AUTOMOTIVE INTERIOR MATERIALS AND PROCESSES: EVOLVING TOWARD THE FUTURE

PRESENTED BY:
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PRESENTED AT:
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May 9, 2017
• New drivers and enablers for interiors technology

• Examples of materials/process innovation

• The Interiors technology maturity curve: Current status/future vision

• Interiors supply chain shifts

• Provide examples for:
  - “smart” as interiors innovation driver
  - foams
  - skins
  - filled and reinforced compounds
  - the human machine interface (HMI)
  - emerging processes

See materials/process abbreviations at end of presentation
<table>
<thead>
<tr>
<th>FEATURE</th>
<th>PLASTIC OR TPE TYPE</th>
<th>STATUS/ CURRENT MATL’S</th>
<th>NOTE/TARGETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft touch</td>
<td>SBC, TPO</td>
<td>Current(a)</td>
<td>2-shot molding helps drive innovation</td>
</tr>
<tr>
<td>Silky feel</td>
<td>SBC, s-TPV(b)</td>
<td>- Silicone-based</td>
<td>- Steering wheel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- s-TPV was first</td>
<td>- Other locations</td>
</tr>
<tr>
<td>Better seals</td>
<td>SBC, o-TPV</td>
<td>Improving</td>
<td></td>
</tr>
<tr>
<td>Lower hardness w/o</td>
<td>TPU, TPO, SBC</td>
<td>- TPO/SEBS starting</td>
<td>Coated fabrics</td>
</tr>
<tr>
<td>compromise</td>
<td></td>
<td>- TPU difficult</td>
<td></td>
</tr>
<tr>
<td>Smart surfaces</td>
<td>TPO,ETPs, conductives</td>
<td>Starting</td>
<td>Sensing and controls. Integrating printed circuits/electronics into moldings(c)</td>
</tr>
<tr>
<td>Scratch resistance</td>
<td>TPO, PP compounds</td>
<td>Steady gains</td>
<td>Has been a long term target</td>
</tr>
<tr>
<td>3D structural printing</td>
<td>ETPs, TPEs</td>
<td>Starting (MIT, others)</td>
<td>Vibration damping/structure control</td>
</tr>
<tr>
<td>Leather/textile look/feel</td>
<td>SBC, TPU, TPO</td>
<td>Getting there slowly</td>
<td>-IP, door trim</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-via injection</td>
</tr>
</tbody>
</table>

(a) Via coatings, some materials innovations/fabrication process innovation
(b) Via silicone-based s-TPV. Note combination of soft touch and silky feel
(c) For example from TactoTek

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2017
QUALITY SPECTRUM OF COCKPIT AND DOOR TRIM PANEL SKIN TECHNOLOGIES

INJECTION MOLDED SKIN/SUBSTRATE

SOURCE: KRATON; ROBERT ELLER ASSOCIATES LLC, 2017
AUTOMOTIVE PP TARGETS

AUTO SYSTEMS TARGETS

BODY/GLAZING SEALS*

BODY SEALS*

GLAZING SEALS*

HVAC

FLAPPER DOOR GASKETS

OTHER AIR DUCTS

EXTERIOR

FASCIA PANELS

INTERIOR(a)

BOOT/BELLOWS

HOSE/TUBE/DUCT(b)

ELECTRICAL

AIRBAG DOORS

COATED FABRIC

FLOOR SYSTEMS*

SKINS

SEVERAL PROCESSES

ACOUSTIC*

MATS*(c)

CARPET BACKING*

NOTES:

* = RUBBER/TPE INTERFACE

(a) DOES NOT INCLUDE RIGID-FILLED TPOs USED IN INTERIORS

(b) E.G., FUEL, COOLANT, OILS, OTHER HOSE

(c) HIGH GROWTH APPLICATION (in SEBS)/SBS

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2017
INTERIOR SOFT TRIM PROCESSES/MATERIALS: THE ACTION TODAY

**INJECTION**
- CONV. INJECTION
- 2-SHOT
- OVERMOLD
- BACK INJECTION
  - SOFT TOUCH PAINT
    - SEBS
    - TPV
    - TPU
  - COATED FABRIC
    - FOILS
    - UNCOATED FABRICS

**SKIN PROCESSES**
- SLUSH MOLD (CAST)
  - SEBS (TPE-S)
  - TPU
  - TPU BLENDS
  - PVC
  - TPO
- VAC FORM FOILS
  - SEBS (TPE-S)
  - TPU
  - TPU BLENDS
  - PVC
  - TPO
- THERMO-FORM
  - TPO
  - PVC
  - TPU ALLOY SHEET
- BACK INJECTION OR LOW PRESSURE MOLDING
  - BACK INJECTION (b)
  - HAND WRAP (a) OR VAC FORM

**COATED FABRICS**

**Note:**
- Indicates recent share gain, “smart” coatings could enter several material types
- (a) Polyurethane dispersion (PUD) coated fabrics gaining share, improved TPO grades and SEBS may challenge
- (b) Growth process

**SOURCE:** ROBERT ELLER ASSOCIATES LLC, 2016
STRUCTURAL AUTOMOTIVE CANDIDATES: CARBON FIBER/PP IN THE RUNNING

Materials Comparison

<table>
<thead>
<tr>
<th>Specific TS, MPa</th>
<th>Cost/cu. in., $</th>
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<tbody>
<tr>
<td>300</td>
<td>0</td>
</tr>
<tr>
<td>250</td>
<td>0.2</td>
</tr>
<tr>
<td>200</td>
<td>0.4</td>
</tr>
<tr>
<td>150</td>
<td>0.6</td>
</tr>
<tr>
<td>100</td>
<td>0.8</td>
</tr>
<tr>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>1.2</td>
</tr>
</tbody>
</table>

- Steel
- Aluminum
- Magnesium
- CF/Epoxy Prepreg
- SMC Ultralight
- SMC
- CF55 RTM
- LGF40PP DLFT
- LCF40PP DLFT
- LGF40PA66 DLFT
- SCF20PA66

SOURCE: ZUMHAGEN COMPANY LLC, 2017
# NAFTA/EUROPE FLOW: CHANGING THE AUTOPLASTICS SUPPLY CHAIN

<table>
<thead>
<tr>
<th></th>
<th>NAFTA/EUROPE</th>
<th>FLOW</th>
<th>ASIA</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OEMs</td>
<td>✈</td>
<td>TO BENEFIT FROM HIGH GROWTH POTENTIAL</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>RESIN SUPPLIERS/ COMPOUNDERS/MOLDERS</td>
<td>✈</td>
<td>TO FOLLOW OEM CUSTOMERS</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>TECHNOLOGY FLOW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>DOMESTICS ESTABLISH SUPPLY CHAIN TO SERVE WESTERN TRANSPLANTS</td>
<td></td>
<td>TECHNOLOGY BARRIERS ARE POROUS</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>VIA ACQUISITION/ GREENFIELD</td>
<td>←</td>
<td>ASIAN OEMs</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>SERVE WESTERN OEMs: - BUSINESS WON IN ASIA - EXPLOIT COST ADVANTAGE - VIA ACQUISITIONS?</td>
<td>←</td>
<td>ASIAN RESIN SUPPLIERS AND COMPOUNDERS</td>
<td>IS COST ADVANTAGE TRANSFERABLE?</td>
</tr>
</tbody>
</table>

**Source:** ROBERT ELLER ASSOCIATES LLC, 2017
• Paths to market:
  - Greenfield
  - Tolling
  - Distribution of imported compounds
  - Follow the customer

• Forces driving supplier transplants to NAFTA:
  - Access Western markets
  - Learn Western business/marketing skills
  - Access Western distribution channels (in some cases via tolling)
  - Employ large cash holdings from years of profitable operations in China
  - In some cases, serve existing customers in West that were developed in China
  - Access to rich, stable Western markets
  - Need for “global” presence

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2017
## IMPROVEMENT TARGETS IN INTERIOR COMPONENTS

<table>
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<tr>
<th>PROPERTY</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart skins</td>
<td>Luminescent skins, lighting function, transparent windows(b), sensing</td>
</tr>
<tr>
<td>Indentation recovery</td>
<td>Important for contact surfaces(a)</td>
</tr>
<tr>
<td>Airbag score read-through</td>
<td>Key role for laser technology</td>
</tr>
<tr>
<td>Tailoring haptics(c)</td>
<td>Via controlling polyolefin foams/ surface coating</td>
</tr>
<tr>
<td>China interior emissions reqt’s</td>
<td>Becoming more severe(d)</td>
</tr>
<tr>
<td>Smarter lightweighting</td>
<td>Via 3D? Put structure where required</td>
</tr>
<tr>
<td>More leather-like look</td>
<td>Coated fabrics becoming competitive with leather</td>
</tr>
<tr>
<td>Structural improvements</td>
<td>Reinforcements (nanocellulose, carbon fiber)</td>
</tr>
</tbody>
</table>

(a) Door trim panel, armrest, console cover  
(b) Display, lighting, switching/sensing functions  
(c) Via both surface touch coatings and foam modification  
(d) Interior emission requirements in China more severe than U.S. or Europe  

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2017
CARBON: MANY FORMS ➔ INNOVATIVE APPLICATIONS

MOF = Metal-organic framework

SOURCE: GRAPHENICS
SELECTIVE 3D MOLDING: ROLE IN AUTO?

- Weight save potential
- Putting resin where structural requirements dictate
- Deposition via sintering (suited for some TPEs (e.g. SEBS, PP powders?))

SOURCES: PLASTICS TECHNOLOGY MAGAZINE 042017; COMMENTS: ROBERT ELLER ASSOCIATES LLC, 2017
CONNECTED/AUTONOMOUS CAR: NEW FUNCTIONS ➔ INTERIORS OPPORTUNITIES

- Acoustics
- Shielding
- “Windows”/transparent sections in the surface
- Lighting
- Image projection
- Sensing.smart surfaces
- Smart touch
- Damping
- Conduction
- Signaling.data transmission

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2017
EXAMPLE OF SMART SURFACES VIA INJECTION MOLDED STRUCTURAL ELECTRONICS (IMSE)

PHOTO: TACTO TEK
EXAMPLES OF IMSE AUTOMOTIVE APPLICATION AREAS

- Illumination & control solutions in curved decorative panels
- Force and capacitive sensing integration for enhanced applications, preventing unintentional activations
- Illumination adjustment

Smart steering wheel
Multi-function overhead control panels
Illuminated ventilation trim panels and controls
Curved & flush designed smart center consoles

Multi-function headliner
Smart B-pillar e.g. keyless entry

Multi-function seatbacks

Smart tailgates and lighting
Soft fabric sensing e.g. seat sensors

Smart door handles e.g. keyless entry

Re-architected controls e.g. Door controls relocated into dash panels

SOURCE: TACTO TEK, 2017
INTERIOR PROCESSES/MATERIALS: FUTURE DIRECTIONS

MATERIALS:
- Natural fiber reinforcement
- Nano cellulose reinforcements
- Role for graphenes/graphene-based foams
- Role for carbon fibers
- Smart textiles/skins/molded surfaces/thin film sensors

PROCESSES:
- 3D printing/molded structures
- Smart/luminescent coatings
- Slush molding of SBCs
- Skins injection processes

BROADER FUNCTIONS:
- Lighting/display
- Sensing/switching
- Voice activation
- Shielding

SOURCE: ROBERT ELLER ASSOCIATES LLC, 2017
SUMMARY

• Autonomous/semi-autonomous cars/EVs will create opportunities for new generations of plastics capable of:
  - integrating electronics
  - providing display, sensor and switching functions
  - operating as “smart surfaces”
  - improving acoustics
  - acting as display surfaces
  - streamlining the HMI interface

• The major drivers/opportunity frontiers are:
  - weight save (challenged by regulations shift?)
  - the HMI interface (new control/sensing modes (voice, light, motion, touch))
  - luxury look and feel (haptics)
  - process improvement: replace outdated component fabrication technology
  - role for 3D composite manufacturing: new materials/process combinations
  - electrical/electronic architecture
  - new generation fillers/reinforcements (nanocellulosics, carbon fibers)
  - improved conductive materials (graphenes, carbon nanotubes)
SUMMARY (Cont’d.)

- Continued competition in skins:
  - inter-materials; inter-process competition
  - waiting for SBC slush
  - skins via injection

- TPO skins gaining share on basis of:
  - cost
  - in-house compounding (to produce p-TPVs)
  - controlling rheology
  - new fabrication technologies

- Skin/foam technologies: evolving to meet higher standards/improved performance

- Body/glazing seals: continued growth and broadening of the applications footprint for TPEs

- Enlarged application range for bead foams
ABBREVIATIONS USED

• ETP: ENGINEERING THERMOPLASTIC

• IMSE: INJECTION MOLDED STRUCTURAL ELECTRONICS

• SBC: STYRENE BLOCK COPOLYMER TYPE TPE

• TPV: THERMOPLASTIC VULCANIZATE TYPE TPE

• TPE: THERMOPLASTIC ELASTOMER

• TPO: THERMOPLASTIC POLYOLEFIN TYPE TPE

• TPU: THERMOPLASTIC POLYURETHANE

• PU: POLYURETHANE
THANKS FOR YOUR ATTENTION

Robert Eller Associates LLC
CONSULTANTS TO THE PLASTICS AND RUBBER INDUSTRIES