A collaborative approach to future mobility
Our journey to three: creating world leading companies

2017
We brought together the complementary, innovative portfolios and pipelines of Dow and DuPont

2019
With the intent to create three strong, independent companies

April
Dow
Materials Science

June
Dow
Agriculture

June
DuPont
Specialty Products

>200 years of cumulative partnership with the Global Automotive Industry

We empower the world with essential innovations to thrive...by discovering and delivering results that matter
At a glance: Transportation & Industrial

$5.62bn 2018 net sales
~5,700 Colleagues
39 Manufacturing sites

Transforming industries and improving lives through material science

Net sales (2018):

- Engineering Polymers: 29%
- Performance Resins: 24%
- Performance Solutions: 47%

Market segments:

- Automotive: 34%
- Future Mobility: 18%
- Electronics: 16%
- Industrial: 18%
- Healthcare: 5%
- Consumer: 4%

By business:

- Automotive: 34%
- Future Mobility: 18%
- Electronics: 16%
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Global Footprint to Meet Customer Needs

AHEAD™ Technical and innovation Centers

- Sunnyvale, CA
- Spruance, VA
- Troy, MI
- Kingston, Canada
- Marlborough, MA
- Wilmington, DE
- Neu Isenburg, Germany
- Freienbach, Switzerland
- Meyrin, Switzerland
- Shanghai, China
- Fanling, Hong Kong
- Hwaseong, Korea
- Tokyo, Japan
- Nagoya, Japan
- Sasakami, Japan
- Hsinchu, Taiwan
- Spruance, VA
- Marlborough, MA
- Wilmington, DE
- Neu Isenburg, Germany
- Freienbach, Switzerland
- Meyrin, Switzerland
- Shanghai, China
- Fanling, Hong Kong
- Hwaseong, Korea
- Tokyo, Japan
- Nagoya, Japan
- Sasakami, Japan
- Hsinchu, Taiwan

- Autonomous driving
- Radar transparency
- Virtual reality

- REV.ENG.E-LAB -> Collaboration with A2MAC1
  - Thermal management Rig
  - Connectors overmolding tool
  - Tomograph
  - Vertical press for large housings
  - Virtual reality
  - Thermal conductivity through plane tester

- REV.ENG.E-LAB -> Collaboration with A2MAC1
  - EMI Shielding
  - Lamination units for KV/Nomex
  - Battery Fire testing
Introducing AHEAD™

Accelerating Hybrid-Electric Autonomous Driving

DuPont’s AHEAD™ initiative will provide a single source for varied applications in vehicle electrification, autonomy, connectivity and supporting infrastructure space.

- Supported by expertise in materials science and electronics
- Reinforced by long industry experience
- Leveraging broad, differentiated portfolio of technology and solutions
## AHEAD Focus Areas

### Battery Module
- Bus bar electric insulation
- Thermal barrier pads
- Structural 2K PU assembly
- Dispensable thermal conductive
- Gap filler
- Sealants
- Bus bar holder
- HV connectors
- Module end plate

### PE & E Motors
- Terminal connector
- Bus bar module
- Electric current sensor
- OBC
- E-Axle pinion thrust washer
- E motor hybrid bobbin
- E motor slot/wire insulation
- Control board/PCB
- Compound semiconductors

### Signal Electronics
- Sensors (Touch)
- Radars / Lidars
- Cameras
- Antenna
- Semiconductor
- Electronic Control Units
- Heaters

### Infrastructure
- Transformer insulation
- Charging connectors & plugs
- Wire & Cable
- V2X
- Surface Protection

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<th>Kapton®</th>
<th>Nomex®</th>
<th>Zytel®/Zytel® HTN</th>
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Industry challenges

**Thermal management:** Higher energy-density batteries; small, powerful e-motors and ultra-fast charging create thermal management challenges in safety and efficiency.

**Lightweighting:** Driven by consumer desire for parity between the driving range of electric and fossil-fueled vehicles, further weight reduction in EV chassis, drivetrain and batteries is of paramount importance.

**Safety:** Thermal/electrical safety of EV drivetrains combine with passenger and pedestrian safety standards requiring integration of active and passive safety systems.

**Connectivity, sensing and control:** Accurate, upgradeable and reliable data acquisition systems and electro-mechanical actuators will dictate powertrain electrification acceptance as well as autonomous driving.

**NVH:** Ride experience is more important than ever as autonomous vehicles become work and social environments.

**Charging Infrastructure:** Networks of fast-charging infrastructure will be integral to the proliferation of electric vehicles. Durable, upgradeable and user-friendly charge points will be necessary.

**Durability:** Autonomy and car/ride sharing will increase life cycle expectations for future vehicles, requiring improvements in durability for chassis, electronic and interior components.
Battery: our materials at a glance

**Pyralux®**
FPC for cell monitoring system
(S)(P)

**Nomex® Cl10 (Thermal and Flame Barrier)**
Thermal runaway occupants protection pads
(S)(CE)

**Kapton®**
Busbar electrical insulation
(S)(CE)

**Kevlar®**
Busbar mechanical protection
(S)(CE)

**Nomex® Cl10 (Thermal and Flame Barrier)**
Thermal barrier pads
(S)(CE)

**Nomex® XF, Nomex® ST818 (Flame Barrier)**
Flame barrier solution
(S)(CE)

**BETAFORCE™ 2817 V1, BETAFORCE™ 9050**
Structural 2K PU assembly solutions
(S)(LC)(SB)

**BETASeal™ TC**
Dispensable thermal conductive interface material (gap filler)
(S)(P)(LC)(C)(SB)(AR)

**Nomex® 10T410**
Nomex conductor as an active cooling system
(S)(CE)(P)(LC)

**BETAFORCE™ TC**
Thermal conductive adhesive
(S)(P)(LC)(C)(CE)(C)

**BETAMATE™ 32, BETAMATE™ 7170+Accel2**
Sealants
(S)(C)(SB)(LC)(AR)

**Cristin® FR684NH1, LW9030FR; Zytel® FR95G25VONH, Zytel® HTN FR52G30NH**
Bus bar holder / module
(P)(S)(LC)

**BETAFORCE™ 2806**
Primerless semi-structural adhesives
(S)(C)(SB)

**Cristin® FR684NH1; Zytel® FR95G25VONH**
High voltage connector
(P)(S)

**Vamac®, Hytrel®**
Wires and cables
(P)(LC)(S)

**Zytel® 70G35EF**
Module end plate
(P)(S)

**Zytel® LCPA LC6200, LC7602, Zytel® 70G30HSLR**
Coolant pipe and connectors
(P)(LC)(S)

**BETAMATE™ 2090 / 2098 2K Epoxy**
Crash-durable structural adhesives
(CE)(S)(LC)(SB)

**Kevlar® Fabric**
Intrusion protection for battery shielding
(S)(CE)
Battery Pack: Thermal management

Thermal Conductance

**Dispensable Thermal Interface Material (TIM)**
BETASEAL™ TC
(S)(P)(LC)(C)(SB)(AR)
High thermal conductivity, vibration dampening, low press-in & pull-out force and high dispensing flow, ...

**Applications example**: In manufacturing process dispensable *Thermal Interface* paste between battery module & heatsink

**Thermal Conductive Adhesive**: (S)(P)(LC)(CE)(C)
BETAFORCE™ TC
Thermal Conductive adhesives solution, Heat cure accelerate able, high elongation, vibration inhibitor.

**Applications example**: Bonding cooling unit to heat sink

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(S) Safety  |  (P) Performance  |  (LC) Life cycle  |  (C) Cost  |  (SB) Sustainability  |  (CE) Customer Experience  |  (AR) Aftermarket support
Battery Pack: Assembly Solutions

Battery Case Assembly

**Sealant:**
BETAMATE™, BETASEAL™
- Primerless to: eCoated metal, bare aluminium
- Dielectrical, Fire resistant, Repairable
- Applications example: Battery lid bonding

**Semi structural adhesive:**
BETAMATE™ 2810, BETAFORCE™ 2806 - Primerless
- High elongation, enabling multi substrate assembly of light & economical substrates, vibration inhibitor
- Applications example: Semi structural assembly of module cases & Control Units (plastic to metal)

**Structural 2K PU assembly solutions:**
BETAPRIME™1707 + BETAFORCE™2817 V1, BETAFORCE™9050
- Best in class balance between elongation and structural performance for multi substrate bonding
- Applications example: Battery Frame Bonding

**Crash Durable Structural adhesive:**
2K Epoxy BETAMATE™
- Adhesion on bare aluminum, Glycol resistance
- Applications example: Battery compartment crash integrity applications
# Battery: Thermal Safety

Advanced solutions proven in ballistics and aerospace

**Problems to solve:** Thermal runaway, internal/external fire

## Thermal Insulation
- **Nomex® CI10**

**Applications**
- Cell to cell thermal insulator to mitigate thermal propagation
- Module/pack level thermal protection

## Flame Barrier
- **Nomex® XF30**
- **Nomex® Mica Paper**

**Applications**
- Prevent internal fire propagation to outside of battery enclosure
- Protect key parts (e.g., Bus bar, BMS, Terminals, Cable) against direct flame

## Electrical Insulation
- **Nomex® Mica Paper**
- **Nomex® Pressboard**

**Applications**
- Electrical insulation between cell, module side plate, or other critical parts such as Bus bar, BMS

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**Cell to Cell Insulation**
- **Nomex® CI10**

**Module to Module Insulation**
- **Nomex® CI10**

**Flame Barrier – Parts Protection**
- **Nomex® XF30**

**Flame Protection – Top Lid**
- In Development
Battery: Mechanical Safety
Advanced solutions proven in ballistics and aerospace

Problems to solve: debris intrusion, crash protection

Multi-Material Solution

Impact Behavior

CF or GF SMC
- Primary structure
- Kevlar®
  - Impact/Penetration Resistance
  - Ductility
  - Residual mechanical properties
  - Electrical insulation

Flame Barrier Layer
- Flame barrier
- Thermal insulation
- Electrical insulation

Outside

Kevlar® reinforcement technology
- Ductile composite
  - w/ impact and penetration resistance

Kevlar® XF technology
- High energy flame barrier
  - w/ (residual) mechanical properties

Inside

Mechanical Protection
- ✓ Kevlar® Fabric

Applications
- Protect key parts from mechanical damage (e.g., Bus bar, Terminal, BMS, Battery enclosure)
Renault Sport Racing and DuPont Announce Strategic Partnership

Advanced Technologies for Higher performance

› Multi-year technical partnership to advance Formula 1 and other racing programs

› To extend the developed technologies to consumer and road-car applications (hybrid and electric powertrain solutions)

› Focus includes structural adhesives for thermal management of batteries, and materials for power, infrastructure and signal electronics