Panel II: Process Models

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Panel II: Process Models

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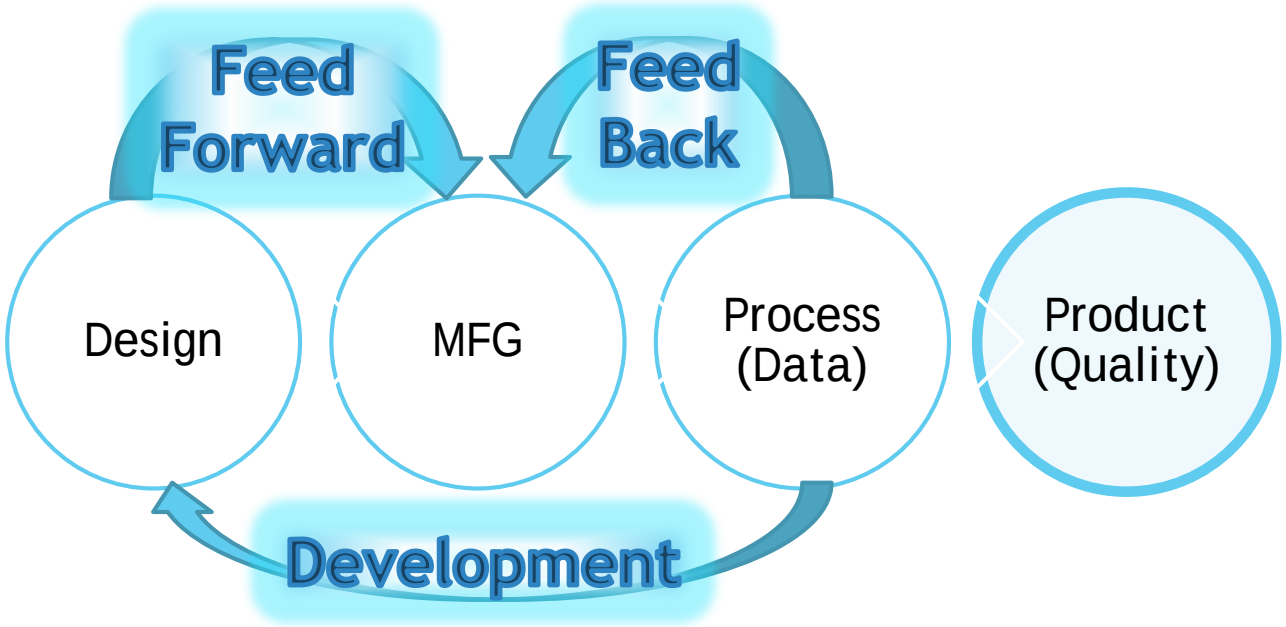
- This panel includes: feedback and feedforward models, thermal modeling, constitutive models, molecular modeling, etc.
- Panelists: Slade Gardner (Slade Gardner Advanced Manufacturing and Materials), Peter Olmsted (Georgetown University), and David Roberson (University of Texas - El Paso)
- Moderator: Kalman Migler (NIST)
- Questions: What types of models are required to achieve fundamental understanding of AM processes; to enable real-time control? What types of input data are required?

Purpose for Process Models

- **Commercialization & adoption of polymers-based additive manufacturing**
- Quality Manufacturing - Achieve design intent through processing
  - Design intent is evolving through generative optimization methods
  - Unique designs require agnostic, reliable and flexible verification – fundamentals
- Quality Control – Production according to established metrics
  - Uniformity and consistency throughout part
  - Part to part consistency
- Quality Assurance – Defect prevention / confidence: requirements will be fulfilled
  - Fit for purpose - product suitable for intended purpose
  - Right first time - mistakes eliminated
  - Management of raw materials, equipment and components, processes related to production and verification processes
  - Certification data according to manufacturing quality metrics
- Standards for Measurement, Verification and Models

Generalized Perspective

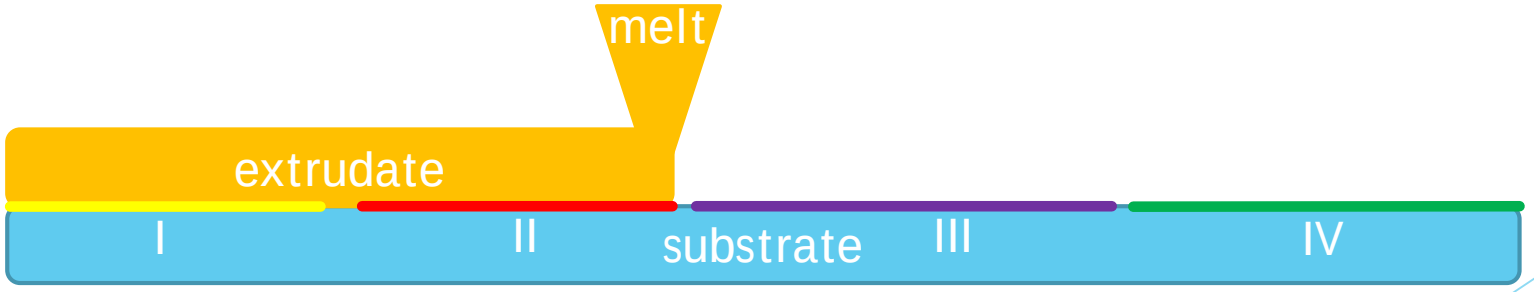
- **Feed Forward – model predictions to guide process**
  - Physics based modeling
  - Process analysis/simulation (multi-scale)
- **Feed Back – measurement of process variables to guide control input**
  - Discrete, Batch and Continuous
  - PLC → multi note sensor network feeding artificial intelligent processor



Process Parameters

- Quality is goal
  - Dimensional control
  - Flow and stability
  - Rheology
  - Thermal History
  - Adhesion (ΔT_g)
  - Bonding / Interdiffusion
  - Chemistry / Composition
- Sensors and Measurement
- Response Time
- Practical Utility of Data

- Melt
  - (II) temperature and flow rate
  - (I) motion control
- Extrudate
  - (II) interaction with melt
  - (I) temperature history
- Substrate
  - (III) preparation for interdiffusion
  - (IV) sensing and measurement



Complications to consider

- Size / Scale
- Complexity
- Path and Design
- Starts / Stops
- Turns and Bends
- Trapped Geometry
- Dimensions (integer thickness)
- Surface Features
- Surface Finish
- Distortion / Thermal Balance
- Multi Material
- Integrated Components
- Atmosphere / Environment