Competency Based
Nanotechnology Curriculum

Foothill College
Nanotechnology Program
Our Program

• **STEM foundation and goals**  
  – Building engineering skills for life

• **Nanotechnology** core

• Disciplines / applications

• **Competency based program design**  
  – Survey driven
  – **KSA / SLO alignment**
  – Industry **competencies**
Survey of Nano Industry

- 40 companies
- 10 verticals
- 20,000 total jobs
- 25 to 50% annual growth
- Industry transformation
- Job transformation
  - Skills are changing as fast as industry!
Target Industry Sectors

- Semiconductors
  – nanoelectronics
- Fabrication (Si fabs)
- Surfaces and thin films
- Characterization
- Biotechnology
- MEMS and sensors
- Energy (cleantech)
Careers / Requirements

• 4 yr degree (or more)
  – Science / technology
• Industry experience
• Interdisciplinary skills
  – Problem solving
  – Critical thinking
• Communication
  – Verbal, writing
  – Interdisciplinary
Multidisciplinary Skills

• Foundation knowledge
  – Chemistry
  – Biology
  – Math
  – Physics
  – Engineering

• Specialization in:
  – Biotech, electronics,
    materials, fabrication

It’s all of the foundation subjects, with key competencies
Nanotech Competencies

- Nanofabrication competency
- Materials characterization / modeling
- Surfaces and thin films
- MEMS devices and sensors
- Semiconductors and nanoelectronics
- Nanobiotechnology competency
Nanofabrication

- Silicon fabrication
- Polymer fabrication
- Metals and alloys
- Ceramics and glasses
- Semiconductor theory
- Process competency
- Lab safety
Materials Characterization

- **Analytical / characterization**
  - Surface and image analysis
  - Organic analysis and characterization

- **Modeling**
  - Physical and *molecular modeling*
  - Computer skills and *informatics*

- **Problem solving**
  - Failure analysis, need process knowledge
Surfaces and Thin Films

- Surface *states and processes*
- Surface *chemistry* and derivatization
  - Laboratory work in wet and dry techniques
- Surface *analytical techniques*
- Thin film *applications and design*
- Thin film *deposition techniques*
- Thin film *characterization* techniques
MEMS Devices and Sensors

- Knowledge of MEMS applications
- Knowledge of MEMS *design* and function
- MEMS *design skills* / CAD / fabless IC
- *Sensor* and *biosensor applications*
- Silicon and non-silicon MEMS processing
- *Integration of IT and MEMS*
  - Extending nanotechnology
Nanobiotechnology

- **Cell** and *molecular biology*
- DNA *sequencing* / analysis
- Protein *structure modeling*
- *DNA microarray* / gene expression and SNP analysis (*bioinformatics skills*)
- DNA microarray *design* and *fabrication*
- *Self-assembly*
  - Proteins and DNA *templating* / *modeling*
Myth of Technicians

• There are technicians…
• But…
• Half have BS degrees
• Many are scientists / engineers
• Only 25% of most ‘nano companies’
• Need a strong STEM foundation
  – And a lot of experience!
Nanotechnicians

• 2005 FHDA nanosurvey results
• Nanotechnicians are valuable if they:
  – Understand *nanostructured materials*
  – Are able to *run and optimize a process*
  – Can *tune instruments and equipment*
• Many assist scientists and engineers
  – Often work in *R&D and manufacturing*
  – Often work as *junior scientists / engineers*
Aligning Competencies & KSA Learning Outcomes

1. Map competencies into an ontology
2. Organize topics / learning outcomes
3. Create course objects with key SLOs
4. Certificate is based on competencies
5. Organized by clusters of courses
6. Use scenario based learning models
### Mapping Work Skills to KSA Learning Outcomes

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<tr>
<th>Work</th>
<th>Curriculum</th>
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<tr>
<td>Task 1 (K&amp;S)</td>
<td>Learning Object 1</td>
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<td>Task 2 (K&amp;S)</td>
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<td>Task 3 (K&amp;S)</td>
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<td>Knowledge 1</td>
<td>Learning Object 2</td>
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NSF Proposal Oct / 2004
Science (Domain know-how)

Competencies

Engineering (Process know-how)

Aggregate Technology

Practice

Multidisciplinary Knowledge

Individual abilities (know-how)

Interdisciplinary Skills

Concept by FHDA / Taxonomize
STEM Foundation

• Science – *why things work*
• Technology – *tools for the future*
• Engineering – *how things work*
• Mathematics – *reasoning / analysis*
• Building a *pipeline* for our partners
• Building a *sound foundation* for life

*Technicians need lifelong learning skills!*
Physics, Biology, and Chemistry Meet in Nanotechnology

Source: VDI-Technology Center, Future Technologies Division
## Multi-tiered Curriculum

<table>
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<tr>
<th>Internship / project based learning / thesis</th>
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<td>Materials</td>
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Nanotechnology Layer

Foundation subjects in science / engineering
**FHDA Nano Certificate**

- Survey course
- Materials science
- Characterization
- Surfaces / Thin Films
- Nanoelectronics
- Fabrication (lec)
- Fabrication (lab)
- MEMS / Sensors
- Nanobiotechnology
- Internship / project

Ten courses of which 3-4 can be *competency clustered*

Certificate will be topic mapped for coordination with CSU

‘Intro to Materials Science’ may be a corequisite
Innovation Value Chain

- **Science**
- **Engineering**
- **Technology**
- **Manufacturing**

- From R&D to final assembly
  - Convergence of **Science**, **Engineering**, **Technology**, and **Manufacturing** *unifies* the innovation value chain
  - *Maintains regional ownership of IP & innovation*
SETM Innovation

- **Science** - discovery
- **Engineering** - development
- **Technology** – process and products
- **Manufacturing** – capturing value
- **Innovation value chain**
  - *SETM in nanotechnology is critical*
  - *SET-M may not have long-lived value*
SETM Model of Innovation

The Innovation Value Chain is a Dynamic Process
SETM Based Curriculum

- **Science** - knowledge
- **Engineering** - skills
- **Technology** - competency
- **Manufacturing** – practice
- **Scenario based** – around a challenge
  - Energy, clean water, food, health / medicine, advanced materials / transportation / space

*Nanomanufacturing* – *we need to make things with high $ value!*

CA Manufacturing Revisited

- California *industries / competencies*
- *MEMS* and sensor technology
- *Nanobio* / molecular manufacturing
- *Microarray platform technologies*
- *Thin films / surface engineering*
- Energy / *clean technology* ($3 \times 10^{12}$)

*There is no reason to be 2nd in engineering / manufacturing!*
Competent Partners

- SJSU / UCSC
- Stanford University
- SRI
- NASA Ames
- IEEE
- Industry partners
  - Modeling and characterization

The key to your program is building a competent team!
Nano Program Summary

- **Survey driven** process
- **Competency based cores**
- Align nano course **SLOs**
- Program has 5 or 6 ‘**cores**’
- Based on **STEM**
- Supporting **SETM**

Nano technicians need STEM skills for life!