Frost & Sullivan: 4-D Printing to Usher in Age of Low-Labor, Fast-Paced Product Manufacturing

Research PREVIEW for

Advances in 4-D Printing
(D545-TI)
Nine Dimensional Analysis of Technology Assessment

- **Market Potential**
  - Market potential in terms of growth opportunities

- **Global Footprint**
  - Global development and adoption - North America, Asia Pacific, Europe

- **Potential Points of Convergence**
  - Convergence of technologies leading to new product development, new markets, new business models

- **Size of Innovation Ecosystem**
  - Strength of innovation ecosystem and stakeholder initiatives

- **Year of Impact**
  - Commercialization
  - Widescale Adoption

- **IP Activity**
  - Assessment of the intellectual property (IP) activity for 4D printing across the globe to identify innovation trends

- **Impact on Megatrend**
  - Impact of the 4D printing technology on various megatrends

- **Funding**
  - Analysis of funding activities across the globe for 4D printing technology to derive trends

- **Breadth of Industries**
  - Applications /industries impacted

Source: Frost & Sullivan analysis
Target Markets and Key Applications

**Target Markets**

- **Health Care**
  - Tissue engineering
  - Self-assembling human-scale biomaterials
  - Design of nanoparticles
  - Nanorobots for chemotherapy

- **Automotive**
  - Coatings that can adapt to the environment
  - Complex metal parts/ systems made more efficiently
  - Automotive body parts using programmable materials
  - Plastic parts used in automobiles

- **Aerospace**
  - Self-repairing parts or planes
  - Solar panels to power satellites
  - Composites that can change shape

- **Military/Defense**
  - Textile with camouflage capabilities
  - Creation of shelters using water
  - Self-healing materials for building bridges and temporary roads in remote locations

*Source: Frost & Sullivan analysis*
Growth Drivers and Industry Challenges

**Short Term**

- **Government and Private Support**
  Considering the potential breadth of applications of 4D printing in various markets, government and private sectors are providing financial support through grants for development. The United States Army Research Office has already given a grant to a few US universities for conducting research on this technology. This would help researchers to further develop this technology that could be used in various applications in, for example, the defense sector and also in the health care and automobile sectors. Several private companies in United States, such as Stratasys and Autodesk, have also established a partnership with MIT to aid in the research.

- **Medium to Long Term**
  - **Reduction in Manufacturing and Process Cost**
    Manufacturing industries worldwide continuously monitor developments in novel materials and processes that reduce time and cost incurred for developing products. This can be achieved with 4D printing technology. As it is possible to manufacture and use products straight from the printer bed, need for resources such as time and human labor is eliminated, which increases production efficiency. Also, this technology allows designers to translate product designs directly into the real product when it is manufactured. This results in reduced product failures, thereby reducing cost incurred in the quality checking of the product being manufactured. As manufacturing parts with 4D printing is largely based on optimized computer-aided design (CAD) models and virtual image models, it helps reduce cost incurred for manufacturing.

**Short Term**

- **High Initial Cost**
  As with any new technology, the cost of developing and incorporating materials and techniques that enable 4D printing technology in various industrial sectors is expected to be high as only a select few companies are currently developing 4D printing techniques capable of supporting this technology. For instance, when a manufacturing entity is planning to manufacture large products using 4D printing, it would be difficult for them to locate the company that would provide the technology for carrying out the task. The initial price of the products that are produced using 4D printing may tend to be significantly high considering the high initial investment and moderately low production volumes.

**Medium to Long Term**

- **Standardization**
  Commercialization of products manufactured using 4D printing technology for the health-care, aerospace, and military/defense sectors might take longer due to the stringent regulatory or performance standards in these sectors.

Source: Frost & Sullivan analysis
4D Printing—Versatile Applications

The primary benefits of 4D printing are increased capabilities of the products being manufactured, potential for new applications from adaptive materials, increased efficiency in manufacturing, and reduction in manufacturing cost and carbon footprint. 4D printing can have the potential to be used for a wide range of applications in different industrial sectors, which would help manufacturers to generate products that meet the growing needs of customers.
## Contents

<table>
<thead>
<tr>
<th>Topic</th>
<th>Slide No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive Summary</td>
<td>3</td>
</tr>
<tr>
<td>Technology Landscape</td>
<td>7</td>
</tr>
<tr>
<td>Year of Impact</td>
<td>13</td>
</tr>
<tr>
<td>IP Activity</td>
<td>16</td>
</tr>
<tr>
<td>Funding</td>
<td>19</td>
</tr>
<tr>
<td>Breadth of Industries</td>
<td>23</td>
</tr>
<tr>
<td>Impact on Megatrends</td>
<td>26</td>
</tr>
<tr>
<td>Size of Innovation Ecosystem</td>
<td>28</td>
</tr>
<tr>
<td>Global Footprint</td>
<td>31</td>
</tr>
<tr>
<td>Potential Points of Convergence</td>
<td>34</td>
</tr>
<tr>
<td>Market Potential</td>
<td>36</td>
</tr>
<tr>
<td>Key Conclusions and Strategic Insights</td>
<td>38</td>
</tr>
<tr>
<td>Key Patents and Contacts</td>
<td>41</td>
</tr>
<tr>
<td>The Frost &amp; Sullivan Story</td>
<td>46</td>
</tr>
</tbody>
</table>
Interested in Full Access? Connect With Us

Ariel Brown
Associate
Corporate Communications
(210) 247-2481
Ariel.brown@frost.com

Research Authors
Jithendranath Rabindranath
Research Analyst
Technical Insights

Twitter
https://twitter.com/Frost_Sullivan

LinkedIn Group
https://www.linkedin.com/company/frost-&-sullivan

SlideShare
http://www.slideshare.net/FrostandSullivan

Facebook
https://www.facebook.com/FrostandSullivan

Frost & Sullivan Events
http://bit.ly/1lpWmeE

GIL Community
http://visionary-it.gilcommunity.com/
Associated Multimedia

Analyst Briefing
Enabling Materials for 3D Printing
http://bit.ly/1j9akCD

Market Insight Articles
3D Printing “Now At Your Service”
http://bit.ly/1yrLKOO

SlideShare Presentation
Internet of Things and Smart Manufacturing
http://slidesha.re/1sURTm2
Global Perspective
40+ Offices Monitoring for Opportunities and Challenges
Industry Convergence
Comprehensive Industry Coverage Sparks Innovation Opportunities

Aerospace & Defense
Measurement & Instrumentation
Consumer Technologies
Information & Communication Technologies

Automotive
Energy & Power Systems
Environment & Building Technologies
Healthcare

Transportation & Logistics
Minerals & Mining
Chemicals, Materials & Food
Electronics & Security
Industrial Automation & Process Control