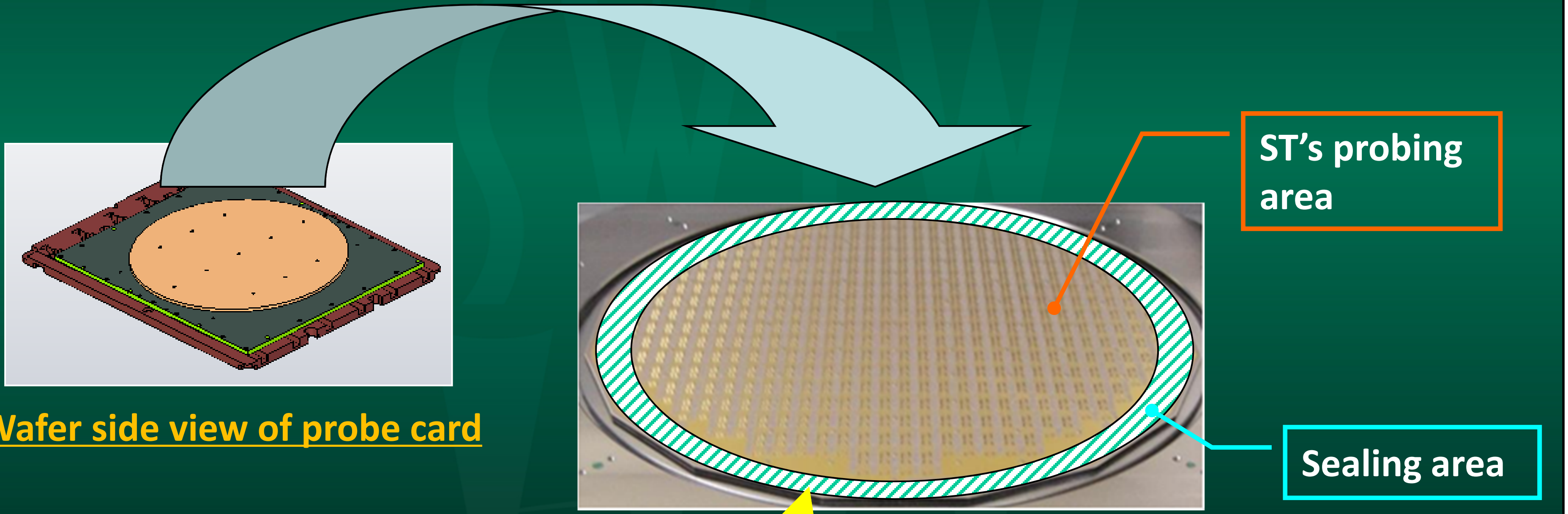
How to vacuum the wafer tray to the space transformer (ST) surface in a conventional probe card structure?

1. To maintain vacuum a wide high-precision surface is needed in the outer ST area.

2. To limit the overdrive a stopper is needed.

3. To prevent probe damage from tilt, self-leveling is needed.

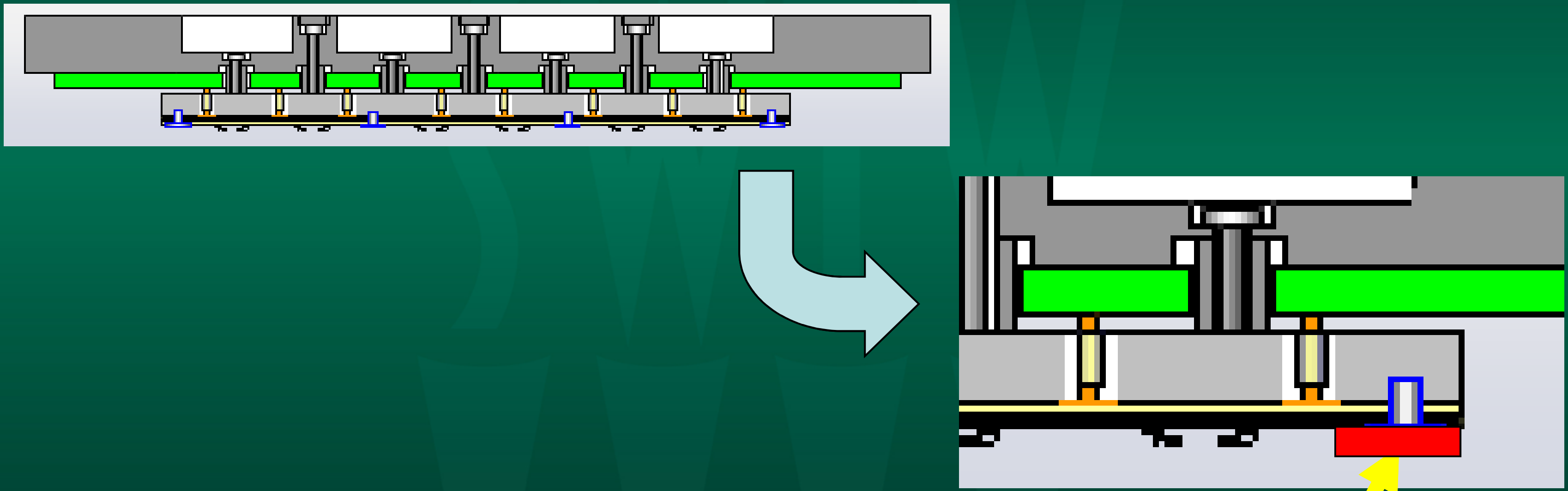
1. Secure Vacuum Tightness on ST Surface



Wafer side view of probe card

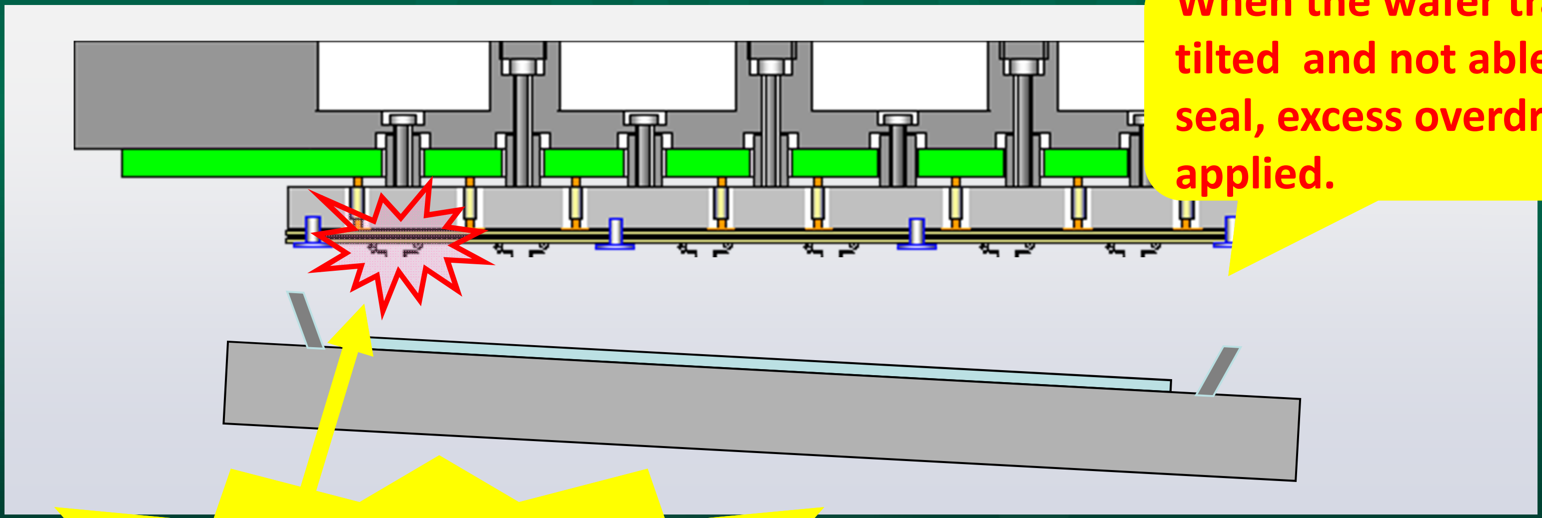
It is difficult to have a secure wide area for vacuum tight in the outer area of the ST surface.

2. Probe Protection



It is difficult to mount a stopper on the ST surface

3. Tilt of the probe & wafer tray

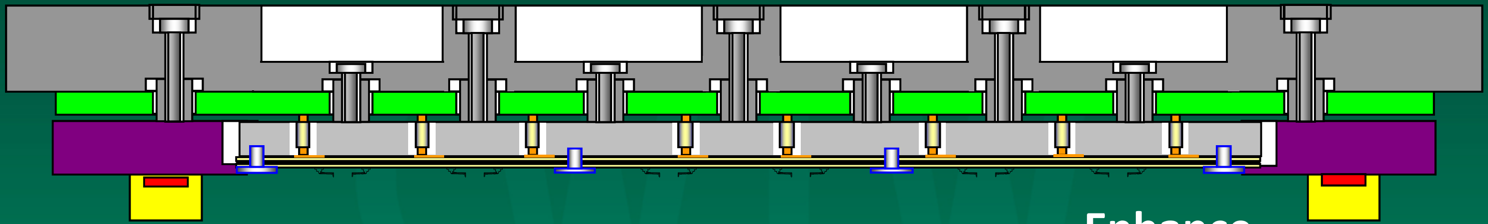


When the wafer tray is tilted and not able to seal, excess overdrive is applied.

Excess OD might damage the probe.

How do we resolve these issues?

Introducing the Unit Holder

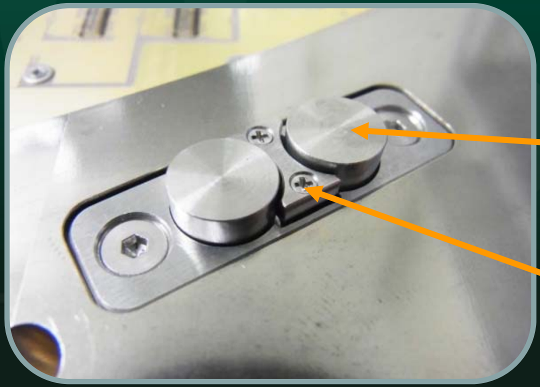


1. Polished fabrication on sealing area
 → Secure vacuum tightness

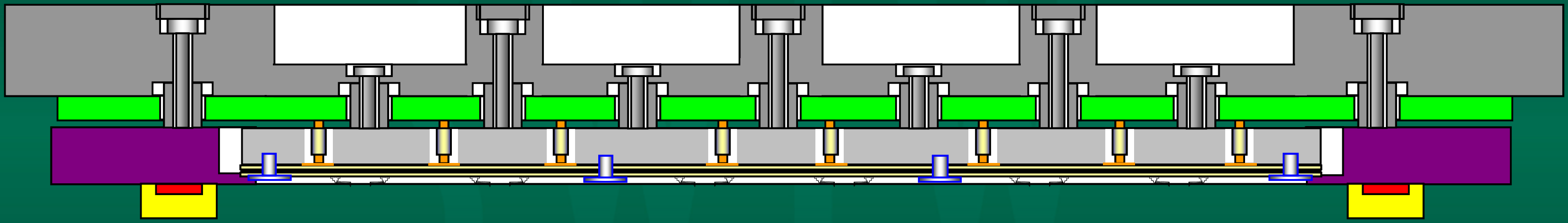
Flatness fabrication of the holder surface

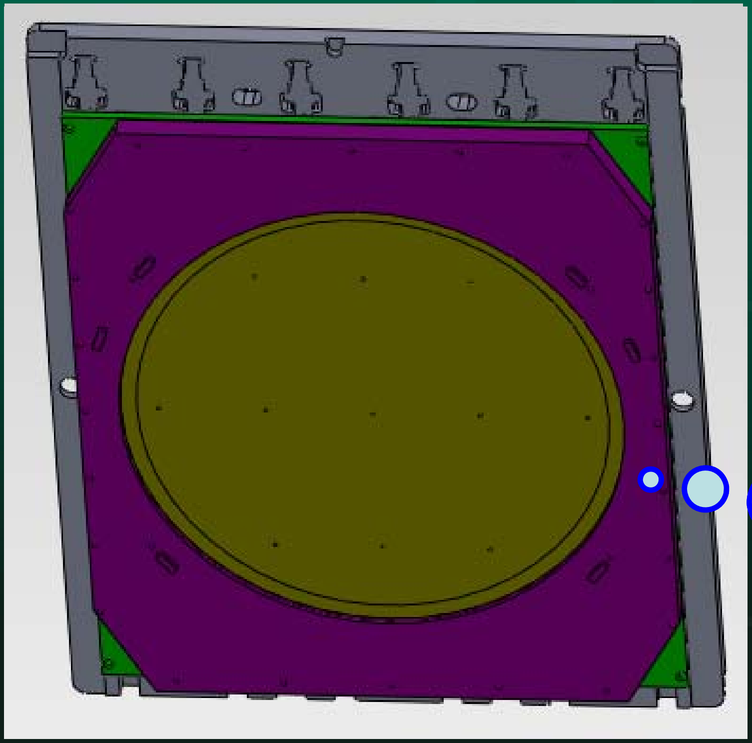
2. Mounting stopper
 → Achieve probe protection

3. Mounting pre-load spring
 → Tilt control of the card & wafer Tray
 → Stable contact



Probe Protection

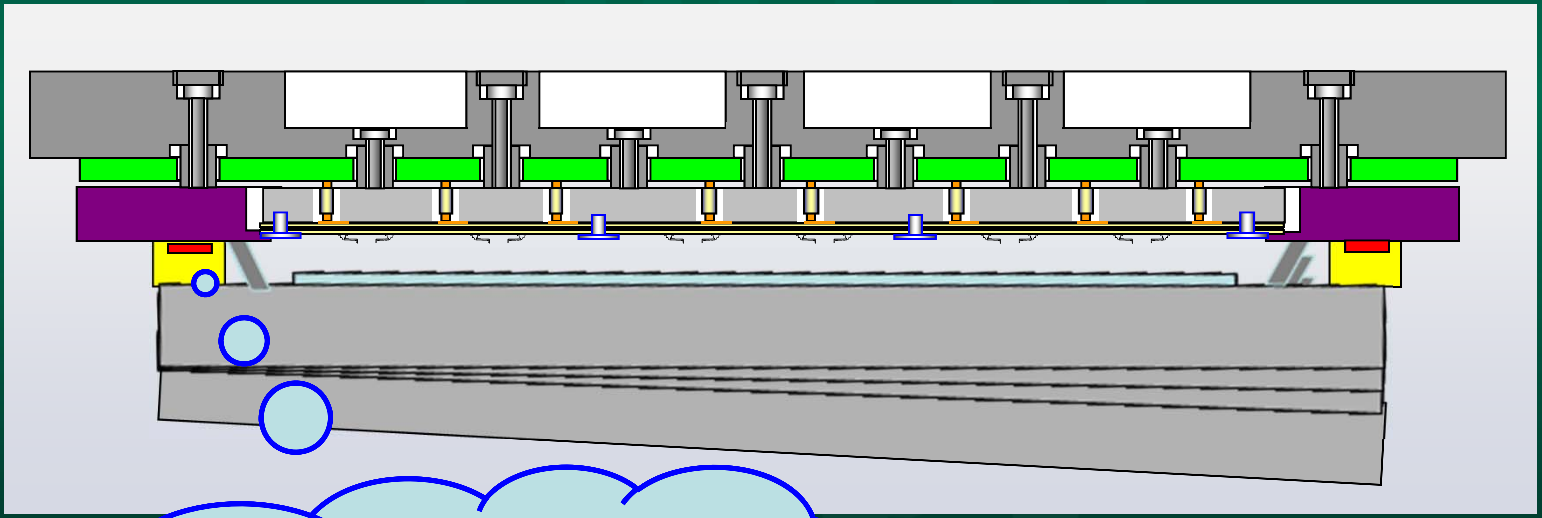




Wafer side view

Incorporate the stopper onto a unit holder which will secure the sealing area and is able to mount the stopper.

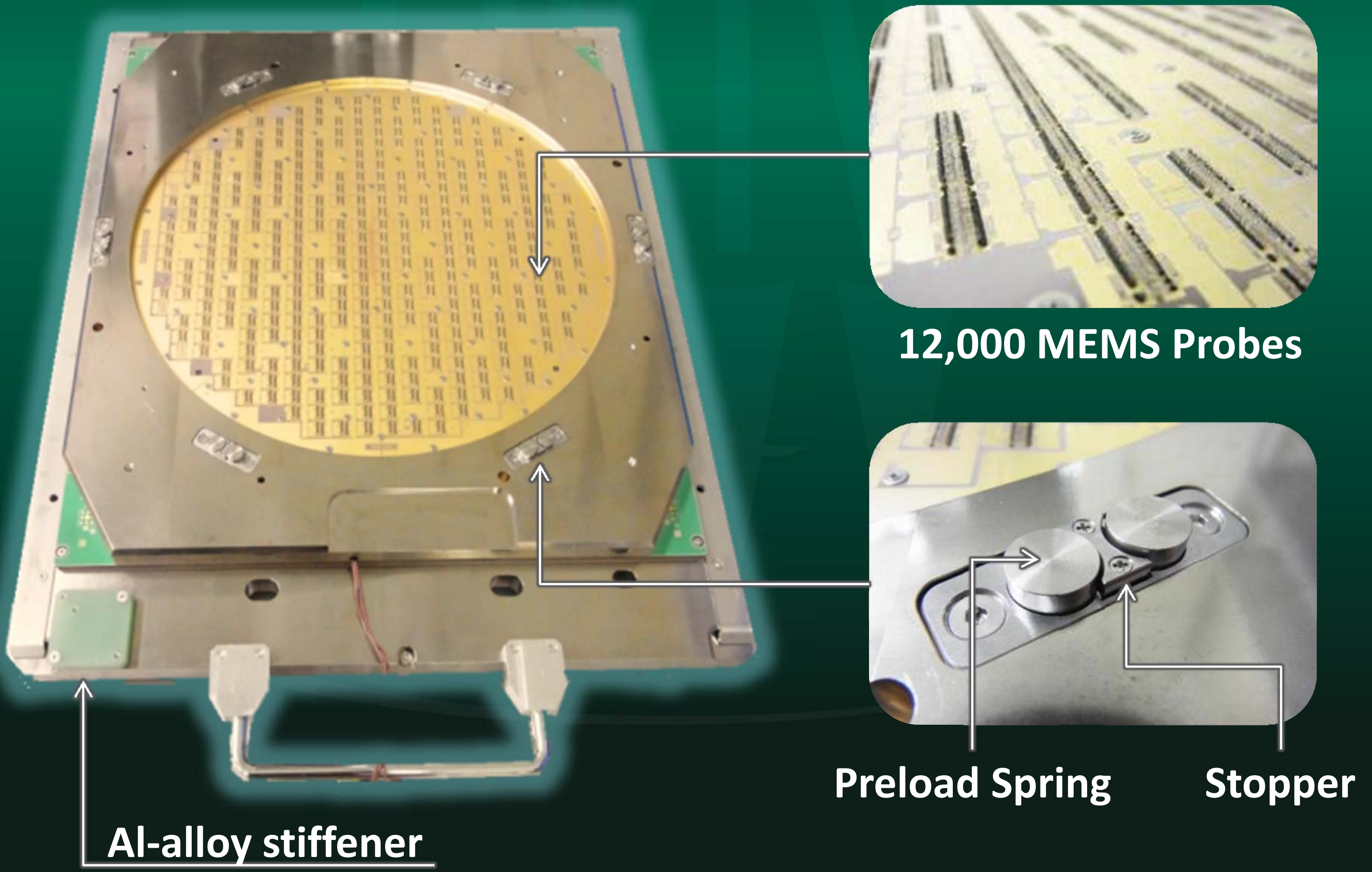
Tilt Control



Using reaction force of the preload spring's stroke movement will correct the tilt of the wafer tray.

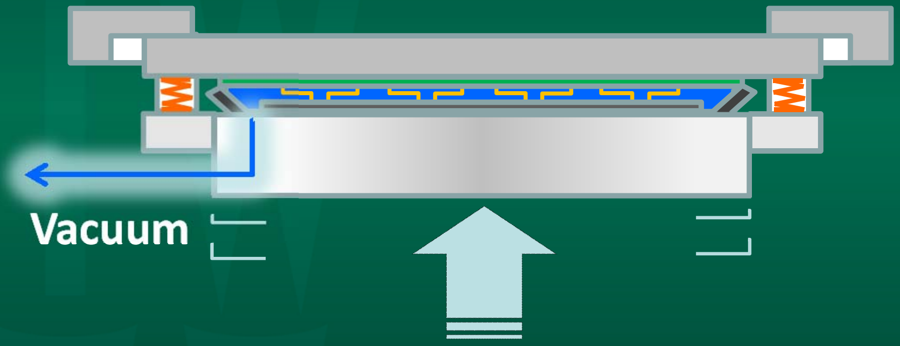
Structure of MEMS Probe Card

300mm VPCS + MEMS Probe

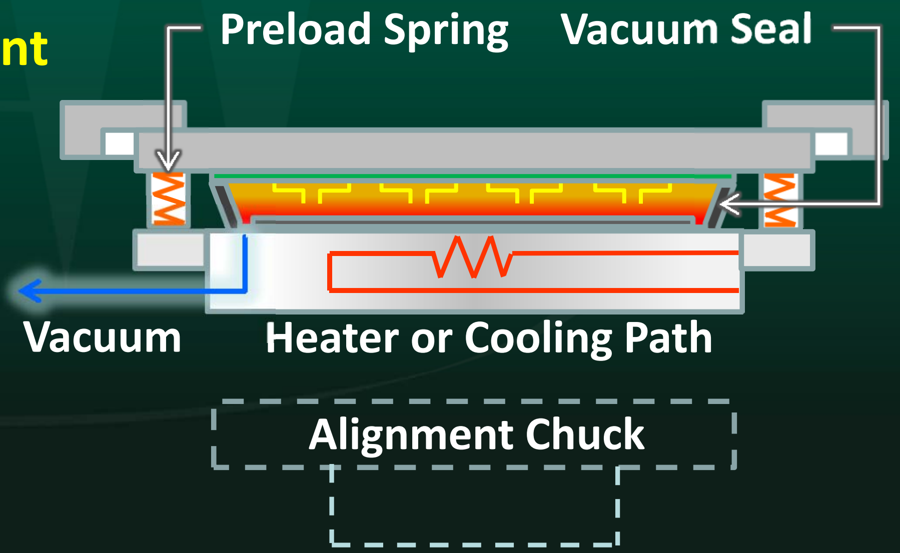


Preheat & Overdrive Control Method

- **Overdrive Control**
  - Probe overdrive is controlled by precise vacuum pressure control

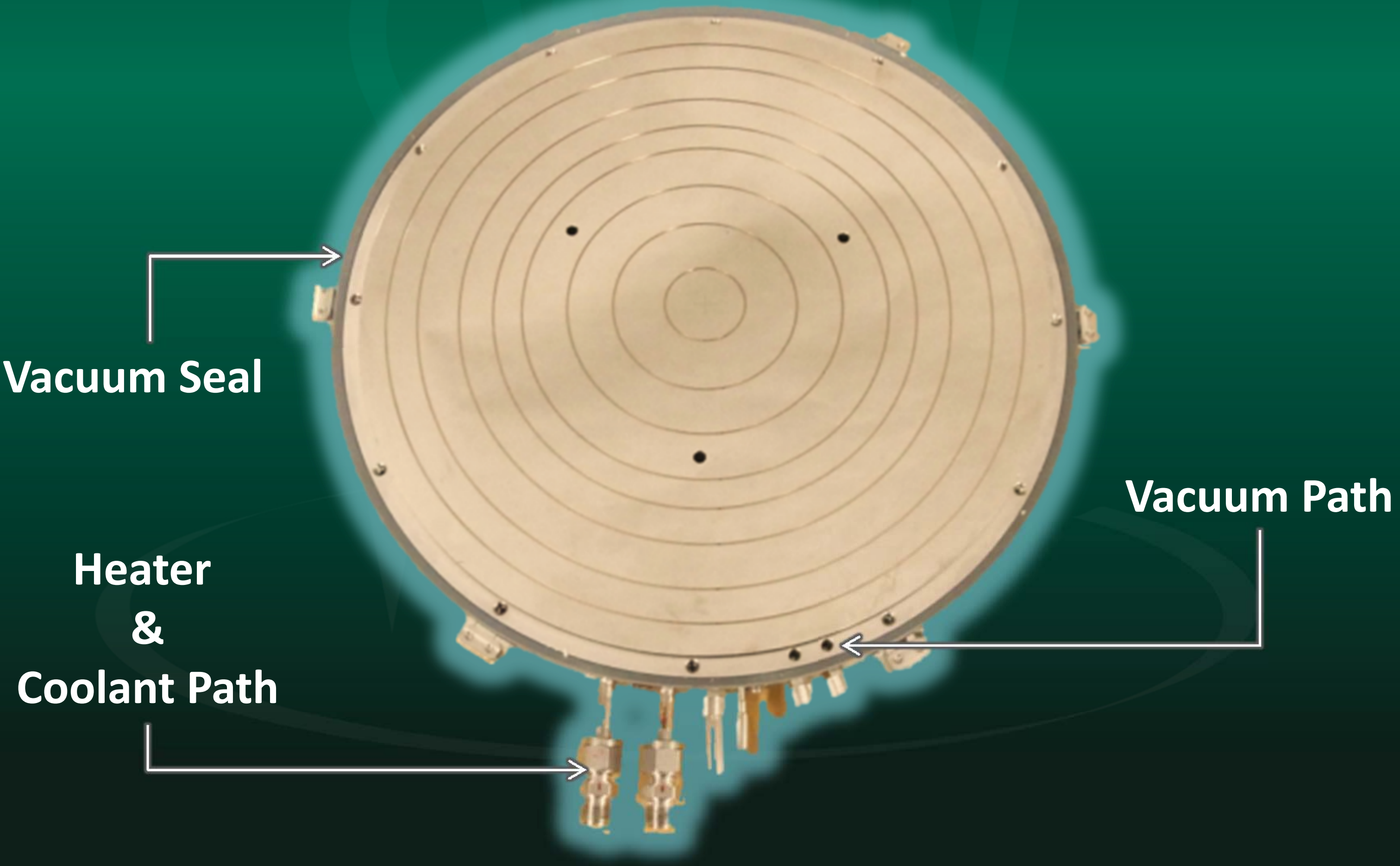


- **Preheat Control without an alignment chuck before probes touch**
  - Spring F >
    Vacuum F - Wafer tray weight
  - Hi T/Lo T preheat control without alignment chuck is possible

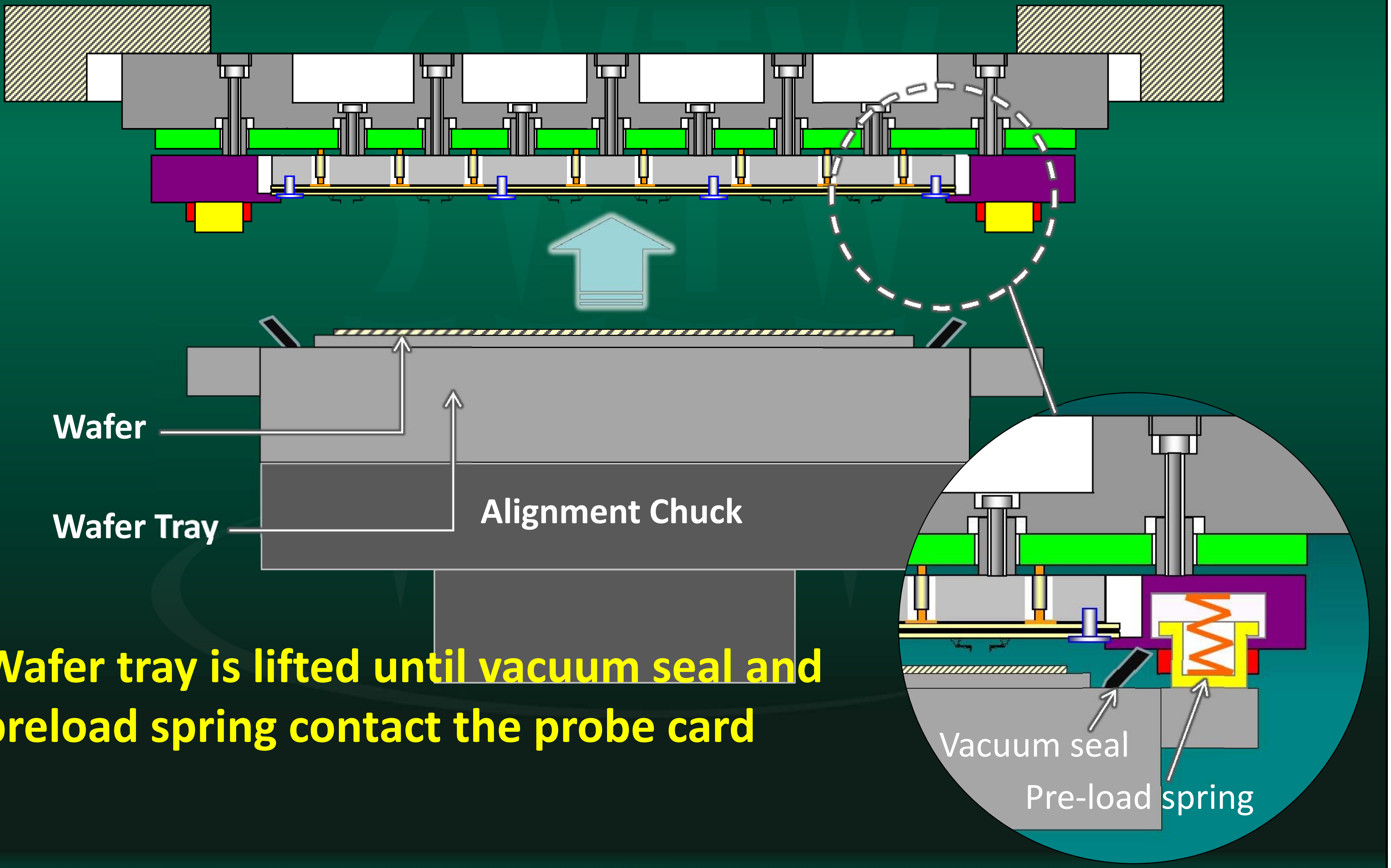


Structure of Wafer tray

300mm VPCS + MEMS Probe

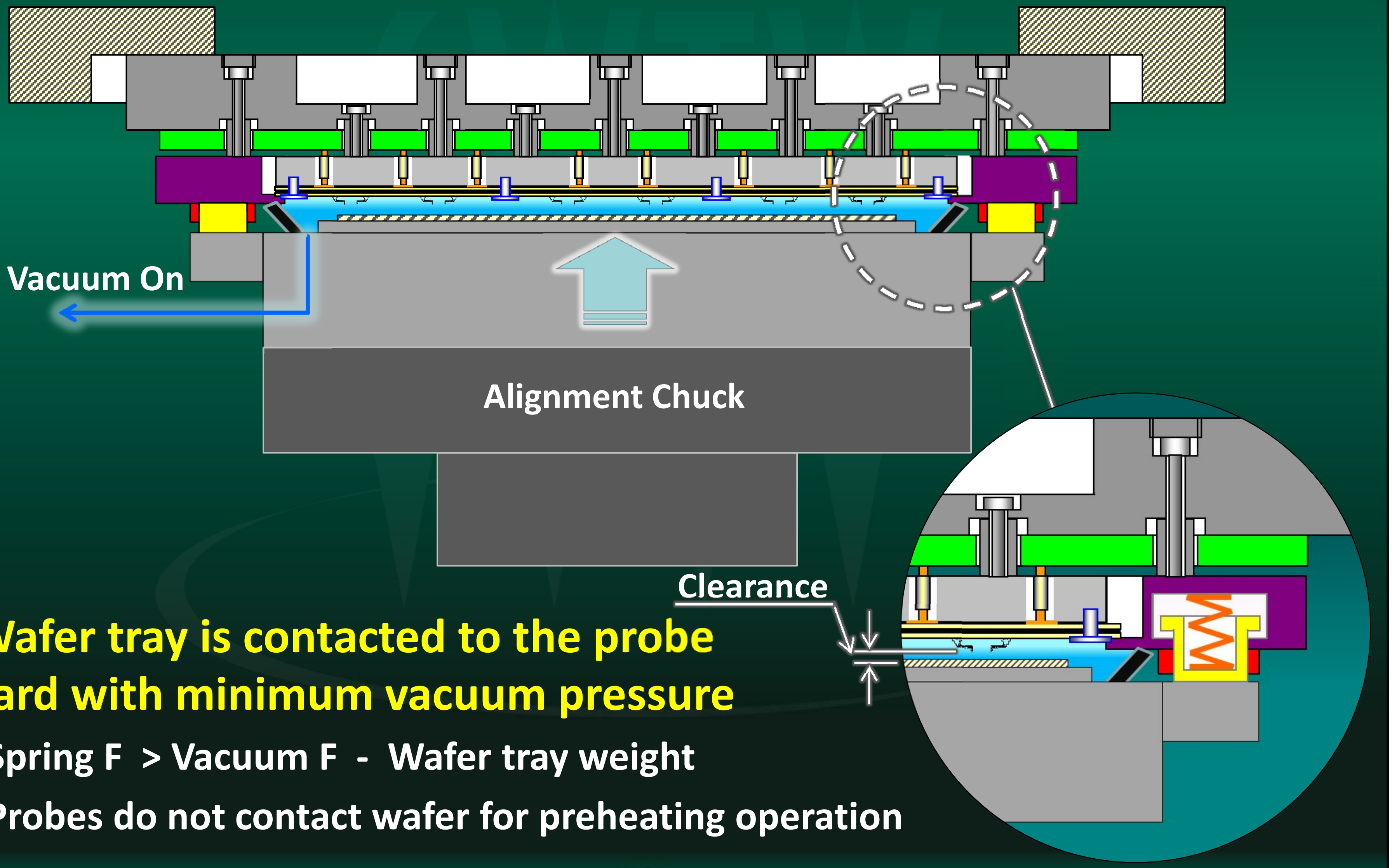


1TD Contact Procedure（1/4）



Wafer tray is lifted until vacuum seal and preload spring contact the probe card

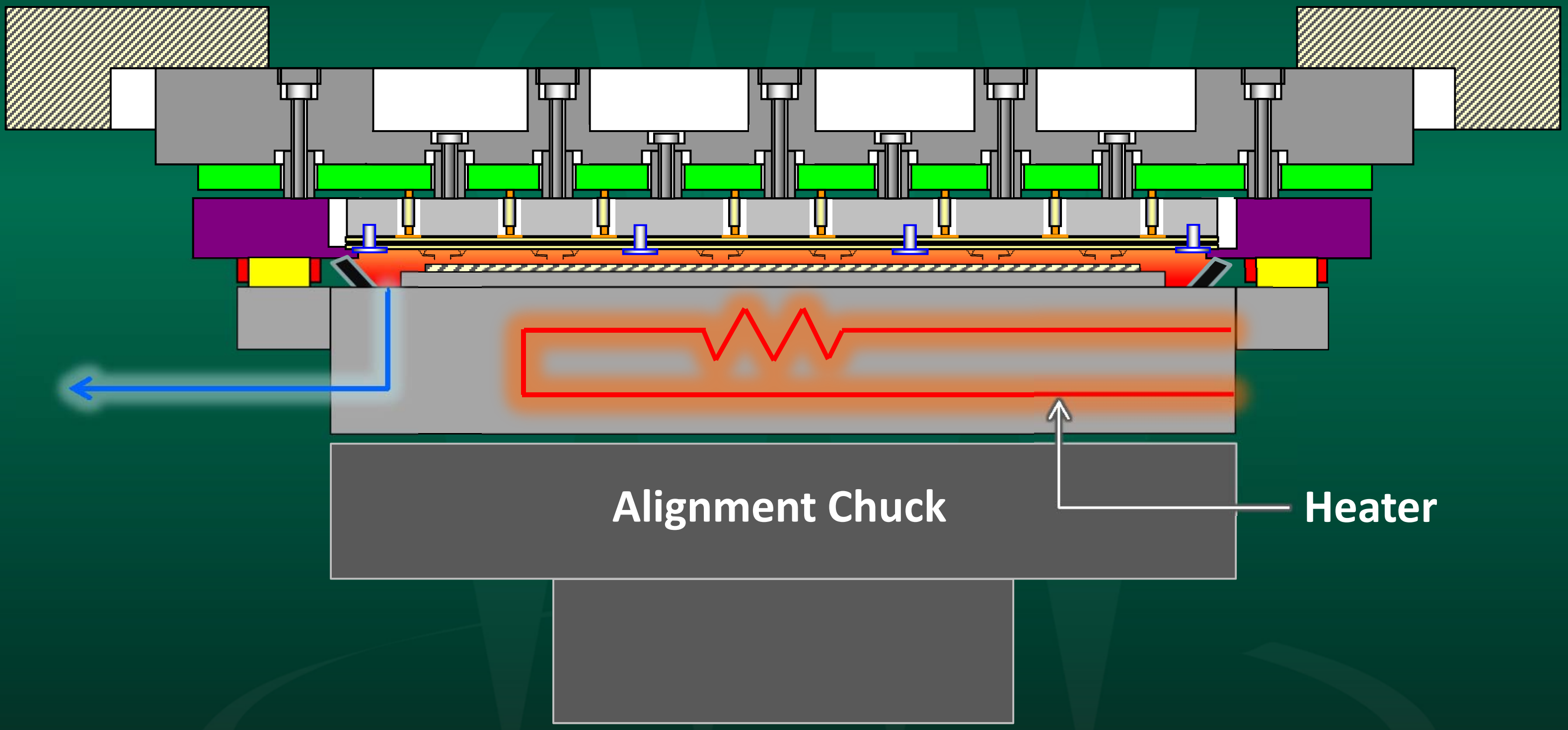
1TD Contact Procedure（2/4）



Wafer tray is contacted to the probe card with minimum vacuum pressure

- Spring F > Vacuum F - Wafer tray weight
- Probes do not contact wafer for preheating operation

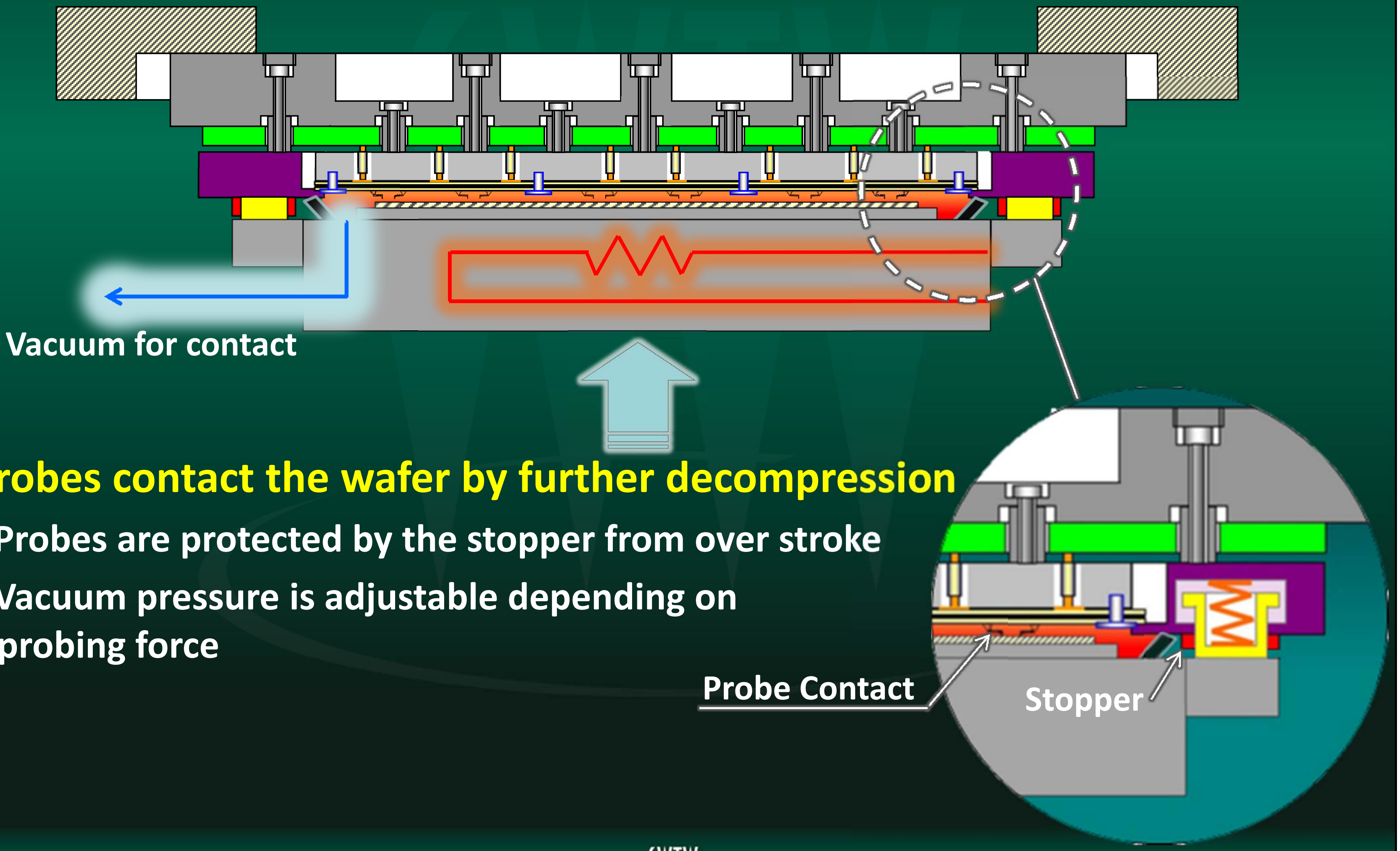
1TD Contact Procedure（3/4）



Probe card is preheated by the heater installed in the wafer tray

- Probes do not contact the wafer
- Wafer tray is contacted to the probe card with minimum vacuum pressure

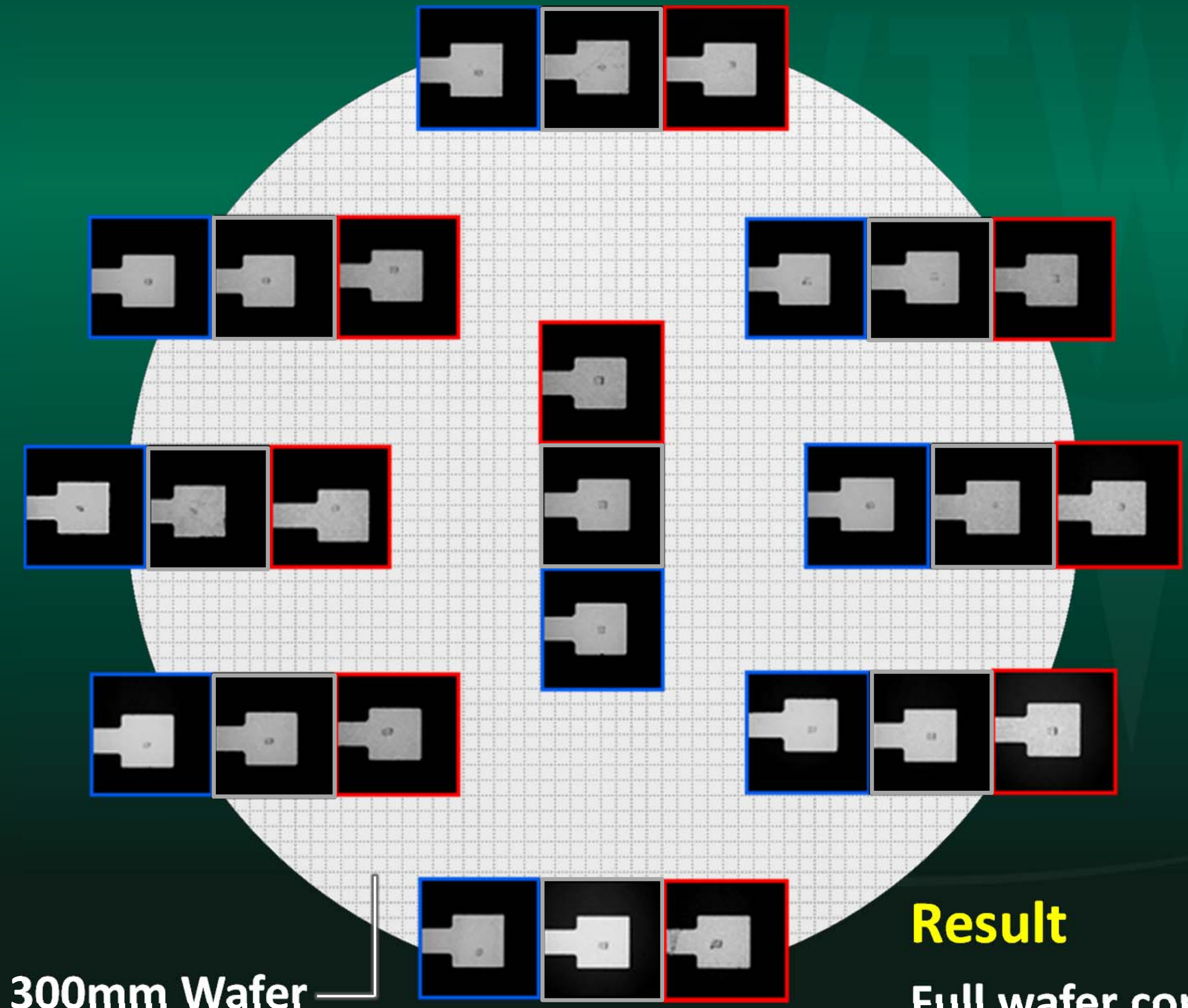
1TD Contact Procedure（4/4）



Probes contact the wafer by further decompression

- Probes are protected by the stopper from over stroke
- Vacuum pressure is adjustable depending on probing force

Scrub Mark

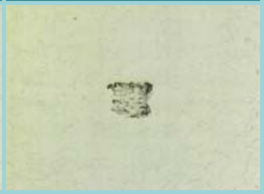
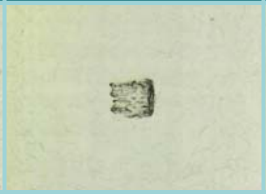
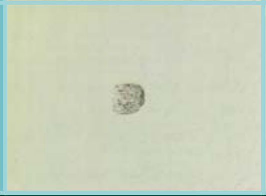
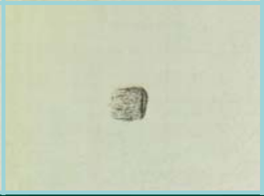
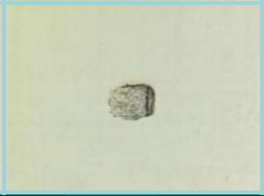
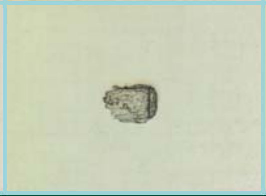
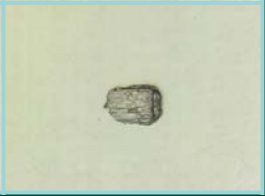


12,000pin
at -12.3kPa

Result

Full wafer contact has been achieved

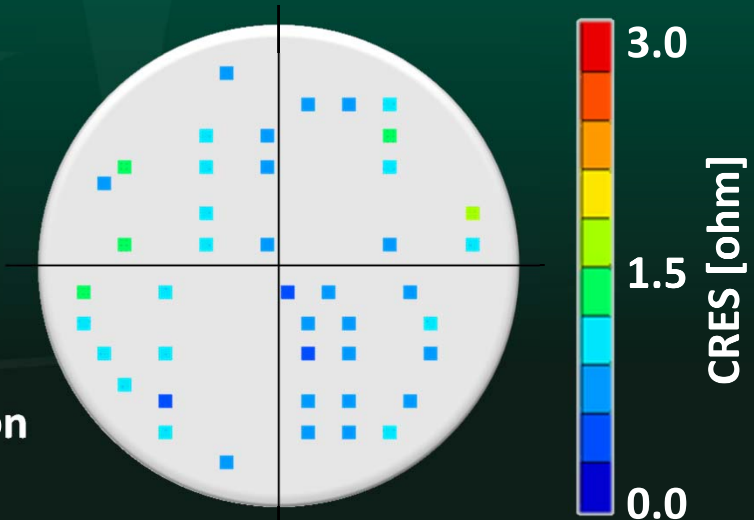
Overdrive Control & CRES (Ambient)

OD	20µm (-5.5kpa)	40µm (-7.2kPa)	60µm (-8.9kPa)	80µm (-10.6kPa)	100µm (-12.3kPa)
VPCS					
Prober					

Results

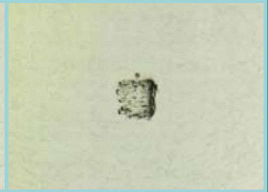
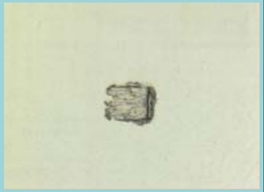
- Proved that the same OD control as a prober is possible with VPCS
- CRES < 1.8 ohm

*Cres is the path resistance including connection from interposer to the probe tip



Measurement location

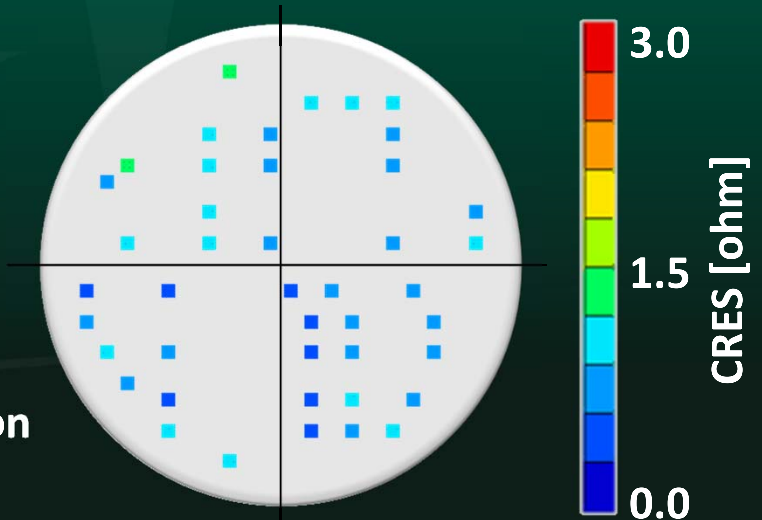
Overdrive Control & CRES (85deg C)

OD	20µm (-5.5kpa)	40µm (-7.2kPa)	60µm (-8.9kPa)	80µm (-10.6kPa)	100µm (-12.3kPa)
VPCS					
Prober					

Results

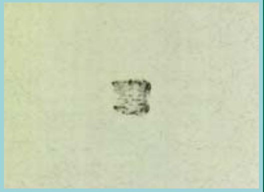
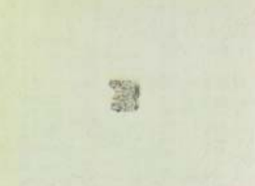
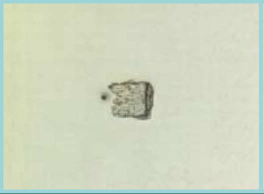
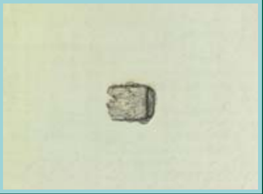
- Proved that the same OD control as a prober is possible with VPCS
- CRES < 1.3 ohm

*Cres is the path resistance including connection from interposer to the probe tip



Measurement location

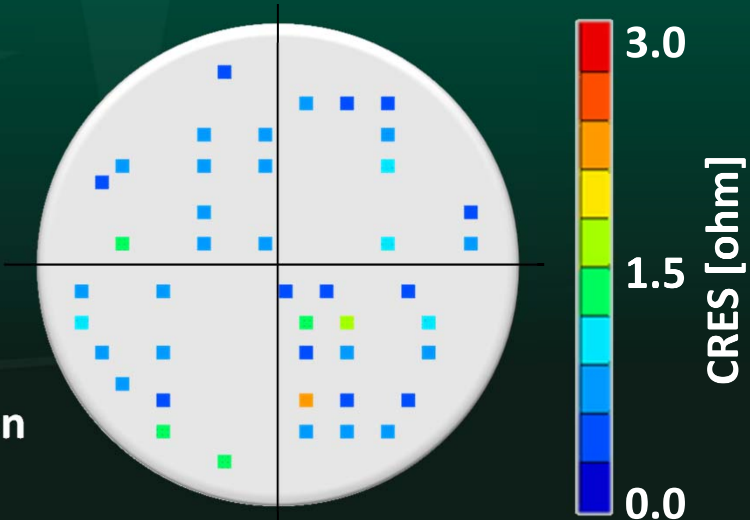
Overdrive Control & CRES (-30deg C)

OD	20µm (-5.5kpa)	40µm (-7.2kPa)	60µm (-8.9kPa)	80µm (-10.6kPa)	100µm (-12.3kPa)
VPCS					
Prober					

Results

- Proved that the same OD control as a prober is possible with VPCS
- CRES < 2.3 ohm

*Cres is the path resistance including connection from interposer to the probe tip



Measurement location

Summary

- **Easily obtained uniform and high contact force**
  - 300mm wafer 576kgF, max 120K pin
  - 450mm wafer 1,297kgF, max 260K pin

    *-80kPa, 5gf/pin

- **Because pressure is uniformly distributed over the tester and the wafer sides, a high stiffness structure is not required for prober and card**

- **Realized full wafer contact by VPCS + Existing MEMS probe**
  - Achieve Probe overdrive control by VPCS
  - Proved using existing MEMS which is advantageous on reliability and cost

VPCS + MEMS is a powerful solution for 450mm wafer 1TD test

Next step

450mm Full wafer contact

- Over 1ton contact force for ultra high pin count
- Enhancement of resolution and precision of vacuum is required for finer overdrive control
- Minimum deformation needed to have uniform scrub mark
- To what extent can the board stiffener be eliminated or shrunk