Low Vapor Pressure Precursor Delivery: A Case Study in MLD of Polyimide

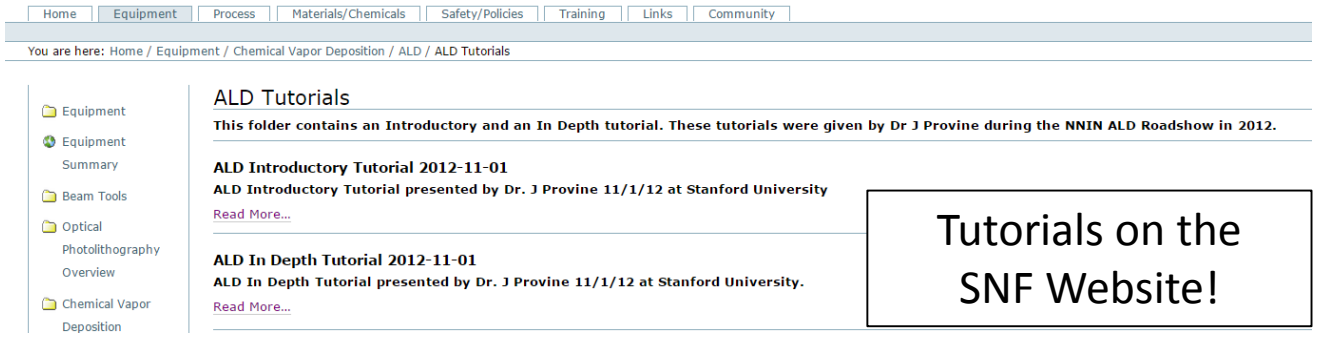
Tim English

Mentors: J Provine & Michelle Rincon

EE 412
6/3/2015

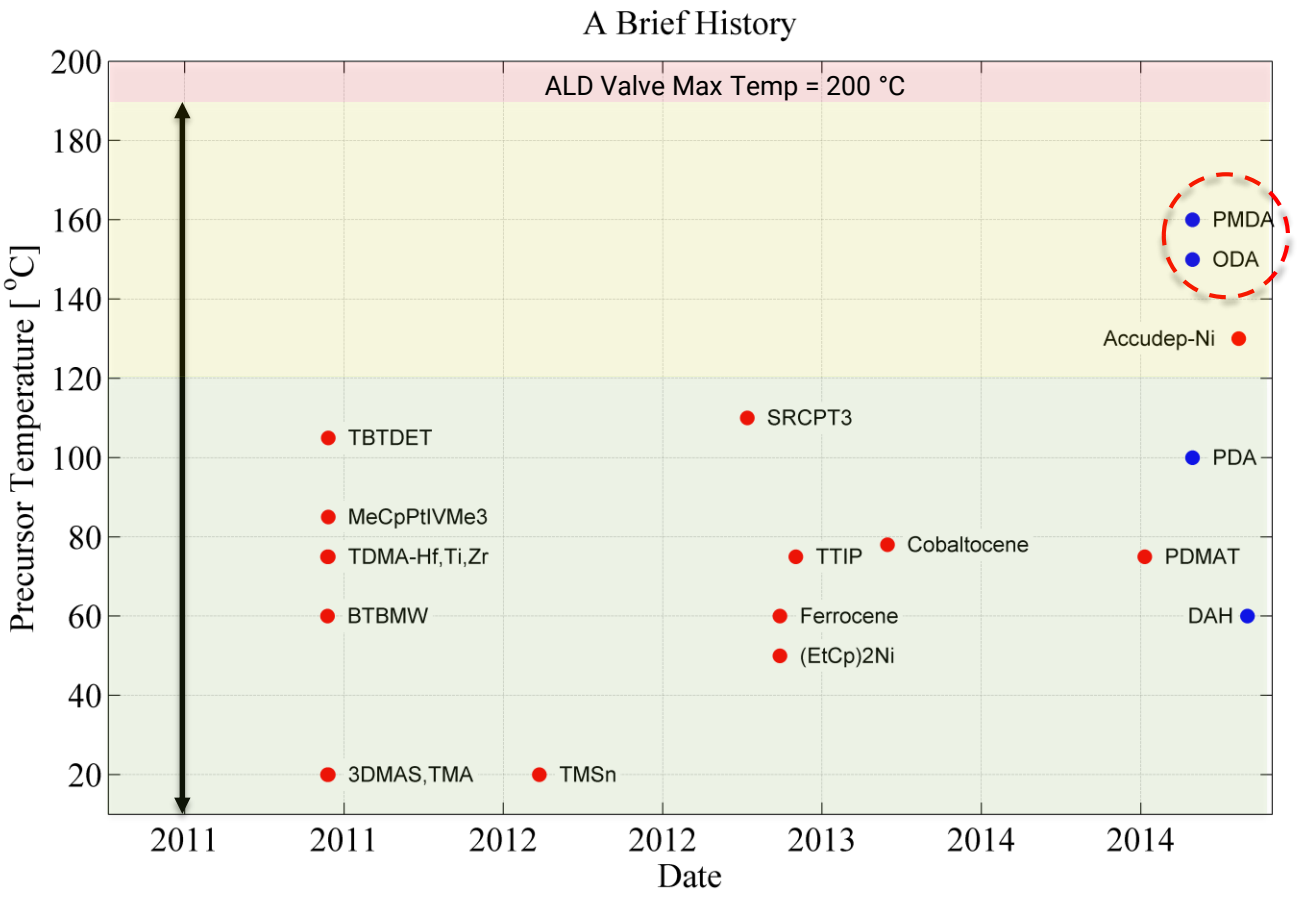
Molecular Layer Deposition

- Leverages the benefits of an ALD process for organic films



- MLD of polymer as an enabling process module:
  - Hybrid organic-inorganic thin films and multilayers
  - Conformal polymer coating for bioencapsulation
  - Pyrolysis and graphitization of MLD polymer to form ultrathin carbon films
  - Solvent resistant, thermally robust, and mechanically compliant passivation enabling microfluidics, operation in harsh operating environments, stress mitigation, and flexible substrate processing
  - Polymer photoresists and masking of high aspect ratio structures

SNFALD Precursors



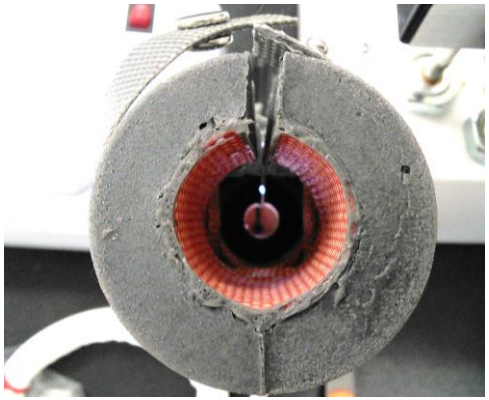
Clogging

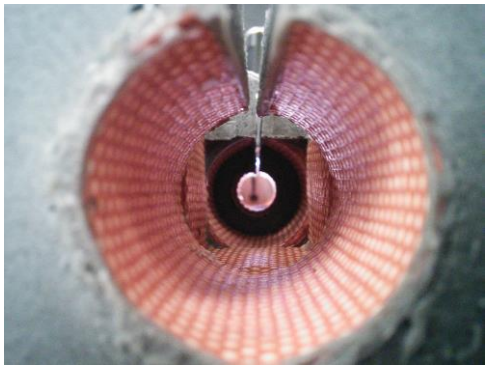
Temperature Uniformity

Precursor Cylinder

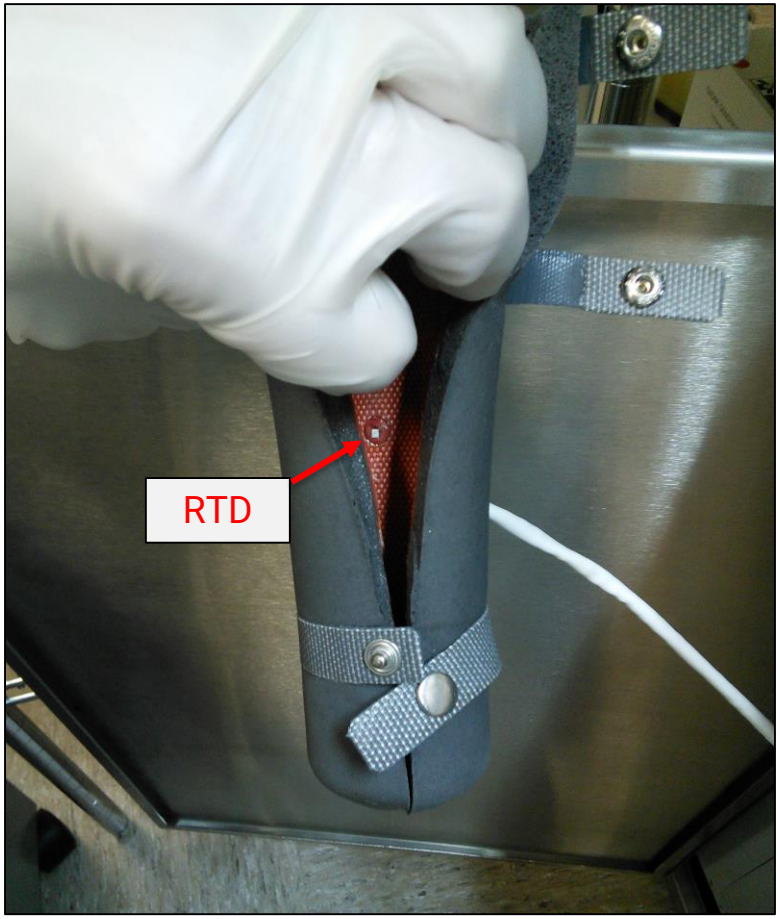
Traditional Jacket

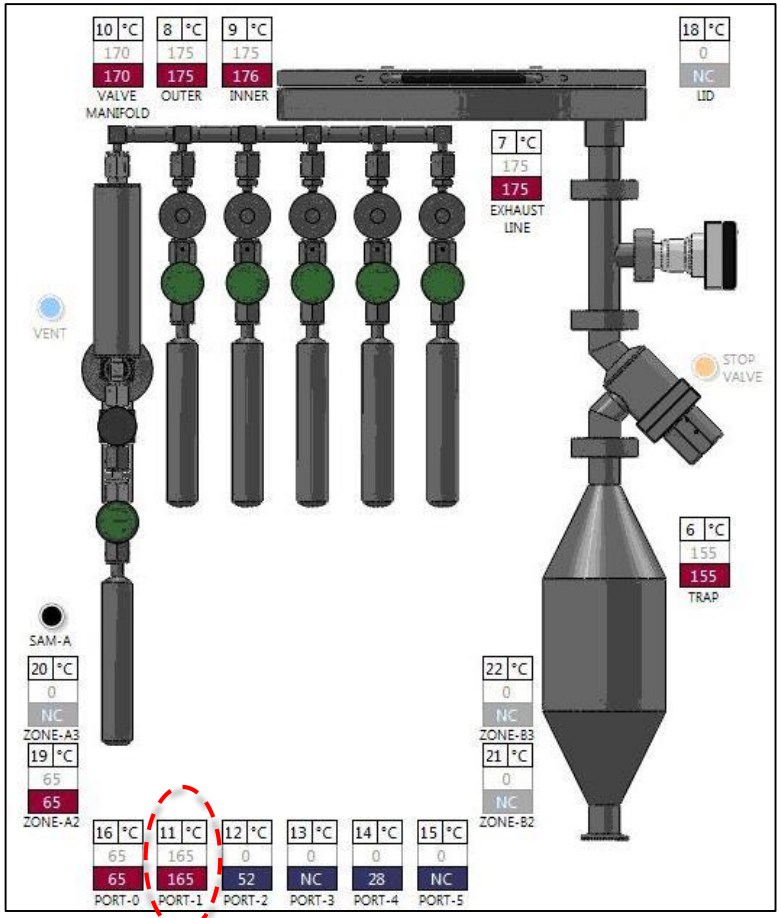
Molded Jacket



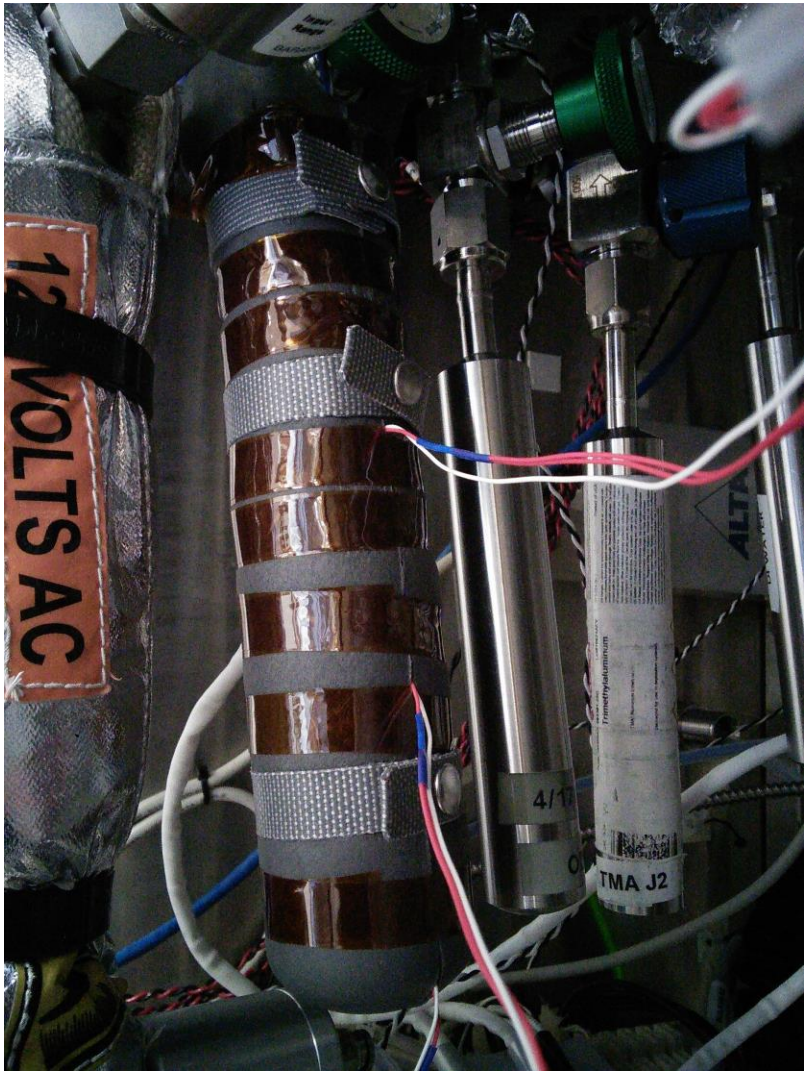


Isothermal Assumption





Molded Precursor Jacket



Molded Precursor Jacket

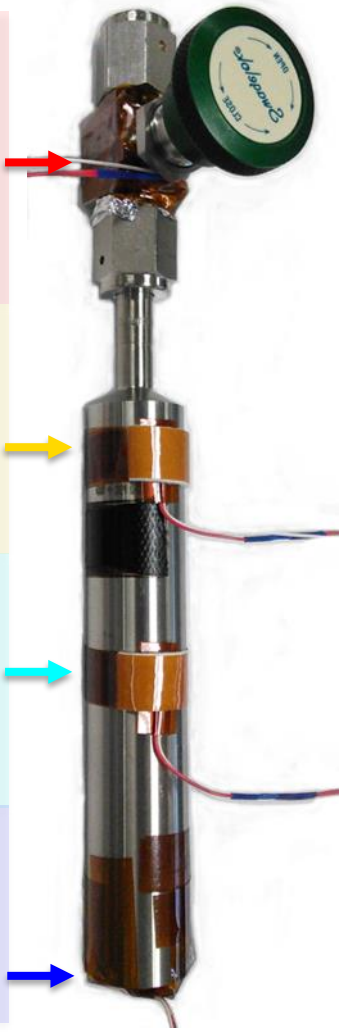
Zones

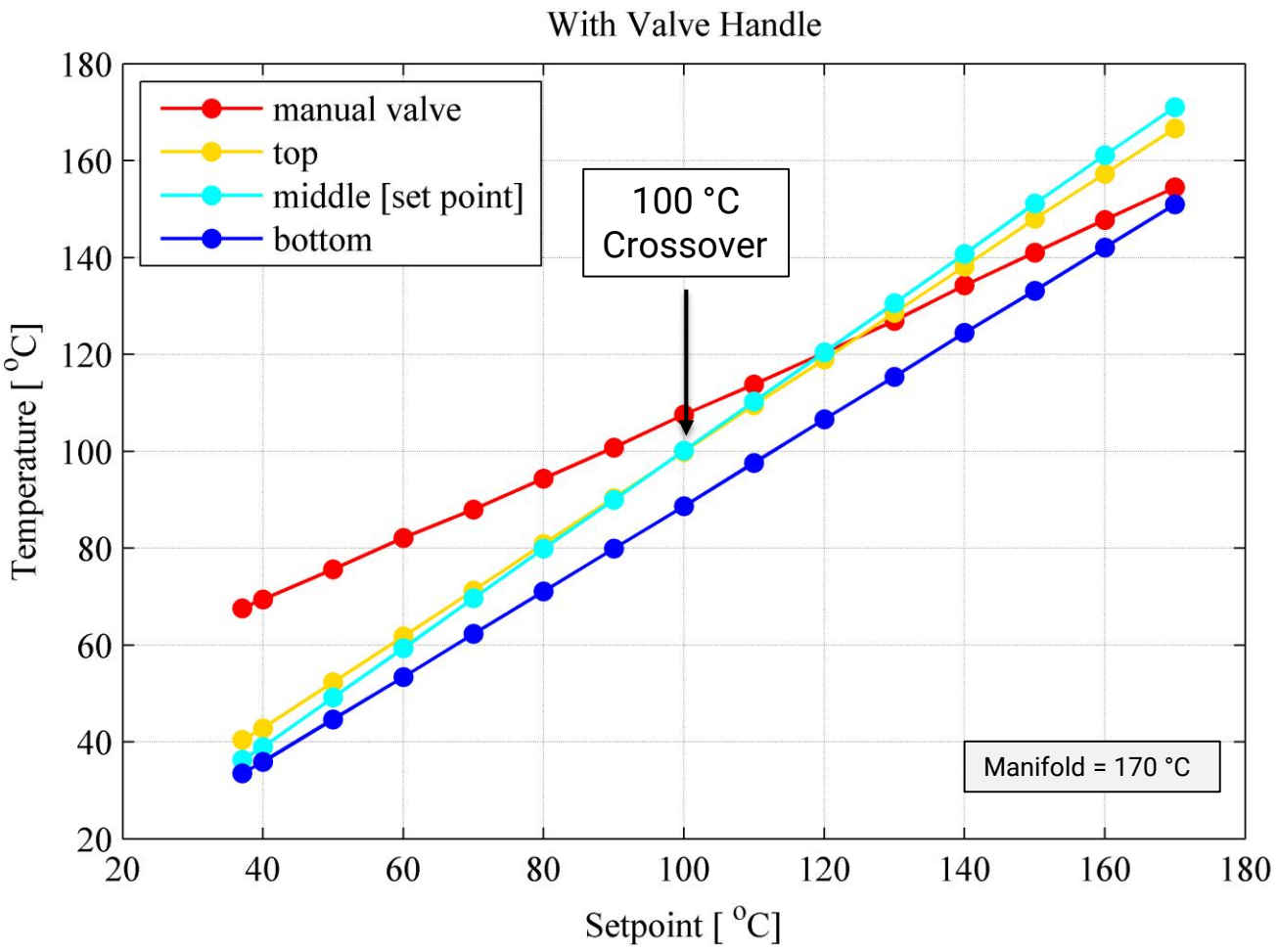
Manual Valve

Top

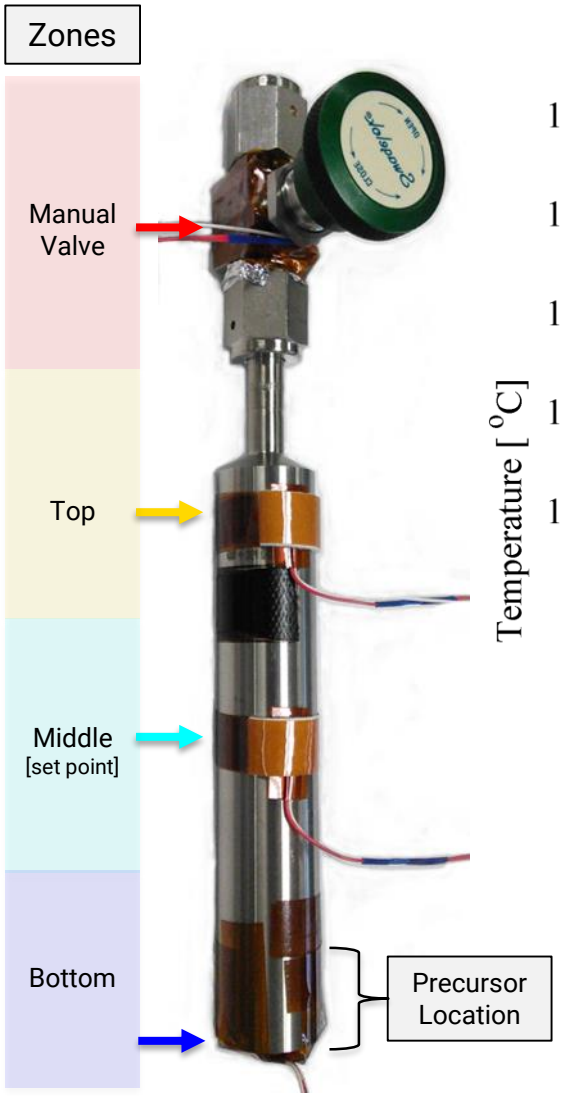
Middle [set point]

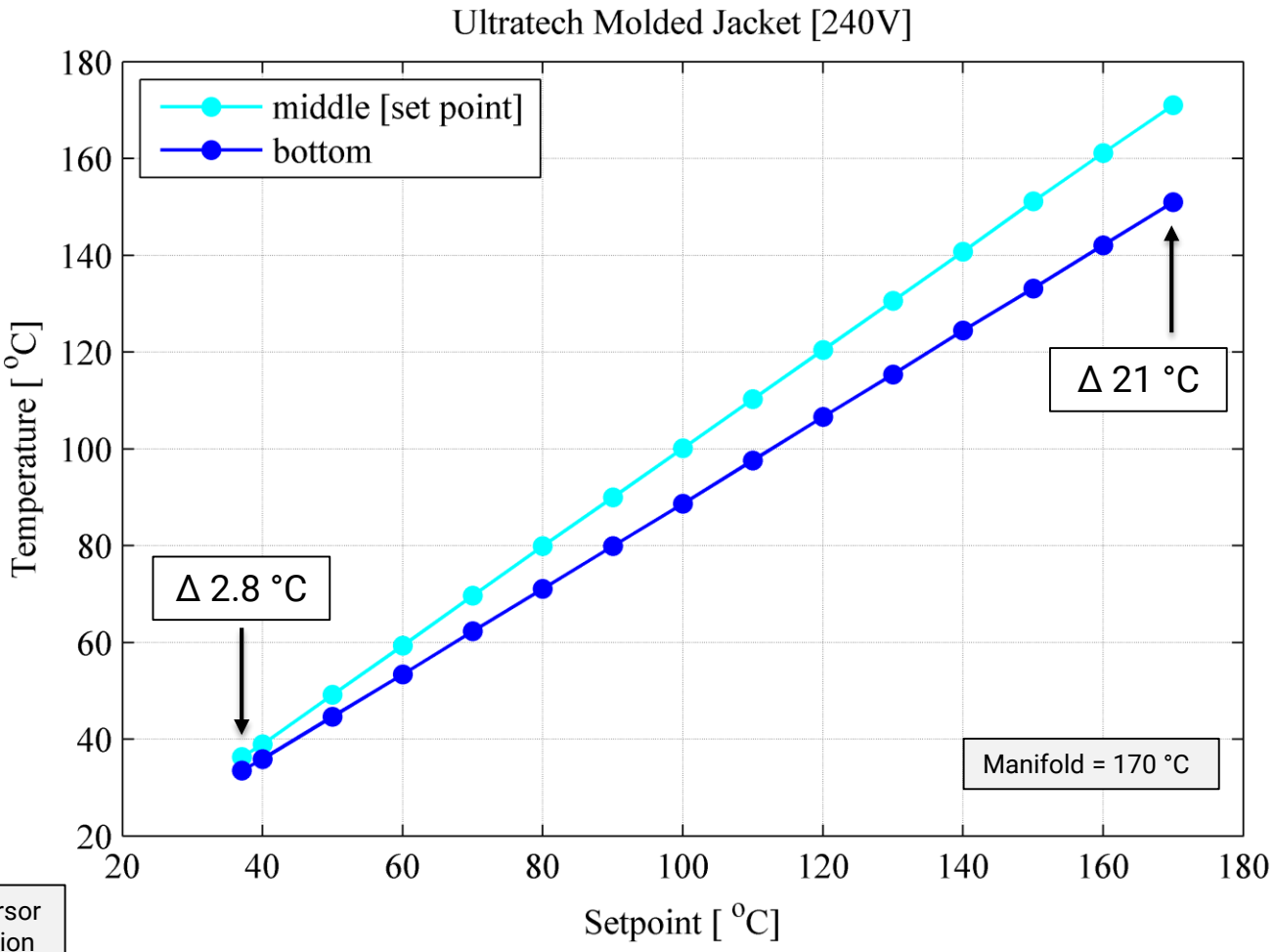
Bottom



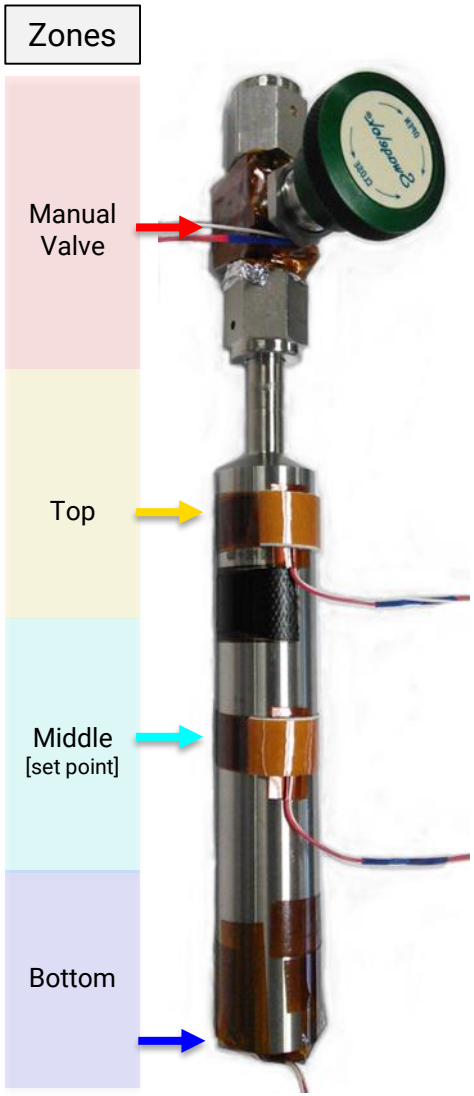


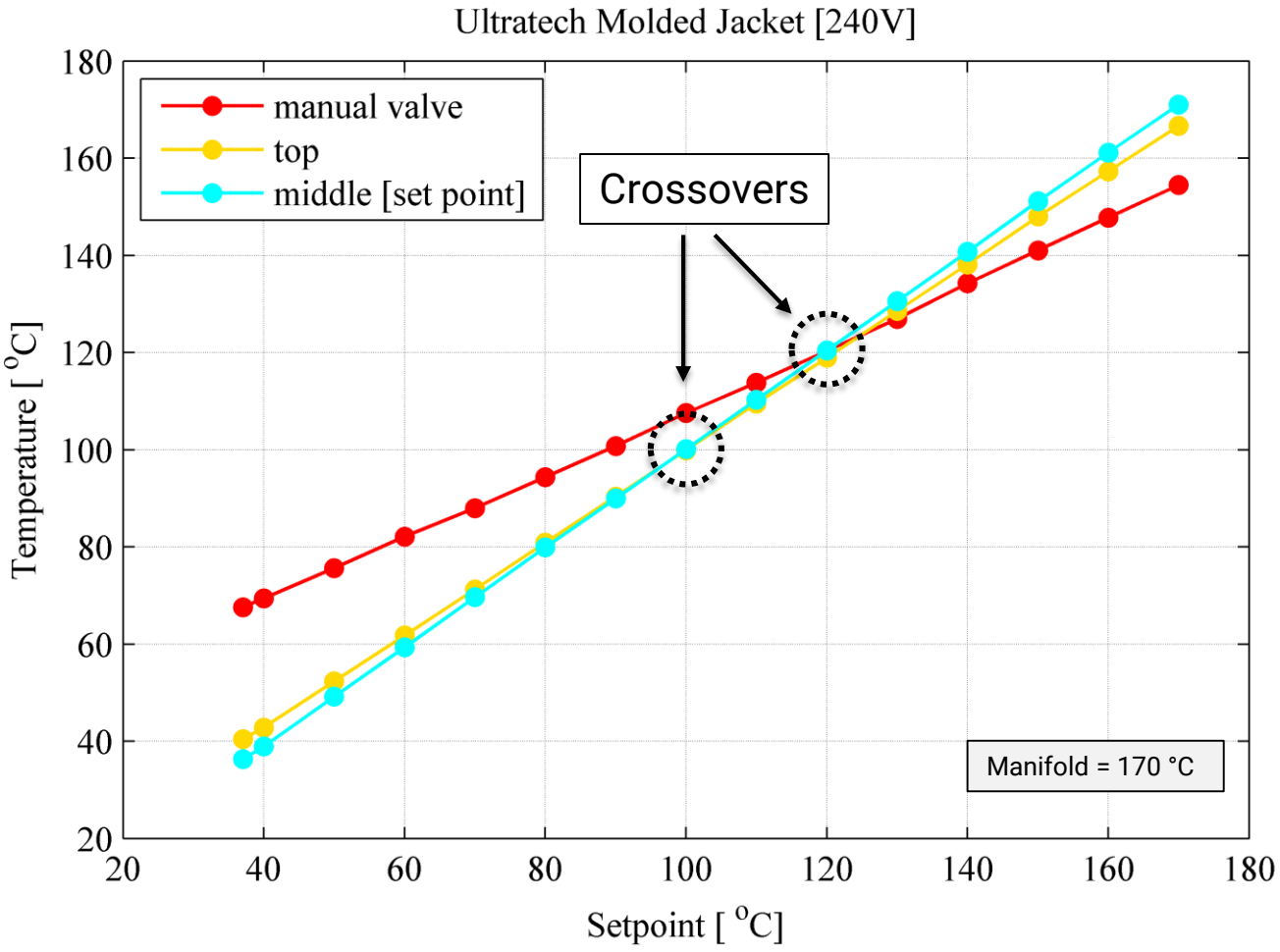
Temperature Offset Error





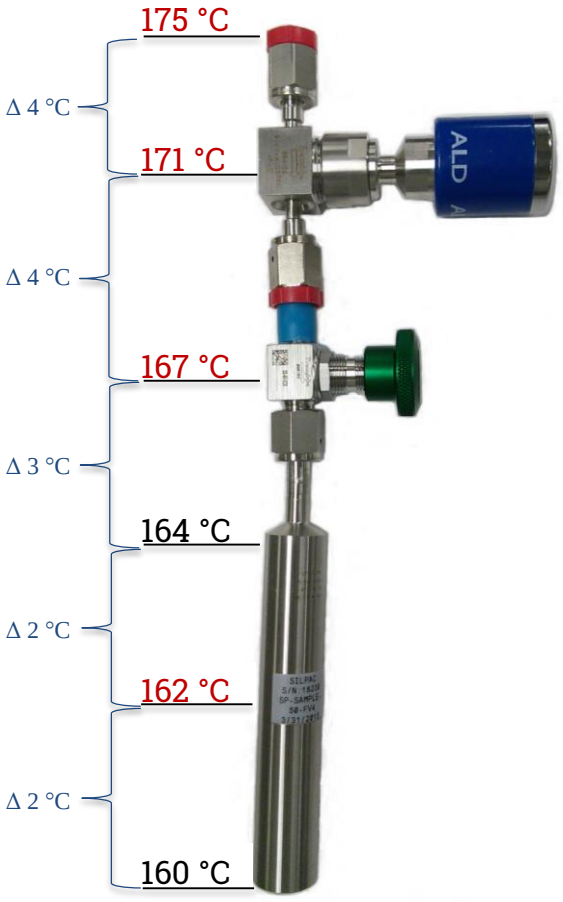
Thermal Gradient Crossover



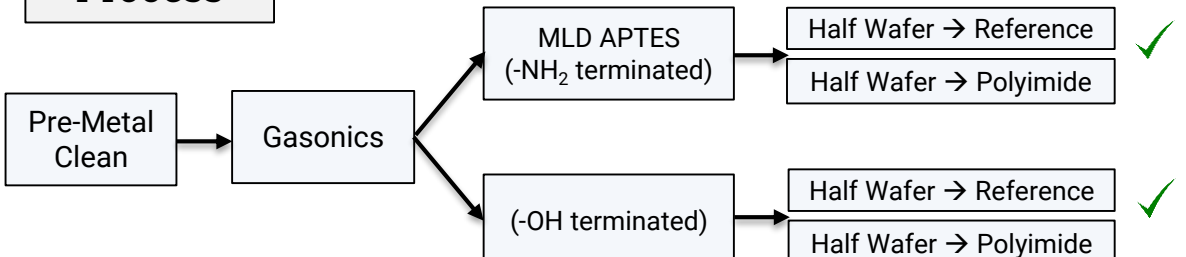


Thermal Management

6 temperature zones
4 PID set points

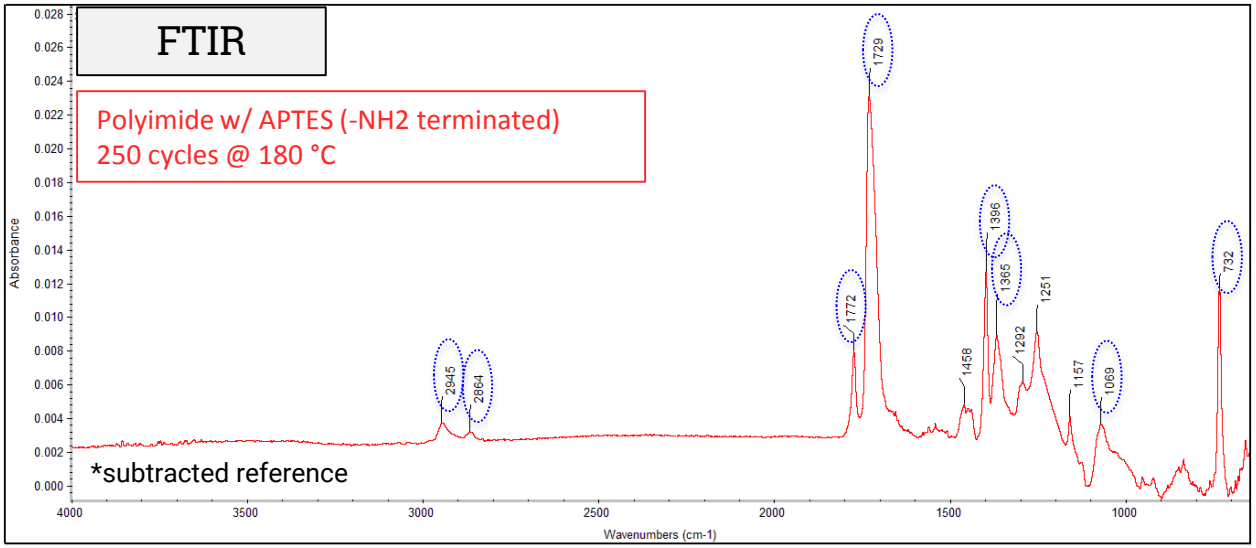


Process



FTIR

Polyimide w/ APTES (-NH2 terminated)
250 cycles @ 180 °C



Conclusions

- Precursor Lessons
  - Fundamental design limitations with manual valve exposed
  - Constant-wattage heater tape with single PID controller
  - Tradeoff → one vs. many temperature zones
  - Jacket data reference for Savannah/Fiji/MLD tools
- Temperature Offset
  - Increases with set point temperature
  - 21 °C @ set point = 170 °C
- Temperature Gradient Crossover
  - 100 °C → middle & top of cylinder (dosing)
  - 120 °C → manual valve (risk of solids clogging)
- Software debugging
  - No crashes since 3/24/2015

Thank You

- Mentors: Dr. Michelle Rincon
  Dr. J Provine
- Stanford NPL: Dr. Jan Torgersen
- Organizers: Dr. Roger Howe
  Dr. Mary Tang