3D Printing-Additive Manufacturing and Nano Technology

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3D Printing Background

- 1984 Charles W. Hull invented the first 3D printer – Birth of 3D Printing
- First Patent was filed in 12/8/1989.
- First objects were made of plastic
- 1999 – 3D printer used in organ creation
- In 2013 became popular with former President Obama "3D printing has the potential to revolutionize the way we make almost everything and is the next revolution in manufacturing."
- Other will say it's the next industrial revolution, based on layer by layer production.
- It's called additive manufacturing
- Cost reduction helped its expansion, and patents expiration.

STRATASYS J750

- Polyjet 3D printer Works similarly to Inkjet printing
- Instead of jetting drops of ink onto paper, PolyJet 3D Printers jet layers of curable liquid photopolymer onto a build tray.

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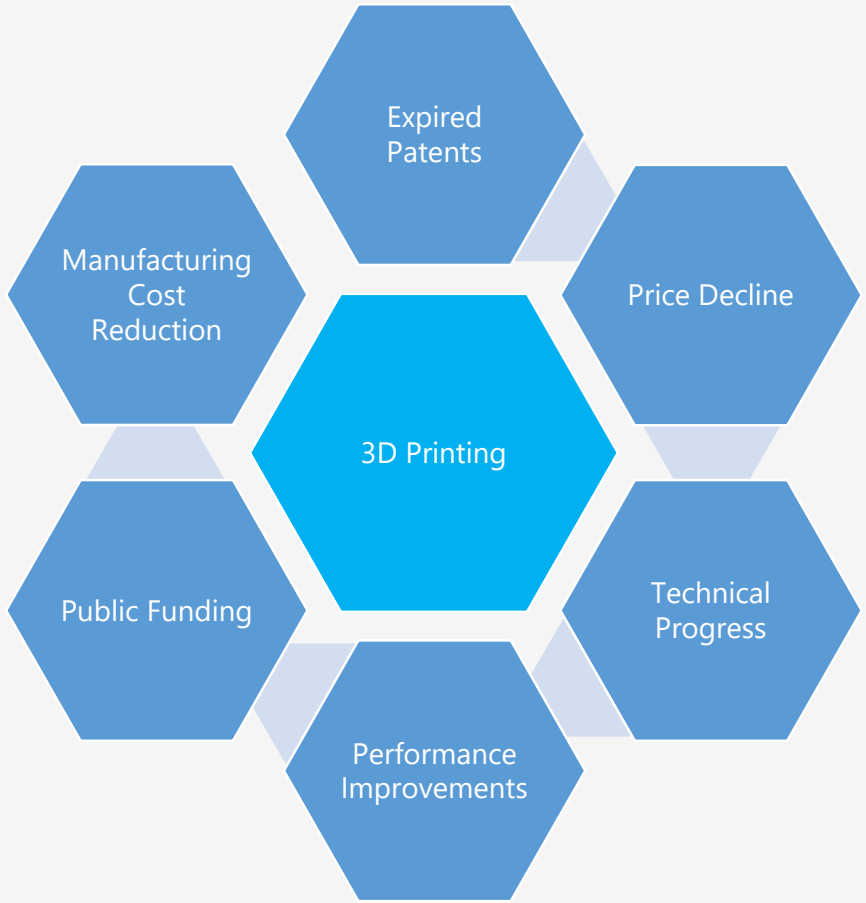
3D Printing R&D Investment

- $245 Million by the Chinese Government over 7 years. (in 2013)
- $400 Million by Singapore over 5 year project. (in 2013)
- $140 Million by USA to build two new research centers. (2014)
- R&D research investment will grow by 20% annually
- In 2020 US 3D printing market will be valued at $6.6 Billion



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SWOT ANALYSIS

Strengths:

1. Less Materials (based on the filling %) = Less Waste (important environmentally) = Light Weight Material
2. Reduce time of product development: prototyping and time reduction
3. Redesigning Old & Creating New Ergonomic products and Designs = Faster, Lighter, Stronger, Safer, Less Expensive
4. Maintaining electronic components.
5. Protecting from external environment and potential mechanical damage, temperature variation and corrosion of materials
6. Cost effective customization, one-offs.
7. Made-To-Order. Accelerating & Transforming Supply Chain, Reduces Inventory and Return Costs

SWOT ANALYSIS

Weaknesses:

1. Speed of production
2. Mass-production
3. Size of product
4. Material cost.
5. Knowledge Cost (Skilled personnel required to program the design).
6. Investment in R&D.

SWOT ANALYSIS

Opportunities:

1. Multiple industries will benefit from it (Cars – Aerospace – Medical – Clothing – Semiconductor – Food – Construction - …)
2. Large market (specially consumer market)
3. Future Innovations, specially in design (Optometry industry)
4. Cost reduction
5. Knowledge Cost (Skilled personnel required to program and design).
6. Investment in R&D.
7. Made-To-Order. Replace traditional industries.

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SWOT ANALYSIS

Threats:

1. Legal – Patent, Copyright and Trademark Issues
2. Nanoparticles emission health and environmental concerns (between 20 and 200 billion ultrafine particles per minute (UFPs))
3. Accessibility to consumer – fabricate on-site instead of buying from supplier
4. Build your own
5. Market Saturation
6. Impact of 3D printed food and biomedical implants on health are currently unknown.
7. Is Industry adaptation fast enough?

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3D-Printing with Nanoparticles

1. Nanoparticles may be used with 3D printed parts in order to limit defects and strengthen structures

2. The addition of nanoparticles solves some of the problems but causes others like particle “agglomeration”

3. 3D printing overcomes problems associated with other fabrication methods because very complex structures are created in incremental tiny layers

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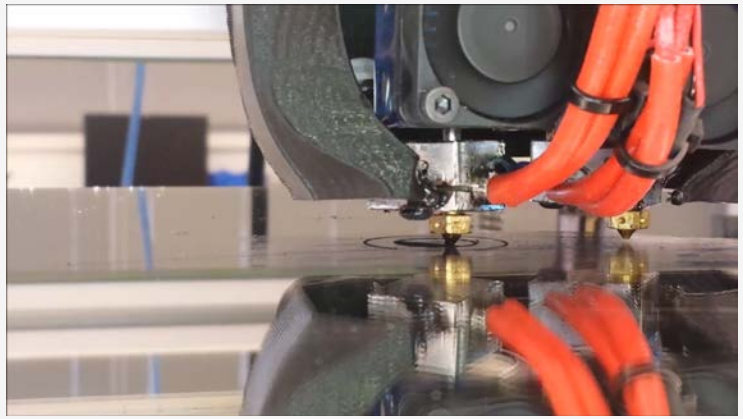
Area of Research (Smith Woosley)

- Fused deposition modeling (FDM) 3D printing
  - Traditional FDM printing uses thermoplastic polymers with no inherent functional characteristics
  - By adding nanomaterials with varied functions (electrical conductivity, bacterial resistance, radiation shielding) we can transform FDM 3D printing into a more complete manufacturing technology



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Research Goals

- Develop a method to incorporate nanomaterials uniformly within thermoplastic printer filaments
- Determine appropriate additive load percentages
- Analyze resulting material
  - Microscopy – Optical / SEM / EDX / TEM
  - Thermal Analysis – DSC / TGA / DMA
  - Mechanical Analysis – Tensile Test / Fracture Analysis
- Perform test prints to show minimum feature size, resolution, and to assess printability performance
- Prove functionality by successfully fulfilling applications with printed nanocomposite materials

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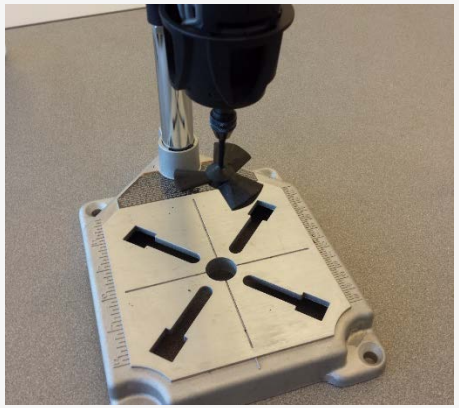
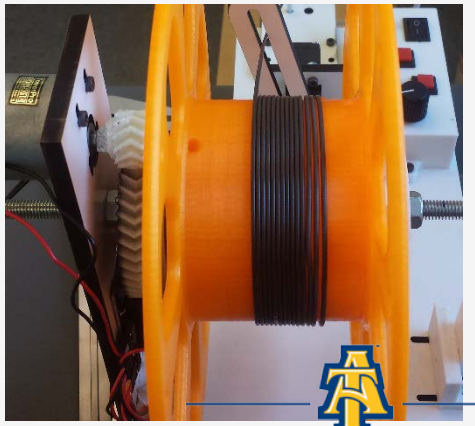
Composite Fabrication

- Solution processing : Dissolve polymer, mix in additive, evaporate solvent



- Filament Extrusion : Grind dried material to powder, extrude filament



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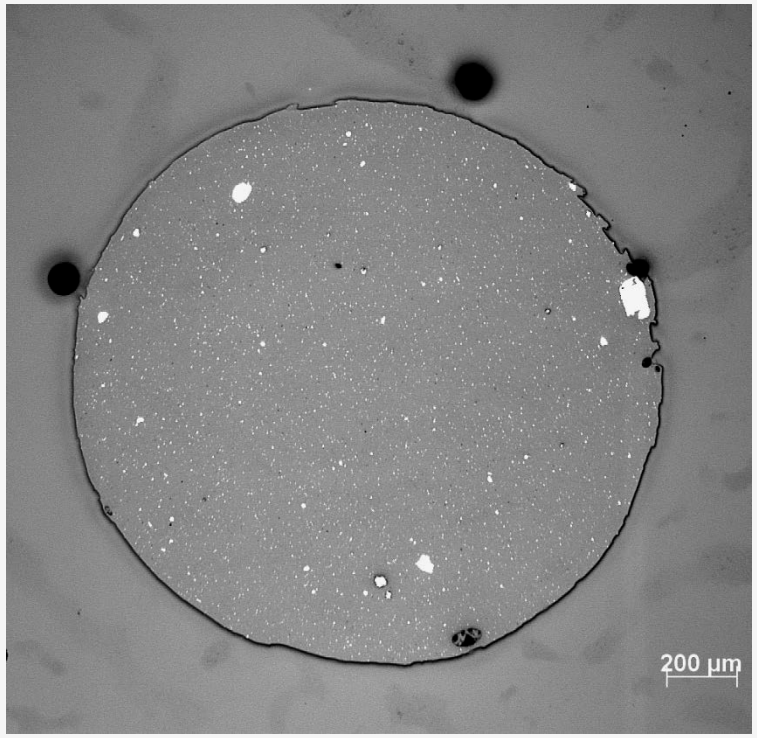
Fabricated Composites

Additive Material	Morphology	Size	Polymer Matrix	Functionality
Nickel	Spherical Particles	< 100 nm	ABS	Magnetism
Carbon Black	Amorphous	~ 40-100 nm	ABS	Electrical Conductivity
Graphene	Platelets	5 µm	ABS	Energy Storage
Carbon Nanotubes	Nanotubes	10 nm x 5 µm	PCL	Mechanical Strength
Iron Oxide	Spherical Particles	30 – 50 nm	ABS	Bacterial Resistance
Boron Nitride	Hexagonal Particles	70 – 80 nm	ABS	Radiation Shielding

Nanonickle / ABS Composites

- Magnetic Functionality

5%



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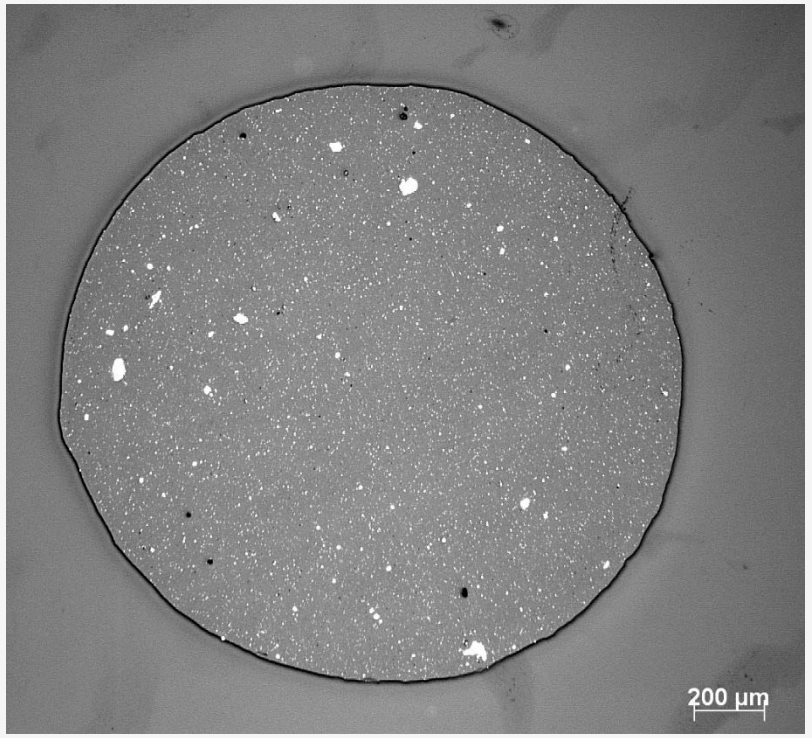

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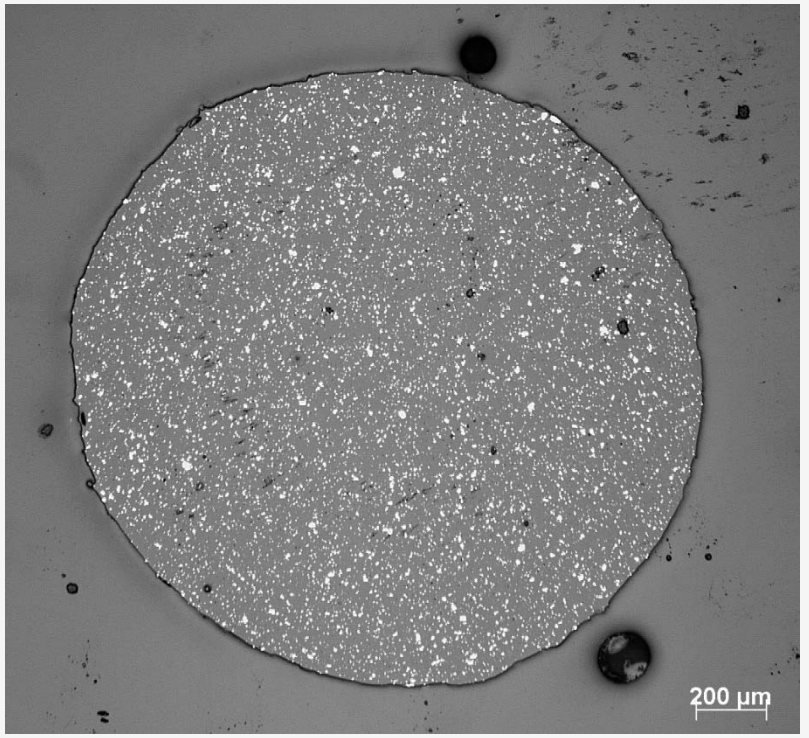

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Nanonickle / ABS Composites

- Magnetic Functionality

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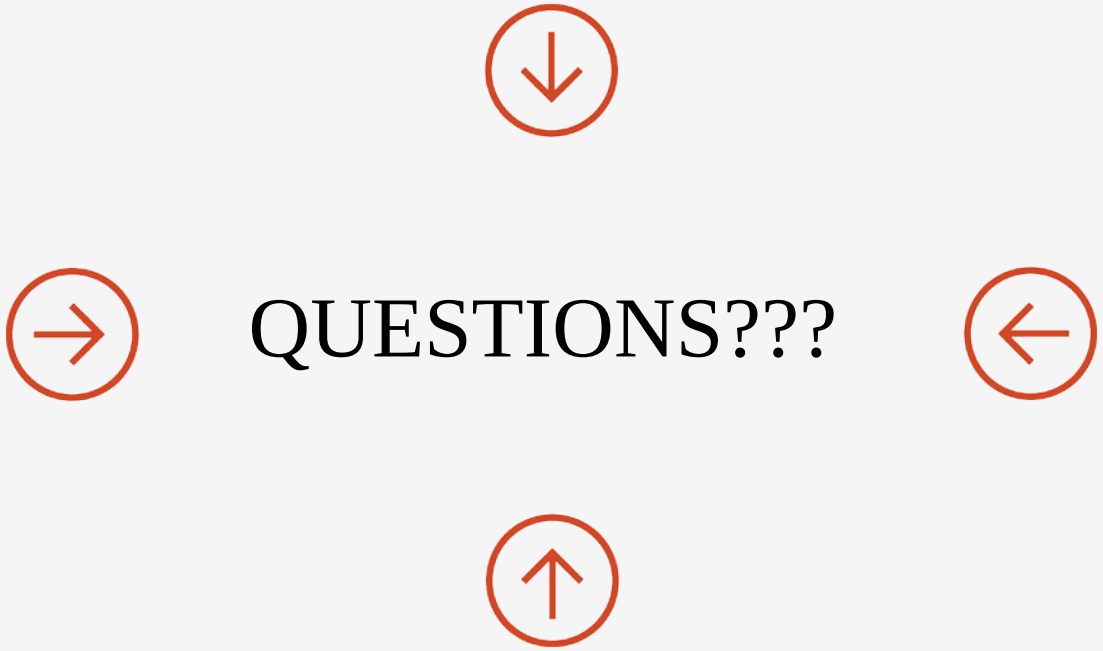
Thank You!



QUESTIONS???

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