AUTOMOTIVE INTERIOR MATERIALS AND PROCESSES: EVOLVING TOWARD THE FUTURE

PRESENTED BY:
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OUTLINE

• 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>
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<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>
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<tr>
<td>Lower hardness w/o compromise</td>
<td>TPU, TPO, SBC</td>
<td>- TPO/SEBS starting</td>
<td>Coated fabrics</td>
</tr>
<tr>
<td></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>
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<tr>
<td></td>
<td></td>
<td></td>
<td>-via injection</td>
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</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
MATURITY CURVE FOR INTERIOR TPEs AND TPOs

- **MIN-FILLED PP**
- **CELLULOSIC REINFORCEMENT**
- **GF-PP**
- **TPVs IN BODY/GLAZING SEALS**
- **LGF AND CF-PP**
- **P-TPVs IN IP SKINS**
- **SBC-TPEs IN BODY/GLAZING SEALS (CHALLENGE TPVs)**
- **SMART SURFACES**
- **FOAMED INJECTION MOLDING WITH ACCEPTABLE SURFACE**
- **NANOCHELLOUSE REINFORCEMENT**
- **AUTONOMOUS TECHNOLOGY RESPONSE**
- **BIO-TPEs?**
- **SMART SURFACES/LIGHTING**

**SOURCE:** ROBERT ELLER ASSOCIATES LLC, 2017

r/mydox/Visio/Life Cycle Interiors 052316
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

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
INTERIOR EVOLUTION VIA NEW MATERIALS/PROCESSES/ FUNCTIONS

- DIRECT p-TPVs
- IN-MOLD PROCESSES
- NEW FOAMING METHODS
  - SKINS
  - MULTI-LAYER STRUCTURES
- ACOUSTIC MAT’LS.
- IMPROVED BODY SEALS
- CURRENT INTERIORS
  - QUIET
  - STRUCTURE WITH WEIGHT SAVING
  - DOOR TRIM
  - OVERHEADS
  - NATURAL FIBERS
  - NANOCHELLOUSICS
  - CARBON FIBER/GLASS REINFORCEMENT
  - 3D MOLDING
- SMART FUNCTIONS
  - SENSORS
  - TOUCH SWITCHES
- LUXURY
  - SKINS
  - SOFT TOUCH
  - SILKY TOUCH
- LIGHTING
  - LUMINESCENT SURFACE
  - IMAGE PROJECTION
- RENEWABLE SOLUTIONS
  - BIO-PLASTICS
  - NATURAL FIBER REINFORCEMENTS
  - LOW VOC
  - PLASTICIZER SHIFT
  - ELIMINATE PLASTICIZERS/OILS
- SOURCE: ROBERT ELLER ASSOCIATES LLC, 2017
STRUCTURAL AUTOMOTIVE CANDIDATES: CARBON FIBER/PP IN THE RUNNING

Materials Comparison

SOURCE: ZUMHAGEN COMPANY LLC, 2017
### NAFTA/EUROPE FLOW ASIA NOTE

1. OEMs TO BENEFIT FROM HIGH GROWTH POTENTIAL
2. RESIN SUPPLIERS/COMPOUNDERS/MOLDERS TO FOLLOW OEM CUSTOMERS
3. TECHNOLOGY FLOW
4. DOMESTICS ESTABLISH SUPPLY CHAIN TO SERVE WESTERN TRANSPLANTS TECHNOLOGY BARRIERS ARE POROUS
5. VIA ACQUISITION/GREENFIELD ASIAN OEMs
6. SERVE WESTERN OEMs: - BUSINESS WON IN ASIA - EXPLOIT COST ADVANTAGE - VIA ACQUISITIONS? ASIAN RESIN SUPPLIERS AND COMPOUNDERS IS COST ADVANTAGE TRANSFERABLE?

**GLOBALIZATION REVERSE FLOW: CHANGING THE AUTOPLASTICS SUPPLY CHAIN**

**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>
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<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

MOS = 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

Multi-function headliner
Smart B-pillar e.g. keyless entry
Multi-function overhead control panels
Smart steering wheel
Illuminated ventilation trim panels and controls
Curved & flush designed smart center consoles

Multi-function seatbacks
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)
• 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

ANALYSIS

Management DECISIONS

Robert Eller Associates LLC
CONSULTANTS TO THE PLASTICS AND RUBBER INDUSTRIES