Trends in Automotive Electrical/Electronics and the Role of Enabling Materials Technology

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R Hiyashi
P Kane
S J Horowitz
Automotive: Key Trends & Needs

- Improved Fuel economy
- Reduced automotive emissions
- Emerging country growth and increased living standards
- Security and safety
- Convenience
- Lighter weight with improved performance
- Energy efficiency and conservation
- Human connectivity

New Electronic Systems, Enabled by Materials Innovations

- Electrical/Electronic systems replace mechanical systems
- Hydrogen Fuel Cells
- Hybrid electric engines
- Smart occupant restraints
- Vehicle stability and rollover avoidance
- GPS and Navigation
- Tire pressure monitor
- Radar for collision avoidance
- Cylinder deactivation
- Intelligent aim able headlights
- Driver information
- Satellite Radio
Growth in Automotive Electronics exceeds growth in number of Vehicles,

<table>
<thead>
<tr>
<th>Category</th>
<th>CAAGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powertrain</td>
<td>3.9%</td>
</tr>
<tr>
<td>Chassis</td>
<td>8.5%</td>
</tr>
<tr>
<td>Safety</td>
<td>12.1%</td>
</tr>
<tr>
<td>Security</td>
<td>4.5%</td>
</tr>
<tr>
<td>Body</td>
<td>6.4%</td>
</tr>
<tr>
<td>Driver Info.</td>
<td>8.5%</td>
</tr>
<tr>
<td>Total</td>
<td>6.7%</td>
</tr>
</tbody>
</table>

- **Number of vehicles growing ~ 3%/year**
- **Electronics content per car continues to increase**

Source: Strategy Analytics, Inc.
DuPont is the #2 supplier of enabling materials solutions to the global electronics industry.

**Materials Innovation for...**

**Plus:** Insulation materials for motors for HEV’s, Wire insulation, PEN and PET Films, Membrane Electrode Assemblies for Fuel Cells, Materials for components such as piezoelectric actuators, sensors,
DuPont in Automotive Electronics

- Antilock Brake Systems, Traction Control
- Gear Shift Illumination
- Rear Window Defroster
- Airbag Sensors
- Fuel sender
- Electro-luminescent Lighting
- Mirror & Seat Heating
- Engine Control Modules
- Voltage Regulator
- Air-Mass Sensor
- Pressure Sensors
- Gear Shift Illumination
- Engine Control Modules
Applications

- Hybrid Electric Vehicles
- Circuits for harsh environment service
  - Ceramic
  - Organic
- Radar and high frequency applications
- Sensors and modules
Hybrid Electric Vehicle
Unique Systems

- Battery
  - Ni-H system
  - Li-Ion system
  - Capacitor

- Generator

- Inverter/Converter
  - DC-AC Inverter
  - DC-DC Converter

- Electric Motor
  - Engine Starter
  - Drive to Wheel
  - Charge to Battery

- ECU
  - Electronic Control for each system

- Gasoline engine
- Planetary gear
HEV: Opportunities for Material Solutions

Generator & Electric Motor
- High temp. eng. polymers
- Insulation materials
- Impregnating resins
- Magnet Wire Enamel

Battery
• Ionic liquids, electrolyte, binder
• Membranes
• Housing: Engineering Polymers

Inverter/Converter
• Engineering Polymers for housings, electrical transformer, new cooling system
• Electronic Materials

Electronic Control Unit
• Housing: Eng. Polymers
• Polymeric film for Insulation
• FCM, MCM
Power Train: Electric Motor (Generator & Front Motor)

- **Function**
  - Engine Starter
  - Drive to Wheel
  - Charge to Battery

- **In Use Requirements**
  - Electrical insulation under high voltage, high temperature & humidity
  - Reliability under ATF oil & higher temp.

- **DuPont Material Solutions**
  - Zytel® HTN for Power Cable Connector
  - Teonex® PEN film, Nomex®
  - Nomex® aramid paper
  - Impregnating resin (motors)
  - Magnet Wire Enamel: Voltron™
Wire and Cable Insulation

**Application:**

- High-temperature extrusion materials
- Good abrasion resistance
- High energy radiation resistance
- Excellent electrical properties

**Trends:**

- Higher voltages (Hybrids)
- Higher temperatures (Hybrids)
- Heated seats
- Flexibility for ease of assembly

**Value Proposition:**

- High-temperature extrusion materials
- Good abrasion resistance
- High energy radiation resistance
- Excellent electrical properties

**DuPont EP Solutions:**

- Teflon® PTFE – high temperature
- Tefzel® ETFE -- High energy radiation resistance
- DuPont™ ETPV - injection moldable or extrudable rubber
Electrical Insulating Systems

- **Wire Enamels: Voltron™**
  - Primary Insulation of Round or Rectangular Copper or Aluminum Wires

- **Impregnating Resins**
  - Mechanical Strengthening of the Winding
  - Electrical Insulation
  - Protection against Chemical/Mechanical Attack
  - Improved Heat Transfer

- **Core Sheet Varnishes: VOLTATEX**
  - Electrical insulation of metal sheet for construction of magnetizable cores

Wire Enamels | Impregnating Materials | Core Sheet Varnishes
Ceramic Circuit Materials in Automotive

**POWER TRAIN**
- Engine Control Modules
- Transmission Control Modules
- CVT Gear Box Control Unit
- Electronic Throttle Control
- Voltage Regulators
- Mass Air Flow Sensors
- Exhaust Gas Sensors – O2

**SAFETY**
- Yaw Rate sensors
- Traction Control Modules
- ABS
- Airbag Accelerometers
- Steering Torque Sensors
- Pressure Sensors – Temperature, Flow, Level, Speed, Position, Shock, Acceleration
- Radar Detection
- Fuel Senders

**Extreme Operating Temperatures**
- High Density
- Circuit Integration
- High Frequency Response
Complete Material System for Automotive Radar

- Blind Spot Detection
- Collision Avoidance
- Parking Assist
- Lane Departure

DuPont GreenTape™
Courtesy of IMST Gmbh
Kapton® Polyimide Film and Pyralux® Laminate in Auto

Heat Resistance
Vibration Tolerance
Chemical Resistance
Ease of Assembly/Modularity
Integration

APPLICATIONS
Transmission circuit
Engine Control Module
Anti-lock brakes
Cam sensor
Diesel pumps Circuit
Air Bag Seat Sensor
Fuel Sender Circuit
Harsh environment connectors

Survives Exposure to:
Brake Fluid, Transmission Fluid, Synthetic Oil, Brake Fluid, Transmission Fluid, Synthetic Oil, Motor Oil, Diesel, Leaded and Unleaded Gasoline...
Sensors & Modules

Scope:
Protection for electronic components such as control modules and sensors. Includes covers, housings and thermoplastic encapsulation.

Protection from:
• High Temperature of under-hood environment and of electronic components themselves (ie heat dissipation)
• Automotive chemicals, oils, and solvents (like transmission fluid)
• Dirt, grease, grime and other contaminants
• Moisture and Corrosion
• Electromagnetic Interference (EMI)
• Damage due to impact from foreign objects
Temperature and Pressure Sensors

- FR4 circuit board
- Plastic Housing

Trends:
- ‘Smart systems’ - many more sensors
- Analog ➔ Digital (IC based sensors)
- Potting ➔ Encapsulation & Laser Welding
- Co-located sensors and modules
- Greater cost pressure

Wheel Speed Sensors

Trends:
- Variable reluctance ➔ solid state sensors
- Fully encapsulated sensors lowers assembly costs
- Corrosion resistance is important for reliability
DuPont in Automotive Electronics

Gear Shift Illumination
Rear Window Defroster
Airbag Sensors
Engine Control Modules

Mirror & Seat Heating
Fuel sender
Electro-luminescent Lighting
Antilock Brake Systems, Traction Control
Pressure Sensors
Air-Mass Sensor

The miracles of science™
Extra Slides
Automotive Electronics Applications

- Air Mass Sensor
- Petrol Engine ECU
- CVT ECU
- Turbocharger ECU
- Alternator Regulator
- EGR Actuator ECU
Automotive Electronics Applications

- Xenon Discharge Lamp ECU
- Fuel Level Sensor
- Ambient Lighting
- ESP Sensor
- Heated Backlight
- ABS/TC ECU
Complete Material System for Automotive Radar
- Blind Spot Detection
- Parking Assist
- Collision Avoidance
- Lane Departure

Design Resources at Your Fingertips

- Integrate Designs in Agilent ADS
- 28-38 GHz Frequency Range
- Commercial, Automotive & Military Applications
- Popular Component Types
- Create Schematics & 3-D Layouts
- Review Simulation Results

Green Tape™ Design Library

- Embedded Passive Components
- Materials Tested to 77 Ghz
- Economical technology choice
- Superior robustness in Harsh Environments
- Demonstrated reliability in field testing
- Operates in all weather conditions
- Object Detection up to 30 meters
Tomorrow, you’ll know us more this way -- Advance Automotive Technology already inside our cars...

Differential Pressure Sensor made with DuPont™ Multilayer Thick Film Compositions

Olight® Displays and Electroluminescent Lighting made with DuPont LuxPrint™

Steering Torque Sensor made with Heatel™

Connectors and other parts molded from DuPont Zytel® HTNLX deliver performance in surface-mount reflow processes using lead-free solder

Airbag Sensors, made with DuPont™ Thick Film Compositions

Antilock Braking System made with Thick Film Composition from DuPont™

DuPont Wedge™ HUD laminate for crisp images

Engine control, Antilock braking systems, and seat belt sensors made with Pyralux® flexible laminates and Kapton® polyimide film, housed and connected in DuPont engineering plastics

Transmission control unit made with DuPont™ Multilayer Ceramic Technology

Electronics for Power and Heat made with DuPont™ Polymer Thick Film

Circuit boards made with Riston® dry film photosist and ImageMaster™ phototools

Mass Air Flow Sensors made with DuPont™ Thick Film Compositions

Zeevo TC2000 Bluetooth Module, Integrates Analog, RF and Digital Using DuPont 951 LTCC System