Toward Manufacturing Sustainability: A Multiscale Complex Systems Approach

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# Manufacturing Sustainability: A Need to Re-engineer Engineering Systems



## Advanced Manufacturing Tech's May Not Be Sustainable

### **Example: Nanocoating under question on EHS**





# **Manufacturing Sustainability Study**

### We need to know:

- where we are?
- what the next goal is?
- what the path is?
- what the investment will be?
- how long it will take?



# **Sciences Sustainability Study**



## **Integrated Material-Product-Process Design**

meso-

time

 Development of functional materials and life-cycle-based sustainability assessment and decision making

micro-

ength

#### Features:

Complexity (integrated development, assessment criteria, etc.)
Uncertainty (correlation identification)

macro.

## **Product and Process Sustainability**

meso-

time

- Complex polygeneration system design and deployment
- Energy/renewable energy manufacturing

micro

length

**Challenges** 

 Complexity (structural, design, management)
Uncertainty (supply chain, policy, etc.)

macro.

## Large-scale Industrial Sustainability

meso.

time

- Industrial zonal development triple-bottom-line based value chain
- Distributed biodiesel mfg planning

micro

ength

### <u>Challenges</u>

Complexity (structural, competing plans, etc.)
Uncertainty (information, prediction, etc.)

macro

## **Sustainable Design of Nanocoatings**



Material

Product



# Summary

- Manufacturing sustainability: essential to the success of manufacturing advancement
- Multiscale sustainability: ranging from nanoscale material design to large-scale industrial system management
- Sustainability assessment: an urgent task for all industries
- Sustainable development: collaboration, synergy