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Microelectronics Packaging of a Micro Gas Analyzer

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Team

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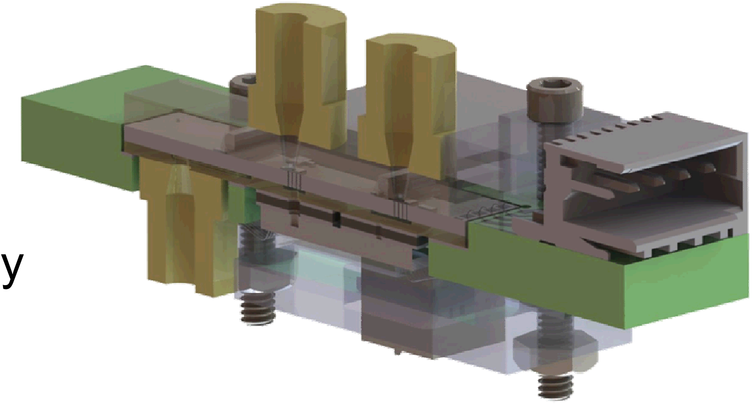
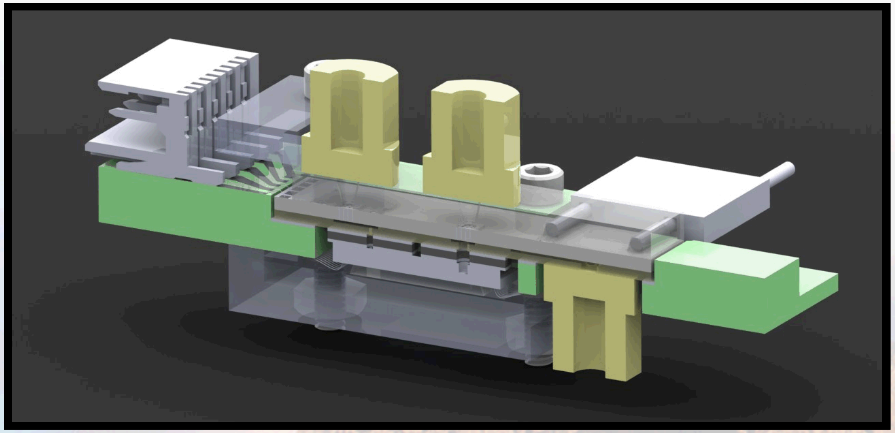
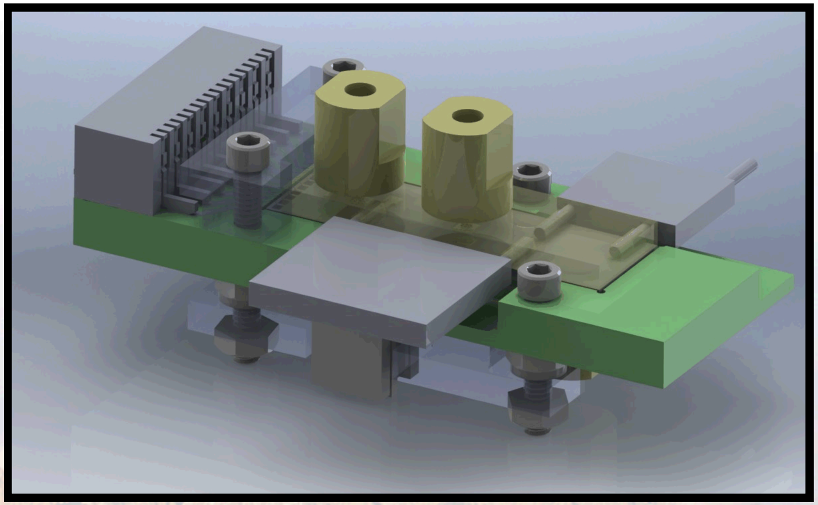
Outline

- Micro Gas Analyzer Objectives
- MGA Description
- Design Requirements
- Design Process
  - Design for Manufacture/Assembly/Reliability
- Packaging Reliability Improvements
- Conclusions

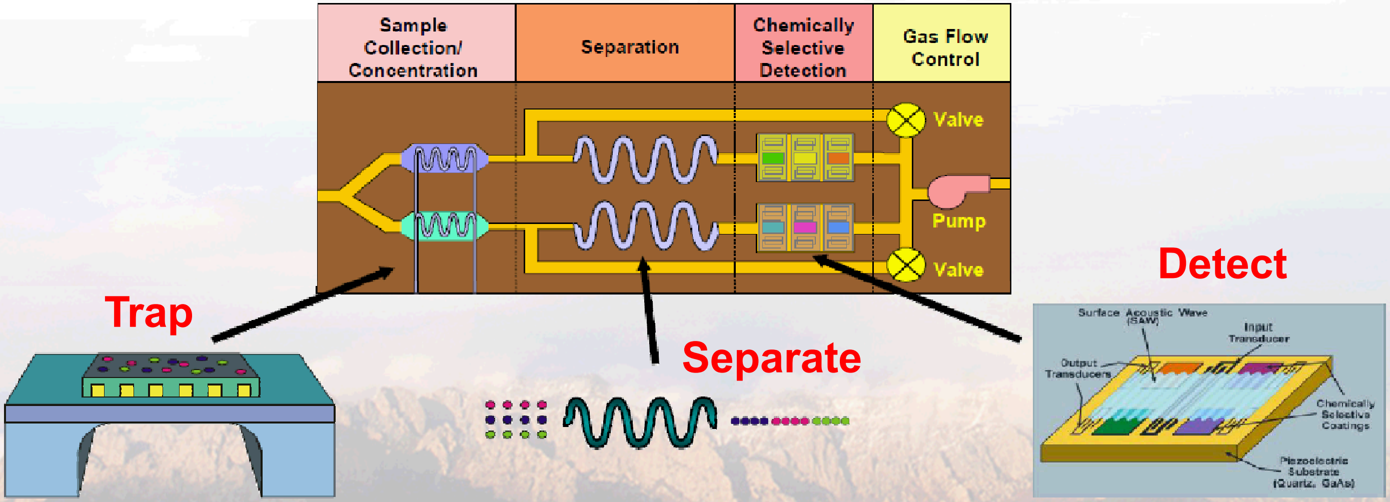




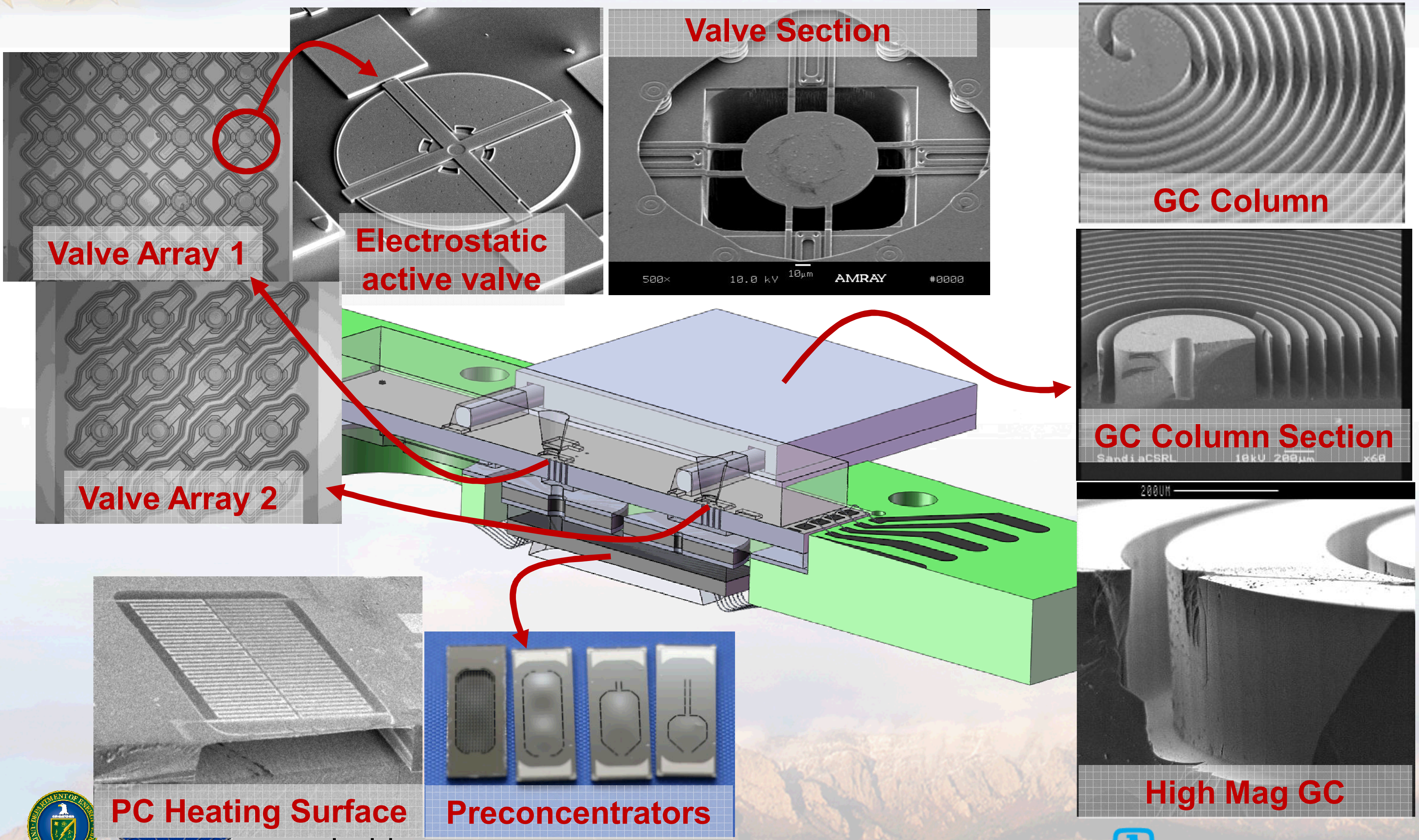


MGA Goals

- **Current commercial systems are slow, bulky, and expensive**
  - 1700 L per sample, 20 minutes/analysis, $200K
- **MGA is a miniature, field-deployable, chemical analysis system**
  - Small sample sizes, <1 minute/analysis
  - Applications:
    - Military – Protection from chemical warfare agents
    - Anti-terrorism – Detection of toxins and explosives
    - Environmental monitoring – Environmental contaminants
    - Industrial process monitoring – Spills, toxic cleanup



MGA Microelectronics Components



Valve Array 1

Electrostatic active valve

Valve Section

GC Column

GC Column Section

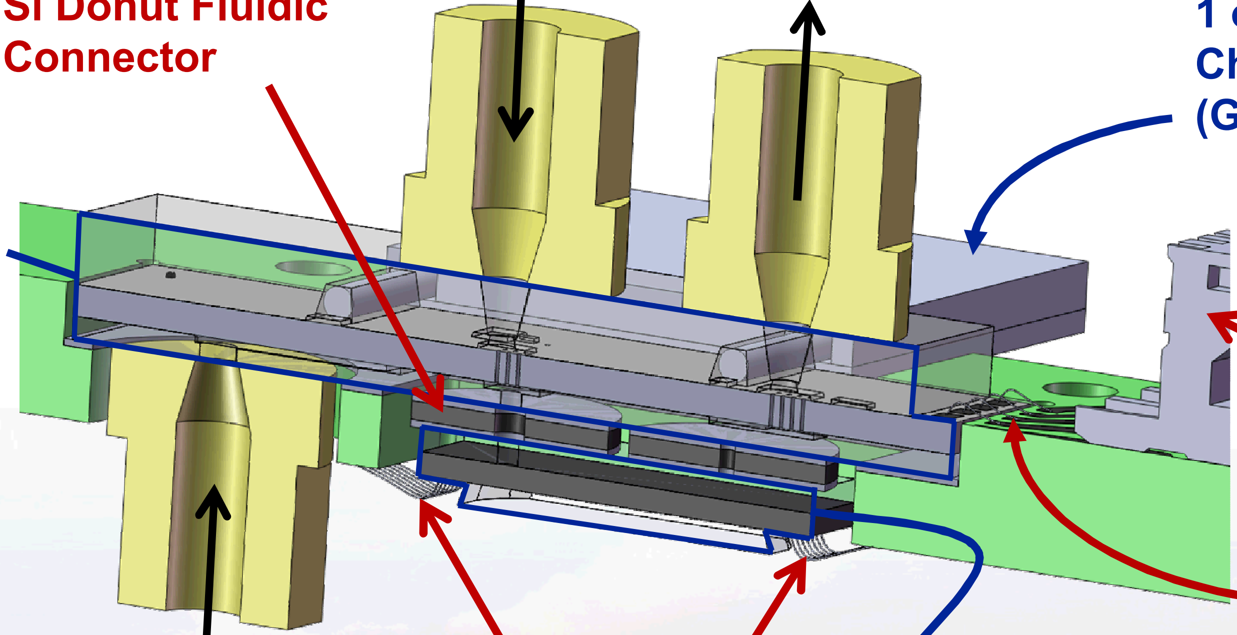
Valve Array 2

High Mag GC

PC Heating Surface

Preconcentrators

MGA Features



Sample Inlet

Pump Connection

Si Donut Fluidic Connector

1 of 2 Gas Chromatography (GC) Columns

Valve Module (VM)

Pyrex-Si-Pyrex Laminate

Connector for VM Controls

Wire Bonds to VM

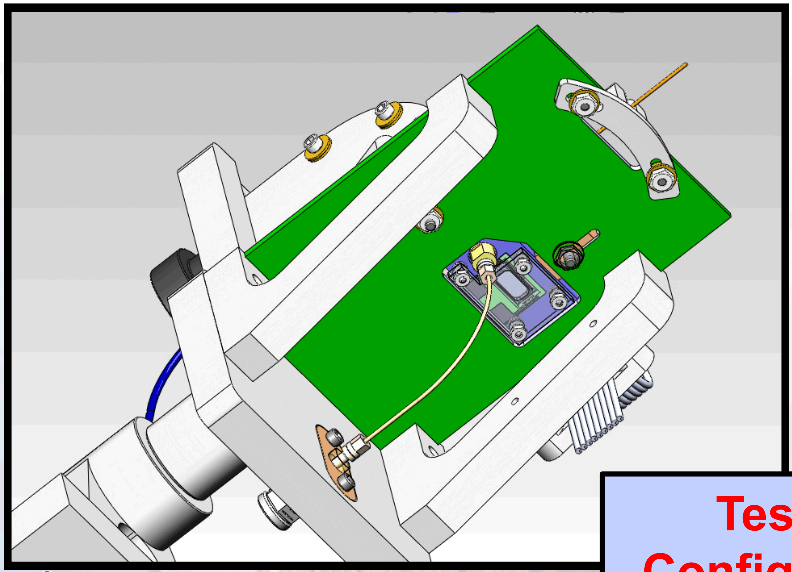
H_2 Carrier Gas

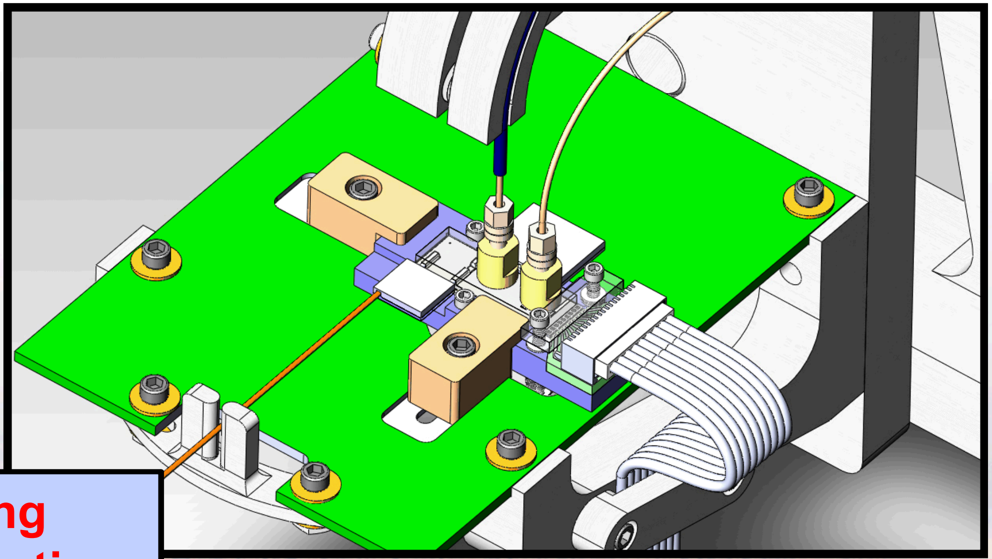
Wire Bonds for PC Heating Current

Preconcentrator (PC) Pyrex-Si-Pyrex Laminate

Design Requirements

MGA Requirements	Packaging Design Requirements
Maximize chemical analysis speed	• Minimize the dead volume in the fluid connections
Device must be portable	• Minimize size and weight
Chemical sensing must be accurate	• No metallic components on wetted surfaces • Minimize outgassing of adhesives in sample path
	• Create a robust and consistent assembly process which minimizes mistakes and human error • Allow for rework in the assembly

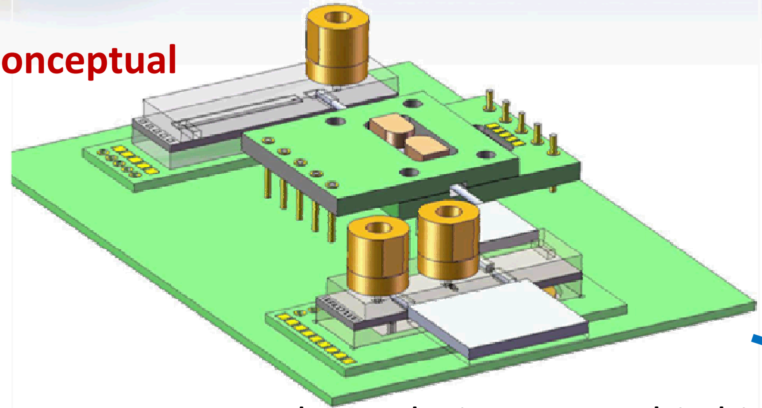




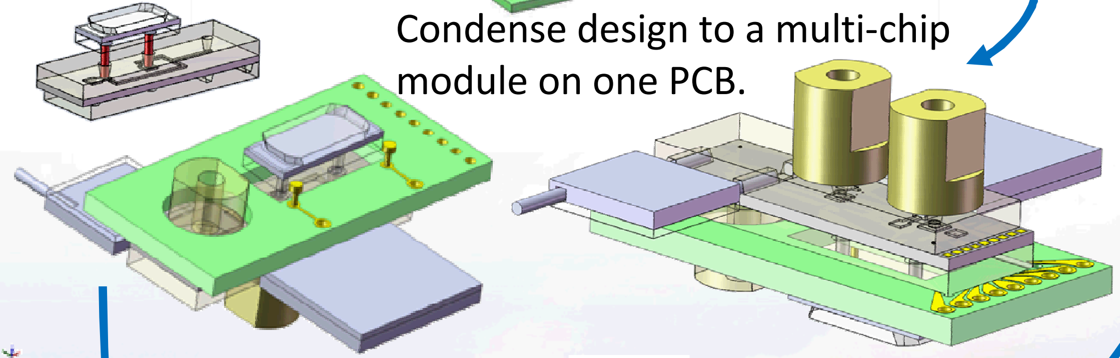
Testing Configuration

Embodiment Design Process

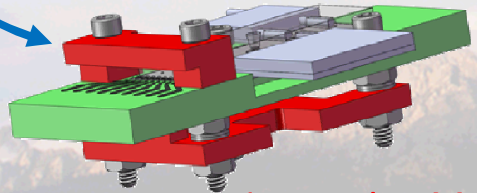
Initial Conceptual Design



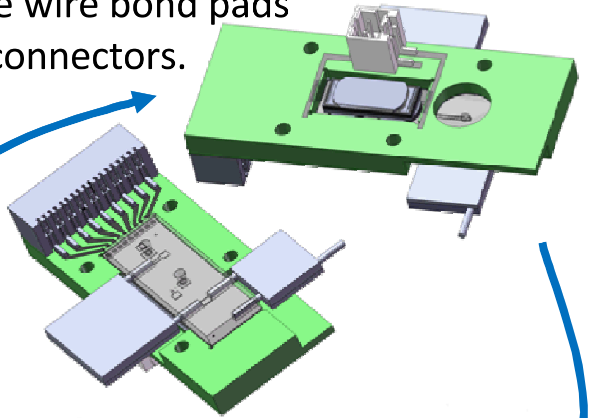
Condense design to a multi-chip module on one PCB.



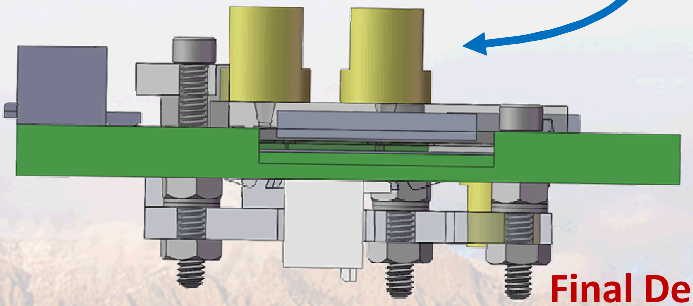
Replace the capillary connections between the VM and PC with donut connections. Add mechanical wire bond protection.



Remove posts and solder connections. Make wire bond pads coplanar and add connectors.



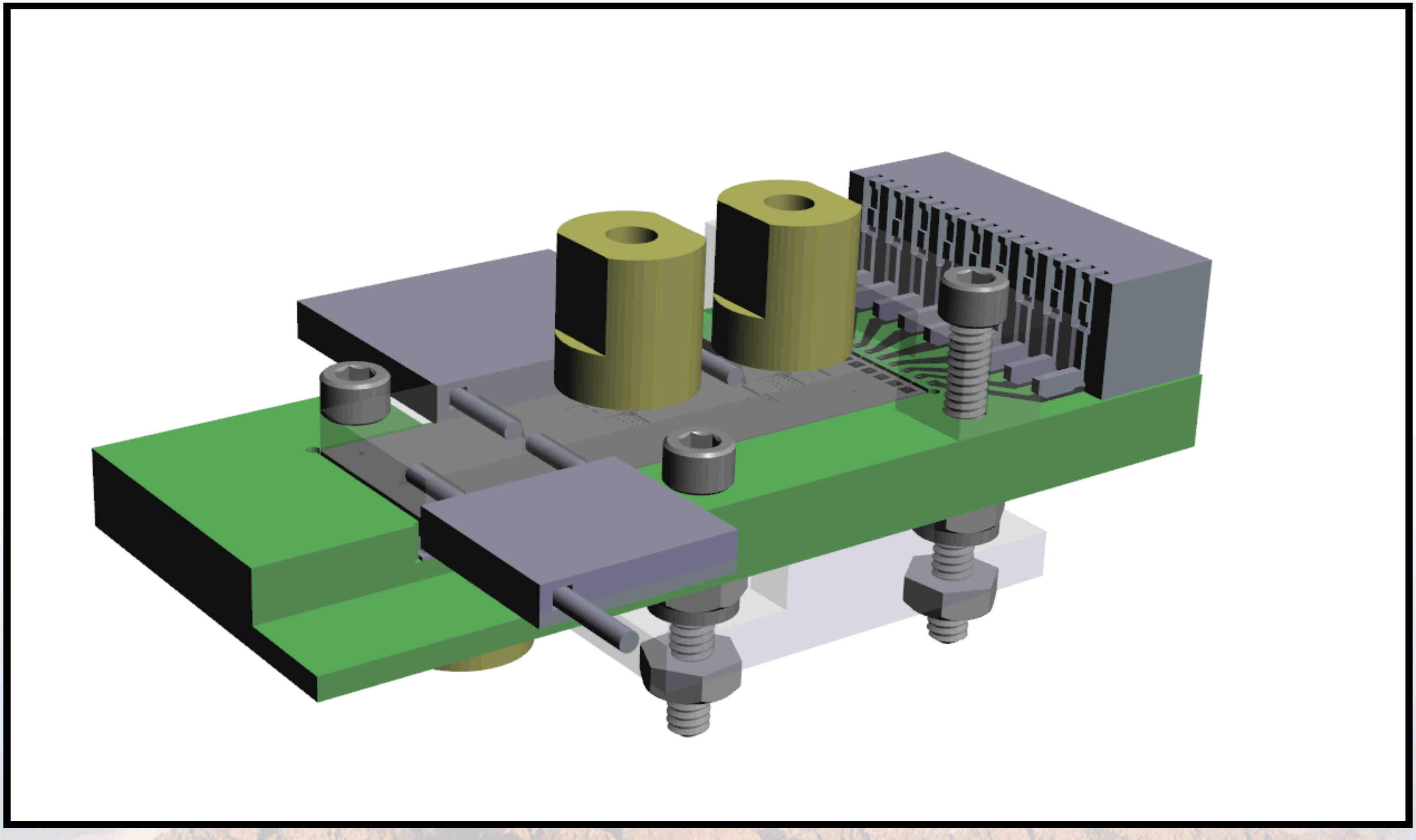
Optimize board spacing for GC heaters, wire bond lengths, and epoxy bond lines.



Final Design

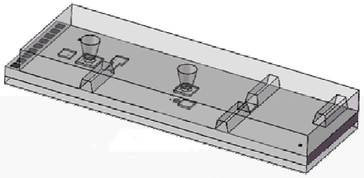
Decreasing System Complexity
Increasing Manufacturing Reliability/Assembly Repeatability

MGA Orientation

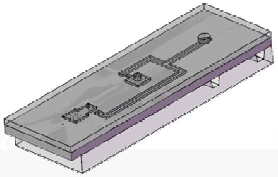


Assembly Process

1. Bond Donuts to VM
2. Bond PC to Donuts
3. Bond VM to PCB
4. Wire Bond
5. Solder Connectors
6. Wire Bond Protection
7. Connect GCs
8. Bond Connectors



Top View



Bottom View

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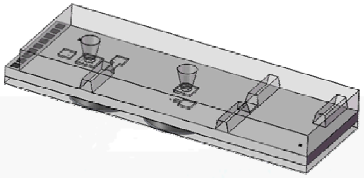

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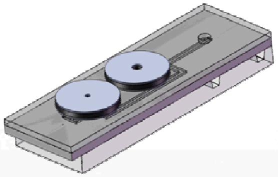

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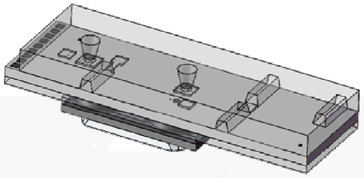

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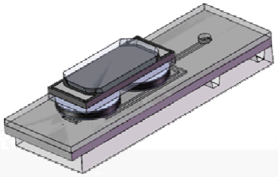

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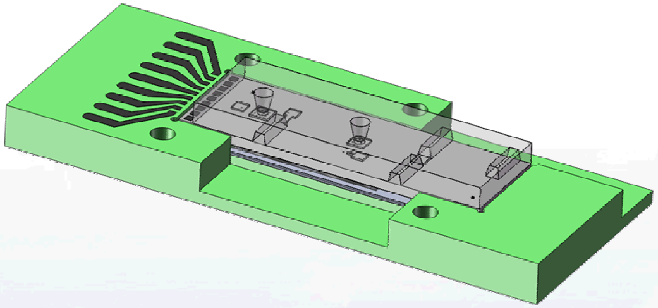

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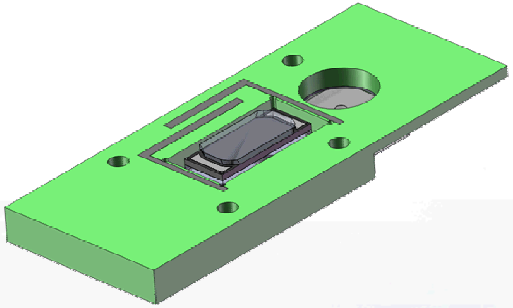

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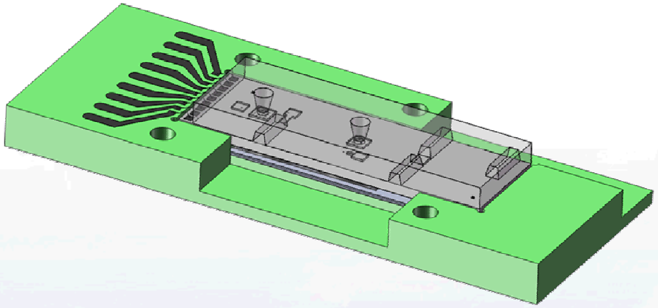

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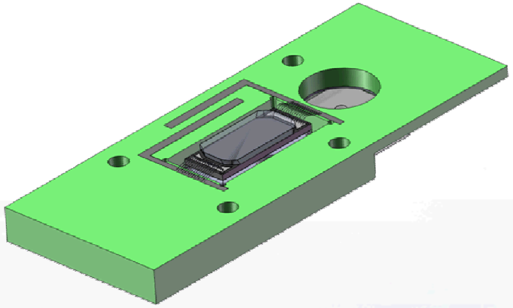

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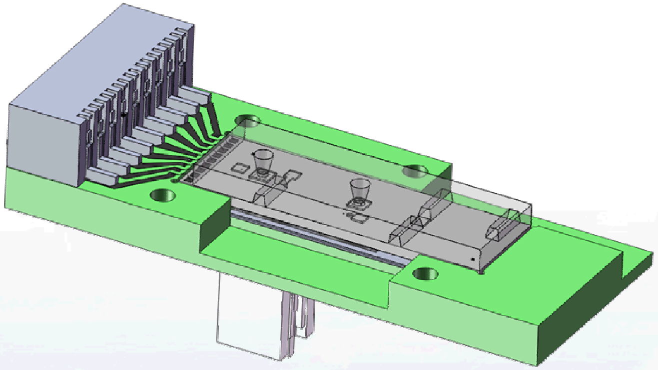

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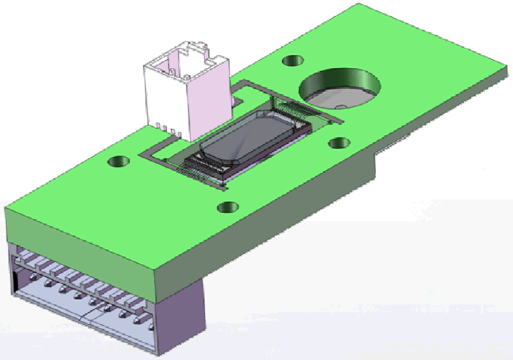

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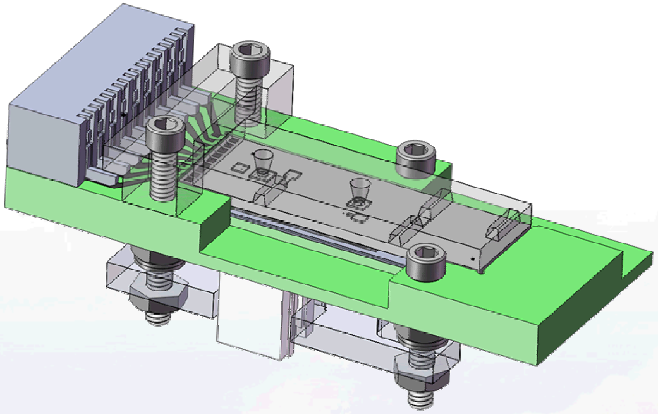

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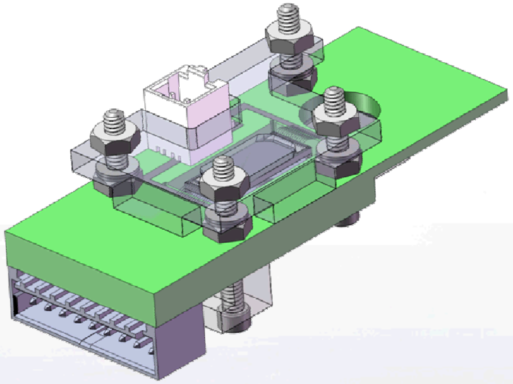

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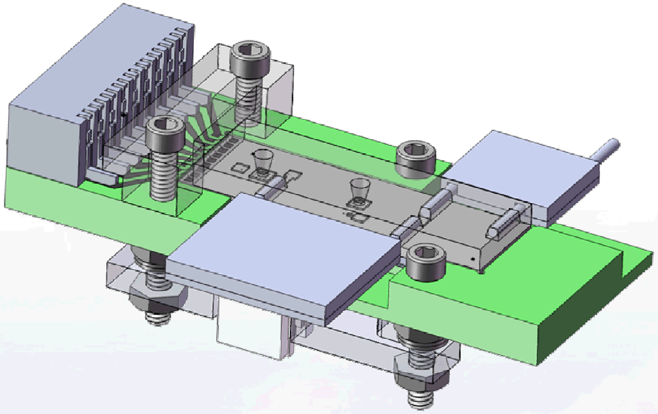

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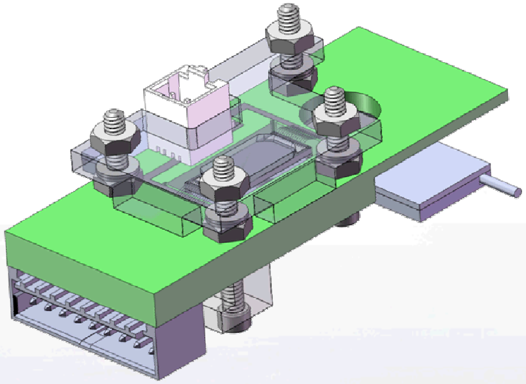

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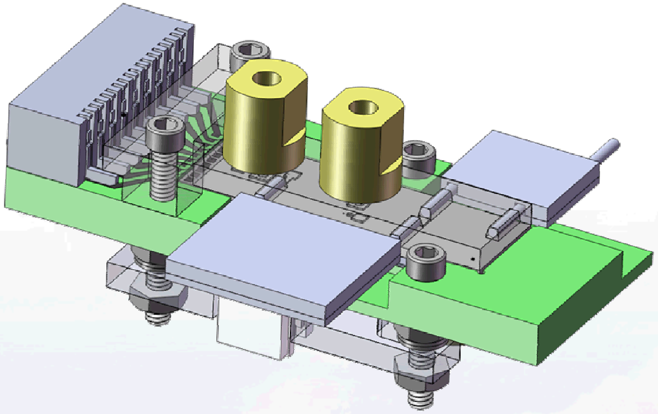

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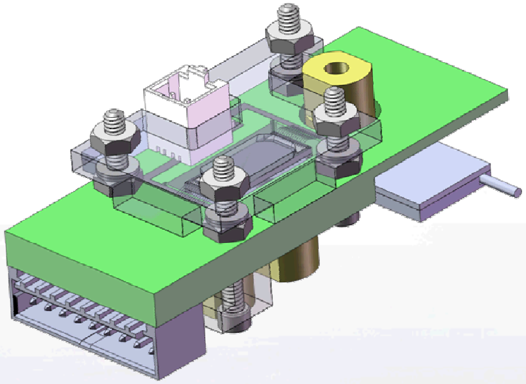
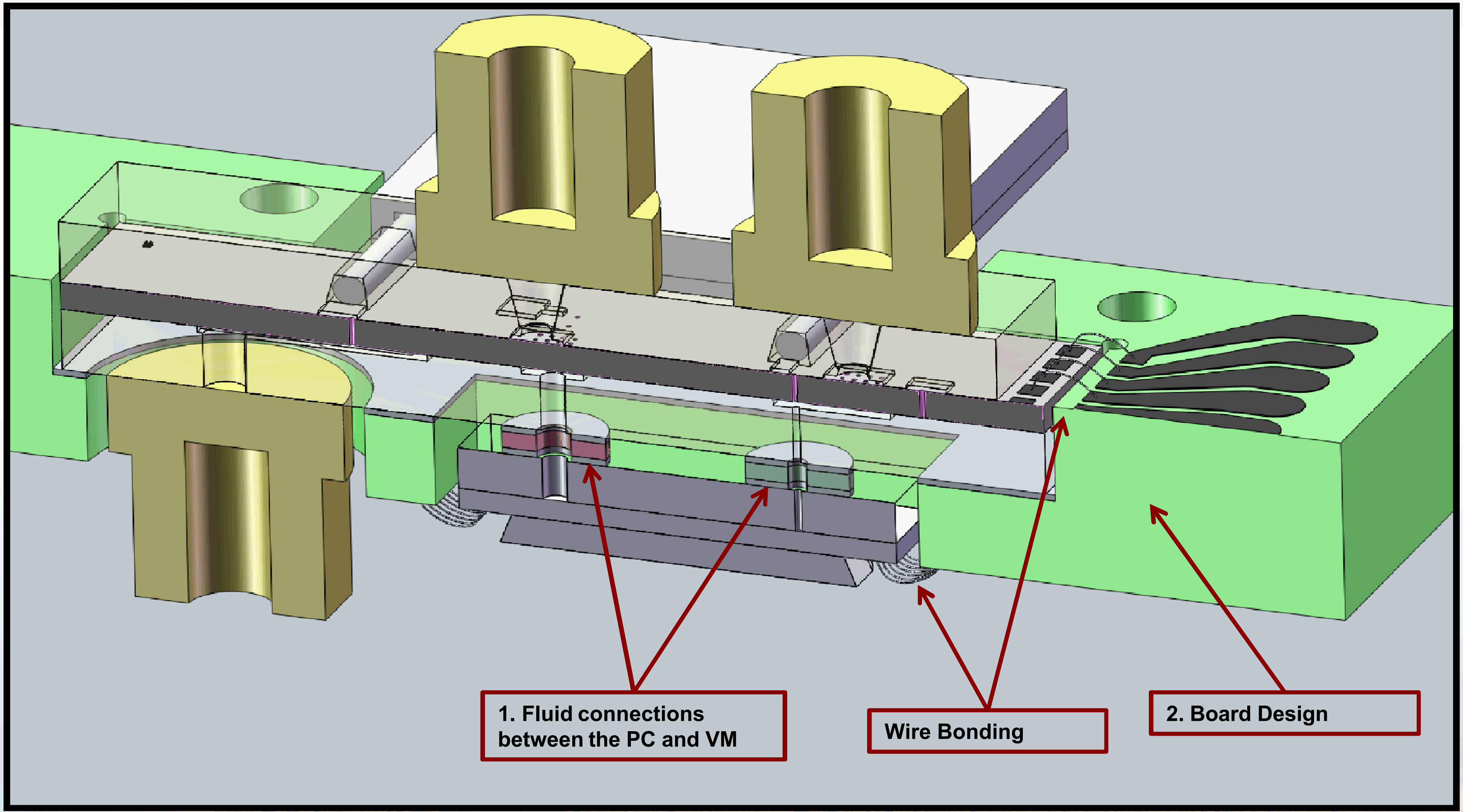


Bottom View

Design Emphasis on Reliability



1. Fluid connections between the PC and VM

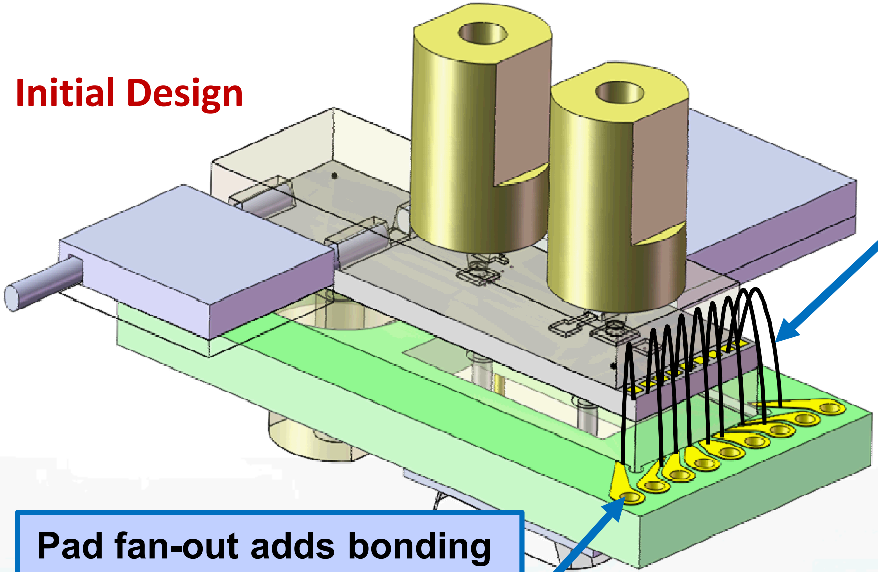
Wire Bonding

2. Board Design

Board Design

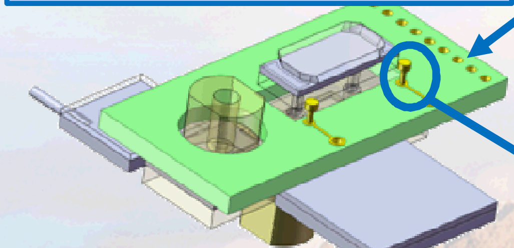
- Traded PCB complexity for assembly ease!

Initial Design



Easier bonding - Created coplanar pads by changing board thickness.

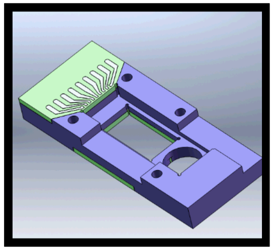
Pad fan-out adds bonding complexity. Need better spacing between pads. 1:1 a good rule of thumb.



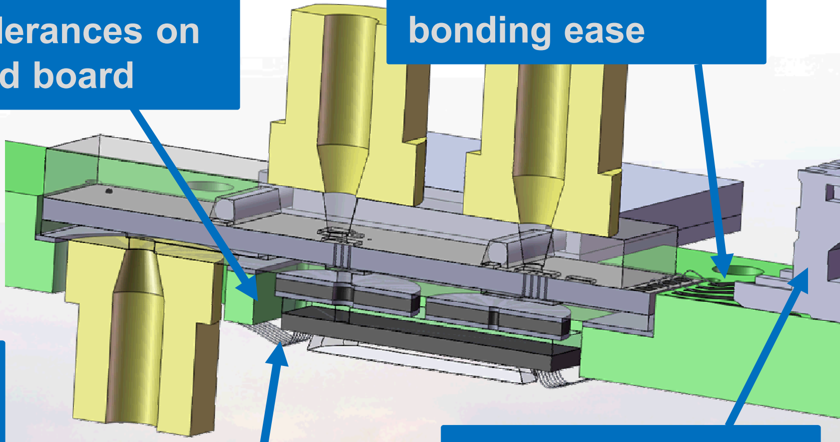
Through vias to centralize connections - Unnecessary

Posts in design because of the PC offset - Extra complexity and a reliability issue

Alternative design: PCB subcomponents epoxied to polycarbonate carrier.



Final Design



Large tolerances on the milled board

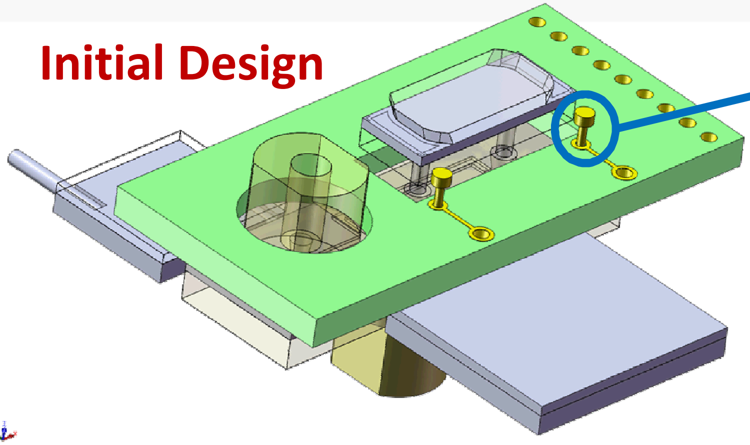
4 oz Cu ENIG for bonding ease

Multiple coplanar bonds

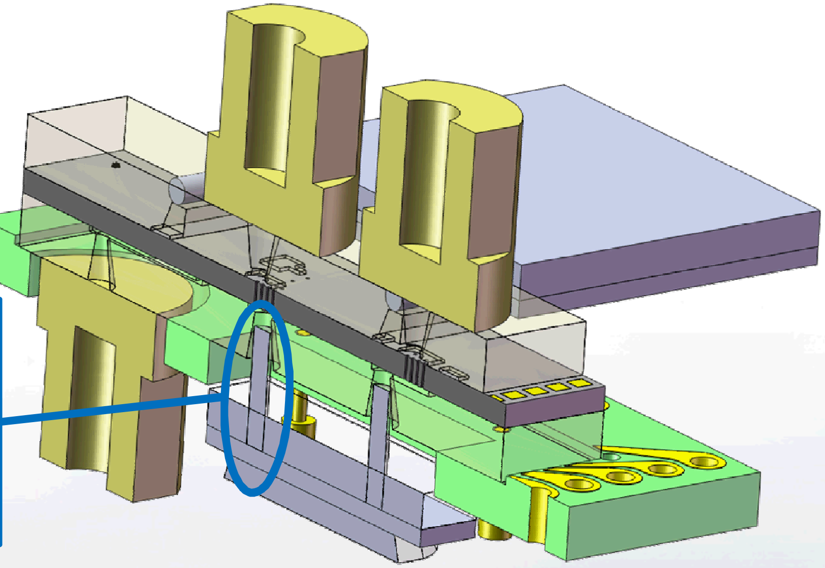
Connectors for multiple testing sessions.

VM to PC Connections

Initial Design



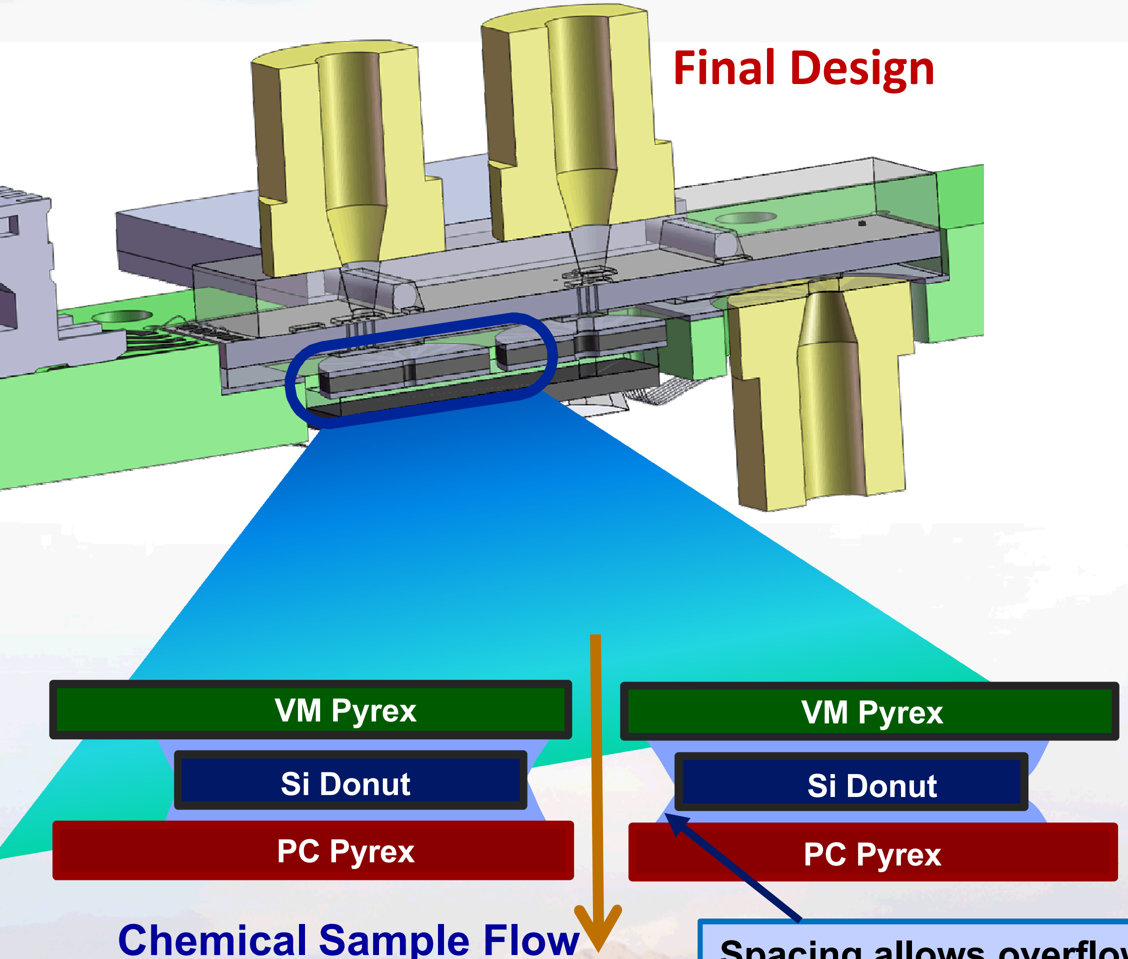
Wire Bond Posts
- PC offset requires posts or very tall wire bonds
- Requires additional assembly steps



Capillary Connections
- PC bond pad height variability
- Potential clogging issues during assembly
- Assembly is very difficult because of the orientation of the capillaries after the first bond is not uniform

- **Multiple concepts proposed**
  - Direct Bonding
  - Anodic Bonding
  - Glass bead spacers in epoxy
  - Melt in glass frit capillaries
  - Gaskets
  - Si spacers

VM to PC Connections



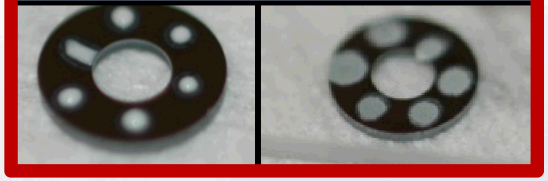
Spacing allows overflow – meniscus doesn't reach pyrex hole

Epoxy Process Optimization

Stamping Concept

Tack and Backfill Concept

Deposited Epoxy Dots

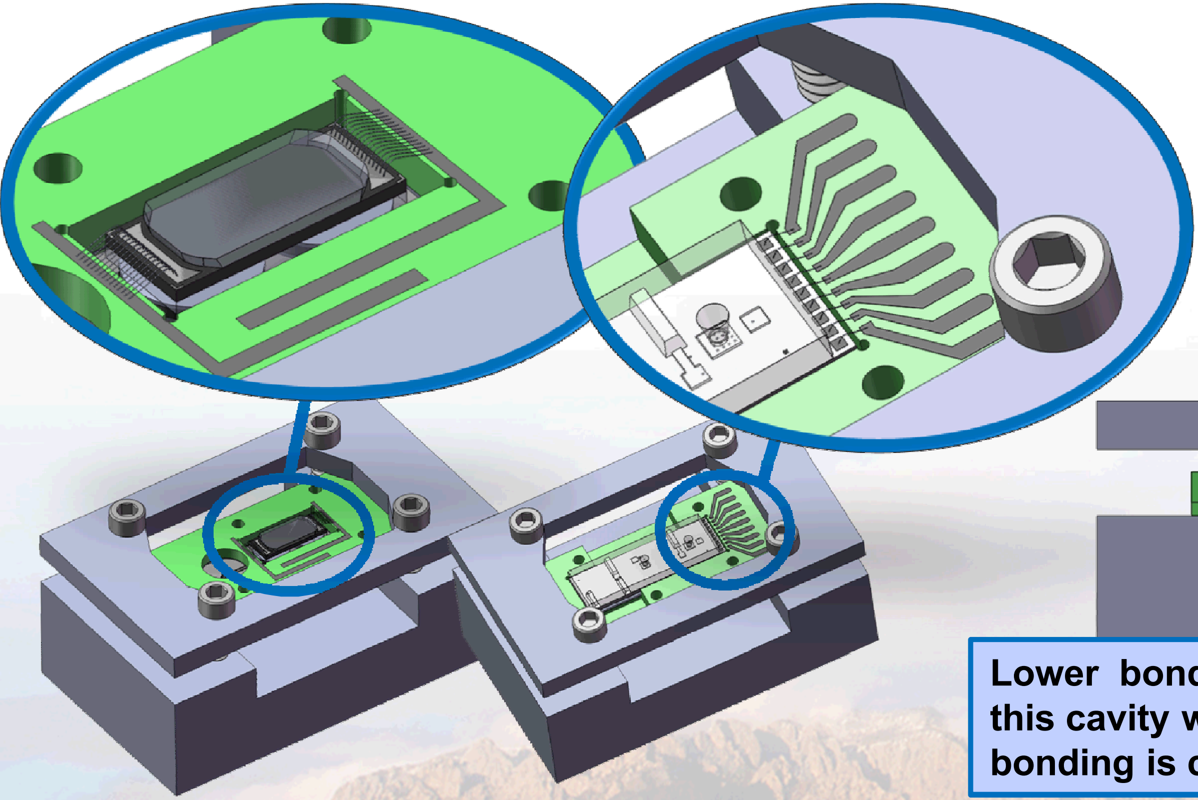


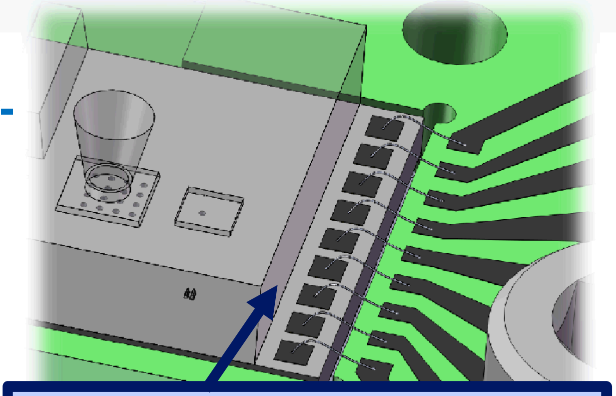
Epoxy Ring

Wire Bonding

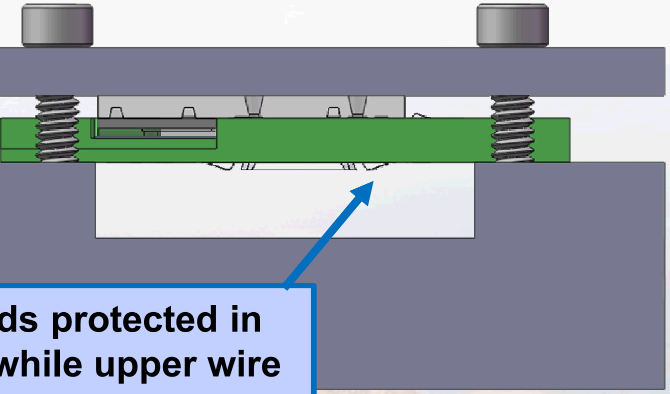
15 1-mil Al wedge bonds carry 1.5 amps to the PC heater.

9 high-voltage 1-mil Al wedge bonds control the electrostatically-activated valves in the VM.





Deep access bond head required to avoid the upper pyrex on the VM.



Lower bonds protected in this cavity while upper wire bonding is completed.

Conclusions

- **MGA required high reliability packaging**
  - Limited number of functional parts
- **MGA designed for manufacture ease and accuracy**
  - Develop multiple design concepts and optimize the best techniques
  - Practice with dead components
- **Design optimized based on**
  - MGA requirements
  - Reducing complexity
  - Improving packaging repeatability and consistency

Questions?

Enable 3D View