How Advances in Stereolithography Technology and Resins Can Speed up Your Product Development

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Presenting:
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Beth Ficek PhD
DSM Functional Materials

www.somosmedical.com
Outline:

• What is Stereolithography (SL)?
• The Stereolithography Process
• Somos® Materials
• Case studies
What is Stereolithography (SL)

Stereolithography, a subset of additive manufacturing, is a process that gives you the ability to replicate/create any computer designed article into a solid 3-Dimensional object within hours.
What is Stereolithography (SL)?
Stereolithography can produce parts of all sizes

<table>
<thead>
<tr>
<th>Very Large</th>
<th>Very Small</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Life-Size Replica!</strong></td>
<td><strong>Micro-Resolution</strong></td>
</tr>
<tr>
<td>Materialise</td>
<td>Best-in-Class Small Feature Capability</td>
</tr>
<tr>
<td>- Machines hold up to 1.5 MT of resin</td>
<td>- Real Ant !!!</td>
</tr>
<tr>
<td>- Machines can produce full size statues, automobile dashboards, etc</td>
<td></td>
</tr>
<tr>
<td>FineLine Prototyping, Inc.</td>
<td></td>
</tr>
<tr>
<td>- Capable of features as small as 40 microns in the drawing plane</td>
<td></td>
</tr>
<tr>
<td>- Build with 25 micron layers.</td>
<td></td>
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</tbody>
</table>
What is Stereolithography (SL)?

Stereolithography can produce complex parts

• SL accuracy allows for complex fit testing
• SL process allows for building of internal structure and spaces
Outline:

• What is Stereolithography (SL)?
  - A process that can create almost any size or shaped parts quickly

• The Stereolithography Process

• Somos® Materials

• Case studies
The Stereolithography Process

In-house Machines and Service Bureaus

DSM can help you find the best/most efficient way to make your parts a reality!

• **Machines**
  - Speeds up production
  - Variable sizes

• **Service Bureaus**
  - No capital investment
  - SL expertise
**The Stereolithography Process**

**Part Design**

- **CAD**
  - Traditional engineering approach
  - Convert to .stl format for SL use

- **MRI, CT-scans**
  - Create 3D images for SL use
  - *Mimics software from Materialise*
    - Segmented data to 3D data for models and visualizations
The Stereolithography Process

Advances in Software: Mimics Software

- Scan data to 3D parts
- Once in 3D form other engineering can be performed
  - Guides, plates, etc.

CT or MRI Scan → 2-D Cross Sections → 3D models → Mimics
Magics (Materialise)

- Very useful to “fix” files
  - Bad files
  - Holes
  - Stray triangles

- Can be used to increase efficiency
  - Auto part placement
  - Nesting
  - Part labeling
  - Supports
The Stereolithography Process

Traditional SL Software

• 3D Lightyear/Buildstation
  - Processes .stl files into files required by the machine for building
  - Allows direct communication with the machine during build
  - User friendly when compared to other additive manufacturing software
The Stereolithography Process
SL in action

- Laser draws 2D image on resin surface
- Platform lowers for each layer to produce 3-dimensional part

[Image of laser drawing on resin surface]
The Stereolithography Process

Post Processing

• Part cleaning
  - Liquid resin must be removed
  - Requires solvents
    • Glycol Ethers
    • IPA

• Support removal
  - Normally requires minimal effort
  - Complex geometries require innovate techniques
The Stereolithography Process

Post Processing

• Basic Finishing
  - SRO (support removal only)
    • Common for basic models
  - Engineering review
    • SRO w/ all layer lines removed
  - Clear coat finish
    • Used for optimal clarity
The Stereolithography Process
Advances in post processing

- Advanced Finishing
  - Polish/Clear coat
    - Mainly for “lens” applications
  - Paint/Dye
    - Show model
    - Functional piece
Outline:

• What is Stereolithography (SL)?
  - A process that can create almost any size or shaped parts quickly

• The Stereolithography Process
  - Can use service providers or in-house equipment
  - Advances in software make designing parts easier
  - Finishing SL parts can visually enhance their appearance

• Somos® Materials

• Case studies
SOMOS® Materials
SL material development expands opportunities

SOMOS®
Materials

Design, Visualization
Planning for Manufacture
Testing
Tooling for Manufacture

Material Properties

Acrylates
Epoxides

Somos® specialty designed SL materials which can mimic thermosets, ceramics, and metals
<table>
<thead>
<tr>
<th>Material</th>
<th>Benefits/Type</th>
<th>Appearance</th>
<th>Viscosity cps @ 30°C</th>
<th>Photospeed E10 mJ/cm²</th>
<th>Tensile Modulus MPa</th>
<th>Tensile Strength MPa</th>
<th>Elongation at Break %</th>
<th>Notched Izod J/cm</th>
<th>Impact @0.46MPa, °C, UV (+TPC)*</th>
<th>HDT @0.46MPa, °C, UV (+TPC)*</th>
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</thead>
<tbody>
<tr>
<td>Somos 8110/8120</td>
<td>Flexible, PE-like</td>
<td>Translucent</td>
<td>600/600</td>
<td>40/35</td>
<td>317/690</td>
<td>26.0/26.0</td>
<td>27.0/27.0</td>
<td>0.87/0.59</td>
<td>54/54</td>
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<td>Somos 9110/9120</td>
<td>All-Purpose, PP-like</td>
<td>Translucent</td>
<td>230/450</td>
<td>55/65</td>
<td>1,590/1,350</td>
<td>31.0/31.0</td>
<td>18.0/21.0</td>
<td>0.55/0.51</td>
<td>50/57</td>
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<tr>
<td>Somos 9420</td>
<td>Robust, PP-like</td>
<td>White</td>
<td>475</td>
<td>95</td>
<td>700</td>
<td>18.5</td>
<td>28.0</td>
<td>0.46</td>
<td>49</td>
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<td>ProtoTherm™ 12110/12120</td>
<td>High Temp Tolerant, ABS-like</td>
<td>Clear, Red</td>
<td>410/550</td>
<td>75/63</td>
<td>3,430/3,520</td>
<td>57.6/70.2</td>
<td>5.0/4.0</td>
<td>0.12/0.12</td>
<td>53 (155)/56 (126)</td>
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<td>Somos 14120</td>
<td>All-Purpose, ABS-like</td>
<td>White</td>
<td>240</td>
<td>64</td>
<td>2,460</td>
<td>45.7</td>
<td>7.9</td>
<td>0.24</td>
<td>53</td>
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<tr>
<td>NanoForm™ 15120</td>
<td>Accurate ProtoComposite™</td>
<td>Gray</td>
<td>570</td>
<td>112</td>
<td>5,000</td>
<td>48.0</td>
<td>2.1</td>
<td>0.15</td>
<td>66 (269)</td>
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<tr>
<td>NanoTool™</td>
<td>Accurate, Ceramic-like ProtoComposite™</td>
<td>White</td>
<td>2,500</td>
<td>84</td>
<td>11,200</td>
<td>69.9</td>
<td>0.9</td>
<td>0.14</td>
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<td>300</td>
<td>57</td>
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<td>ProtoGen™ 18920</td>
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<td>Gray</td>
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<td>76</td>
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<td>ProtoCast™ AF 19122</td>
<td>Low ash, Antimony-free for Investment Casting</td>
<td>Clear, Peach</td>
<td>100</td>
<td>85</td>
<td>2,100</td>
<td>44.9</td>
<td>6.1</td>
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<tr>
<td>DMX-SL™ 100</td>
<td>Tough &amp; Durable, ABS-like</td>
<td>Off-White</td>
<td>1,500</td>
<td>92</td>
<td>2,410</td>
<td>30.9</td>
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<tr>
<td>WaterShed® XC 11112/11122</td>
<td>Clear, Water-Resistant, ABS-like</td>
<td>Clear, Near Colorless</td>
<td>150/260</td>
<td>72/54</td>
<td>2,640/2,765</td>
<td>48.3/50.4</td>
<td>25.0/16.0</td>
<td>0.19/0.3</td>
<td>50/50</td>
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<tr>
<td>WaterClear® Ultra 10122</td>
<td>Optically Clear, Colorless</td>
<td>Clear, Colorless</td>
<td>165</td>
<td>46</td>
<td>2,880</td>
<td>55.5</td>
<td>8.0</td>
<td>0.25</td>
<td>47 (60)</td>
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<tr>
<td>Somos NeXt</td>
<td>Durable, Water Resistant, ABS-like</td>
<td>White</td>
<td>1000</td>
<td>67</td>
<td>2,500</td>
<td>44.0</td>
<td>10.0</td>
<td>0.52</td>
<td>57</td>
<td></td>
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* TPC: Thermal Postcure  
HDT: Heat Deflection Temperature  
*ProtoTherm, NanoForm, NanoTool, ProtoGen, DMX-SL, ProtoCast, and ProtoComposite are trademarks of DSM Somos.  
* WaterShed, WaterClear and Somos are registered trademarks of DSM Somos.
**SOMOS® Materials**

**Resin Types**

- **Toughest resin**
  - SOMOS® DMX-SL
  - SOMOS® NeXt

- **Clearest clear**
  - Best moisture resistance
  - Passes ISO 10993-5, ISO 10993-10
  - SOMOS® WaterShed XC
  - SOMOS® WaterClear

- **Fast, tunable, General purpose, Passes ISO 10993-5, ISO 10993-10**
  - SOMOS® ProtoGen

- **Lowest ash investment casting resin**
  - SOMOS® ProtoCast

- **Ceramic filled**
  - SOMOS® NanoTool

- **High Temperature Resin**
  - SOMOS® ProtoTherm
• SOMOS® DMX-SL: An initial product from a novel material platform toward engineering plastic performance for digital manufacturing

• Features high modulus with high toughness

• Exhibits “thermoplastic-like” yield characteristics

• SOMOS® NeXt - a second generation of tough material that combines toughness with better stability and water resistance
Optimized for High Clarity
Low Differential Shrink
Stable Viscosity & Color
SOMOS® Materials

SOMOS® WaterShed XC: Water Resistance

- Extreme low water absorption
- High dimensional stability
- High Clarity
- USP Class VI, ISO 10993-5 (cytotoxicity) & ISO 10993-10 (sensitization) certified

Water Absorption

Competitive
ABS-Like
SL Resins

SOMOS® WaterShed XC

Water Uptake

Time
• ABS Like RP Resin
• Very Fast and Accurate
• Very Low Differential Shrink
• HDT of 70 C Possible with Only UV Post Cure
• USP Class VI, ISO 10993-5 & ISO 10993-10 certified
• Utilized for wind tunnel testing models, rapid tooling and metal clad composites

• Stiffness and heat deflection temperature (HDT) performance 400% higher than typical unreinforced SL resins

• Exceptionally low water absorption

• Excellent dimensional accuracy

Injection models

Part from injection models
SOMOS® Materials

SOMOS® ProtoTherm: High temperature resin

- High temperature tolerant parts
- Heat Deflection Temperature of 126°C after post-treatment
- Very strong and stiff
SOMOS® Materials
SOMOS® ProtoCast: Investment casting

- Antimony Free Resin
- Foundry Tested

- High Stiffness
- Very Low Residual Ash

Side by Side Foundry Burn Out Comparison
Outline:

• What is Stereolithography (SL)?
  - A process that can create almost any size or shaped parts quickly

• The Stereolithography Process
  - Can use service providers or use in-house equipment
  - Advances in software make designing parts easier
  - Finishing SL parts can visually enhance SL part

• Somos® Materials
  - Not all resins are alike, there are a wide variety properties

• Case studies
Case Studies
Typical Stereolithography applications

- Visual aids
- Functional models
- Fit and assembly
- Patterns for silicone molding
- Investment casting patterns
- Tooling components
- Custom parts
- Prototyping
Case Studies
Stereolithography applications in medical

New SL resins with ISO 10993-5 (cytotoxicity), ISO 10993-10 (irritation and sensitivity), and USP Class VI certifications

- Anatomical Models
- Patient customized surgical/drill guides
- Medical devices
  - Customized
  - Prototypes

DSM is a supplier of SOMOS® stereolithography specialty materials and does not purport in any way to be a medical device manufacturer.
Stereolithography saves time and money. It’s fast, accurate and cost effective.

Investment Casting

Rapid Prototyping

Design
Case Studies
Chicago Architectural Foundation (CAF) Model City

Centennial of the Burnham Plan
Chicago’s 2009 Olympic bid

• 1400 buildings
• 50 feet:1 inch ratio
• 4 months timeline
Case Studies
Chicago Architectural Foundation (CAF) Model City
Showcasing speed over traditional methods

SL saved 4-8 months of intensive labor!

- Traditional method
  - Foam/wood model
  - Roughly 1400 models total to complete the city
  - Too much manual labor involved
    (8 months to a year)

- SL method
  - Data collection most labor intensive
    • Computer data for most buildings available online
      (Google Earth)
  - Building and finishing
    • 3 companies - 1400 models - < 4 months
  - Accuracy and surface finish
    • Spray primer only
    • Excellent feature resolution
Case Studies
Warrior Sports lacrosse head - functional prototype

SL saved months of testing and development

- Traditional method
  - Prototype parts were molded
    - Added cost for mold
    - Added time for mold to be produced

- SL method
  - Various prototype heads could be made at one time
    - Efficiency in prototype testing
  - Simulates typical thermoplastics for “real” testing
  - Changes can be made to 3D file easily and rebuilt on machine in hours
Case Studies
Varian Spatial Phantoms (micro-bore MR)

Functional design sped up production

• Traditional
  - Parts are molded from plastic
    • Limited feature size and detail

• SL Method
  - Part resolution
  - Functional designs could be made and tested independently through proper resin selection
  - Finished parts performed well in test environment
    • Water solution for 1 week plus
Case Studies
Symbient diagnostic lateral flow cartridge

Project was completed in less than four months

• Traditional
  - Machining from plastic
    • Too much time involved
    • Time = cost

• SL Method
  - Parallel designs tested at same time
  - Changes made could be implemented quickly
  - Decreased time to market
Summary

• What is Stereolithography (SL)?
  - A process that can create almost any size or shaped parts quickly

• The Stereolithography Process
  - Can use service providers or use in-house equipment
  - Advances in software make designing parts easier
  - Finishing SL parts can visually enhance SL part

• Somos® Materials
  - Not all resins are alike, there are a wide variety of properties available

• Case studies
  - Time and money savings
  - Decreased time to market
  - Shorten 510K time cycles
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