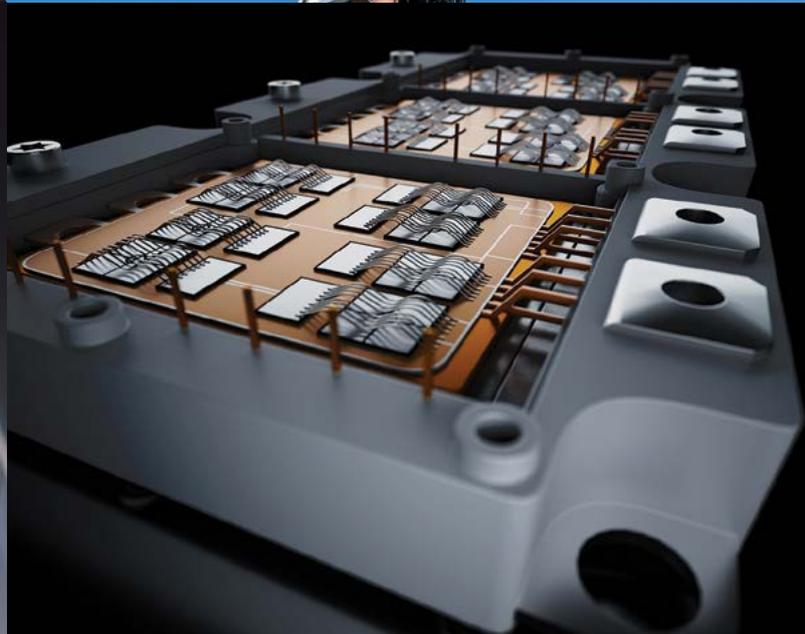
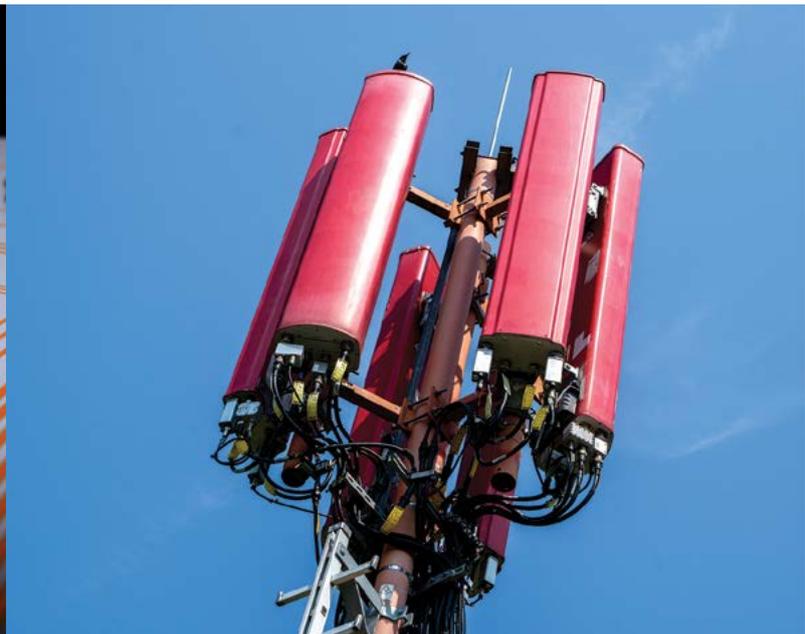
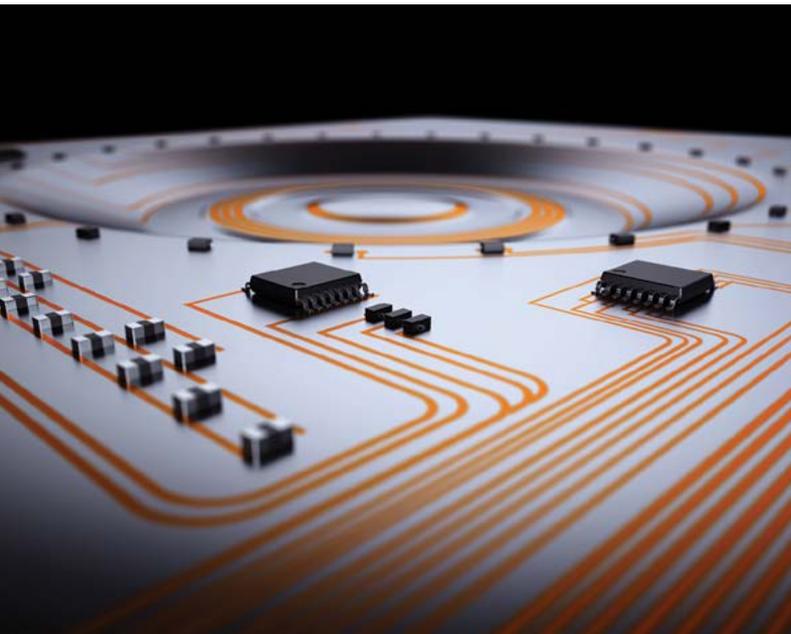




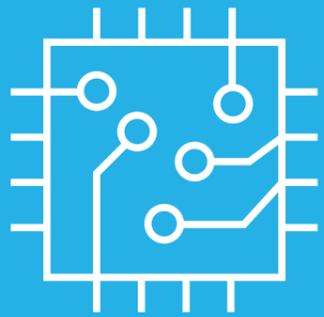
Discover the Flexibility and Reliability of DuPont Microcircuit Materials

Take your designs for printed electronics and components to the next level with DuPont thick film inks and ceramic tapes.



From automotive and telecommunication applications to consumer products and health devices, DuPont is a leading global supplier of printable, stretchable, and moldable functional inks and pastes.

With a 50-year history of innovating for our customers, DuPont's Microcircuit and Components Materials (MCM) are relied upon every day in satellite communications, automotive electronics, guidance systems, aerospace, homeland security, telecommunications, consumer electronics, industrial, and military applications.



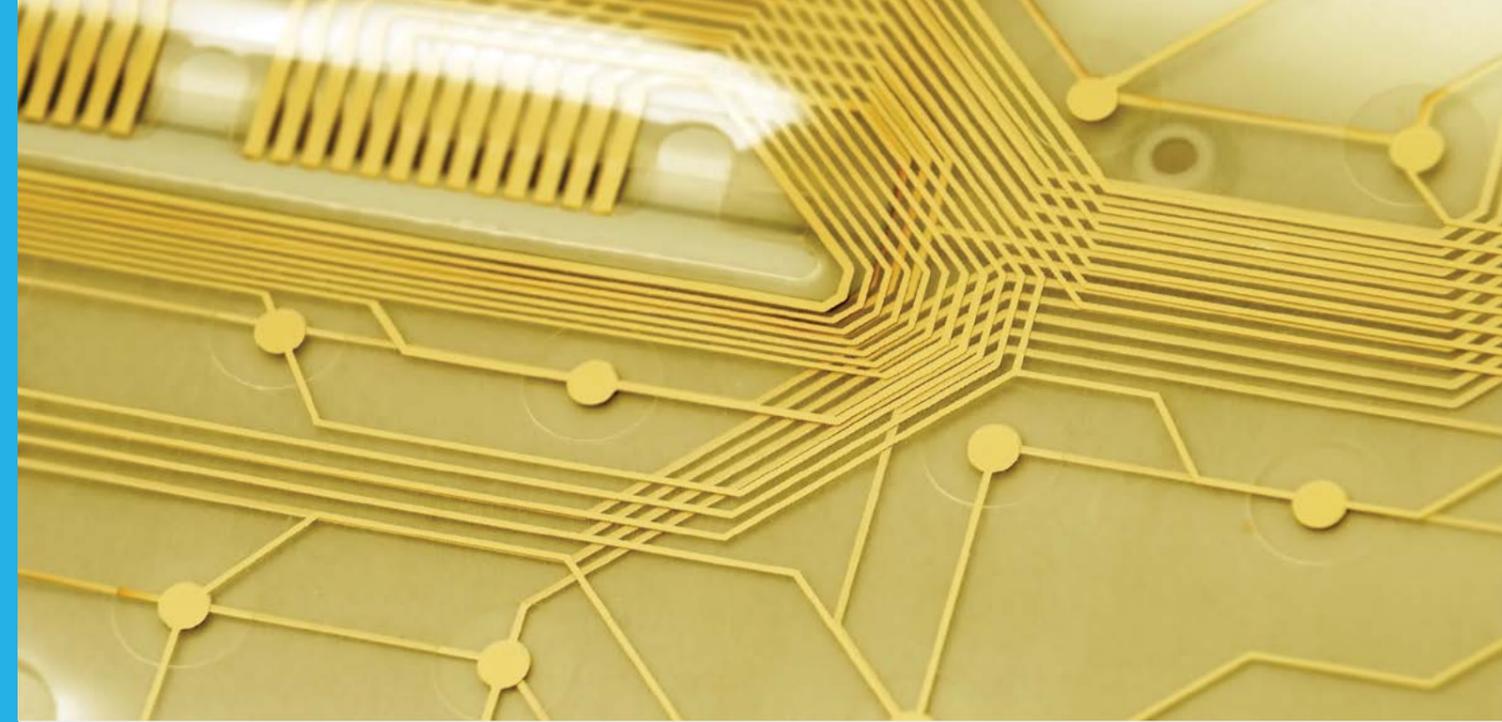
DuPont MCMs allow electrical designers to push the boundaries of design and scale production quickly with:

- Thick film and ceramic hybrid circuit materials
- Low-temperature co-fired ceramic (LTCC) materials
- Passive component materials
- Printed electronic materials

Plus, DuPont MCMs provide high reliability across different substrates, operating environments, temperatures, and metallizations. Our extensive offering consists of material systems with proven compatibility, including a full line of:

- **Hybrid circuit materials**
 - thick film resistor materials
 - laser-structurable pastes
 - conductive materials for hybrid circuits
 - dielectric and encapsulant materials

- **Passive component materials**
 - screen printed resistive materials
 - terminations and electrodes for capacitors
 - thick film multilayer capacitor materials
- **Low-temperature co-fired ceramic (LTCC) materials**
 - DuPont™ GreenTape™
- **Printed electronic materials**
 - inkjet silver conductive inks
 - low-temperature electronic inks
 - material for self-limiting heaters
 - membrane touch switch materials
 - in-mold electronic technology
 - biomedical device materials
 - stretchable ink for wearable electronics



Industry Overviews

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Industry overviews

DuPont brings a deep understanding of materials science to the electronics industry. We provide materials that are used to advance dozens of applications. The four industries on the following pages show the breadth of our product portfolio for printed electronics materials.



Automotive

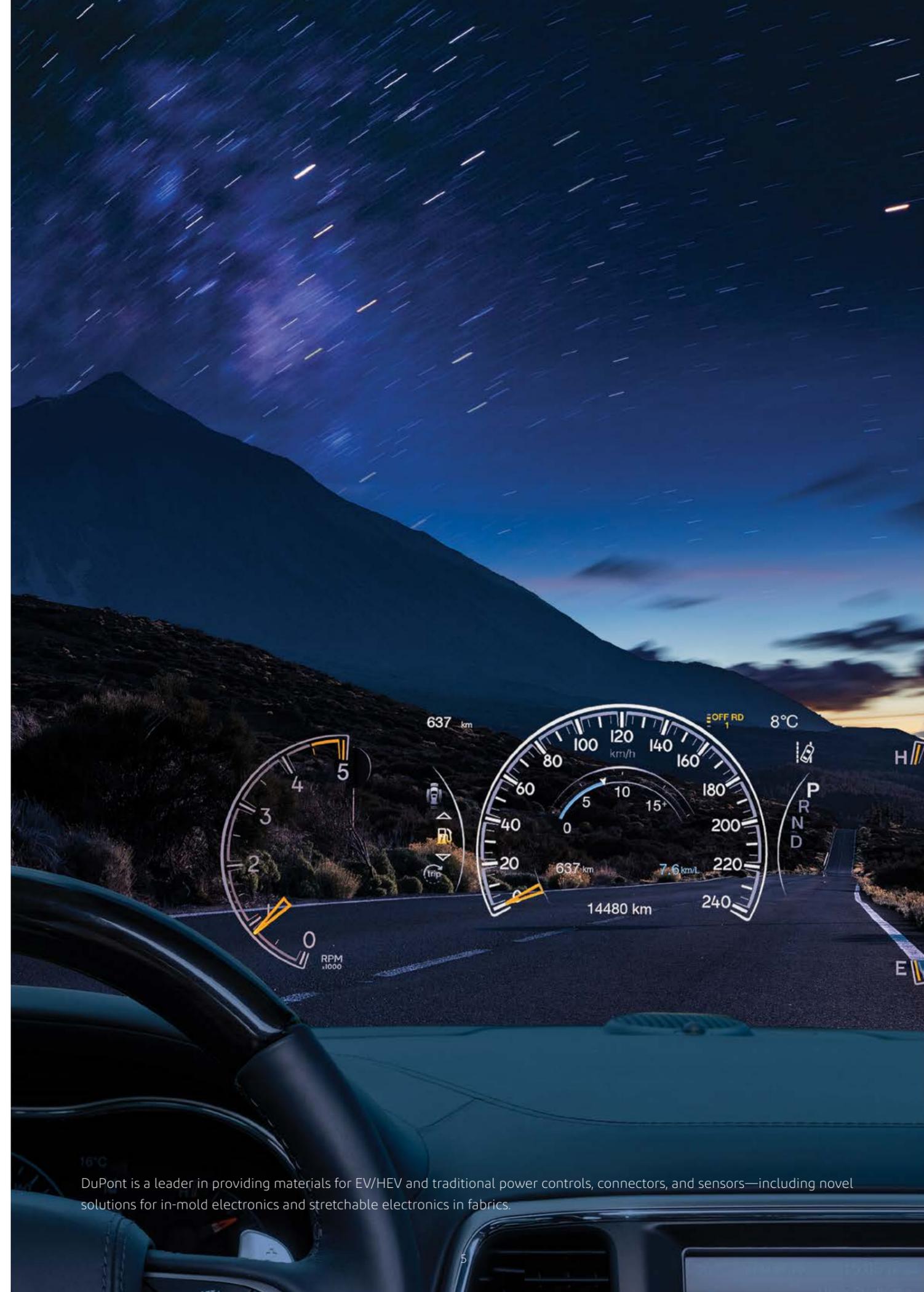
The next generation of automobiles relies on advanced interconnections that facilitate everything from safety controls to powertrain performance to passenger comfort. **DuPont electronic materials are used to enhance automotive safety and passenger comfort in internal combustion engine (ICE) and electric vehicles (EVs) in a multitude of ways.** You'll find DuPont materials in electronic controllers, powertrain sensors and control units, exhaust gas sensors, LED lighting, advanced safety radar, and rear window defroster systems.

DuPont fired-on and polymer thick film pastes, and glass ceramic tapes integrate electronic circuitry on a variety of metal and polymer substrate surfaces. Automotive applications include:

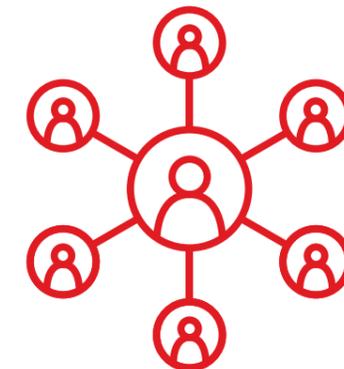
- Human-machine interface (HMI)
- Electronic control units (ECUs)
- Radar applications
- Battery conditioning
- Automatic transmission control
- Injector heaters, glow-plugs, piezoelectric actuators
- Direct injection systems
- Seat occupation sensors
- Cabin and steering wheel heating
- Mirror heating
- Window defogger and transponder
- Rear lights
- LED light demister
- HV coolant heaters
- Power modules

DuPont thick film pastes and glass ceramic tape solutions provide high-speed and high-frequency circuits for sensors and radars of connected vehicles; integrate power electronic control units; and provide integrated hybrid circuits with high reliability.

Additionally, DuPont provides automotive electronic solutions for functional embedded electronics such as in-mold electronics and stretchable electronics in fabrics.



DuPont is a leader in providing materials for EV/HEV and traditional power controls, connectors, and sensors—including novel solutions for in-mold electronics and stretchable electronics in fabrics.



Telecommunications

For product designers and engineers looking to create high-performance printed electronic circuits and components on flexible, rigid, and hybrid substrates, **DuPont offers the most comprehensive suite of printed electronics products and services for 5G telecom, including low-temperature co-fired ceramic (LTCC) materials and thick film hybrids.**

Compared to organic materials, DuPont products are inherently impervious to moisture and offer:

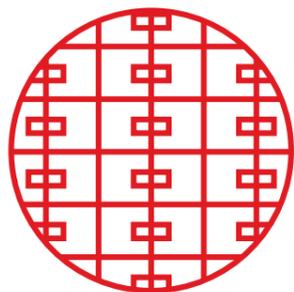
- Higher reliability
- Higher hermeticity
- Lower CTE (coefficient of thermal expansion)
- Higher thermal conductivity

Telecom, military, and commercial organizations know they can rely on DuPont electronic materials because our solutions provide:

- Increased functionality in smaller, lighter packages
- Physical durability and vibration resistance
- Low signal loss and stable dK through mmWave frequency nodes in all operating conditions
- High chemical resistance
- Embedded electronics

DuPont's high-performance LTCC materials enable high-frequency, high-reliability circuitry for 5G telecom. Our LTCC materials are ideal for:

- Satellite and flight hardware
- Airborne radar and flight avionics
- Military communications applications
- Naval and ground-based radar
- Wireless base stations
- Smartphones / mobile devices
- High-frequency transmitter/receiver modules



Passive Electronic Chip Components

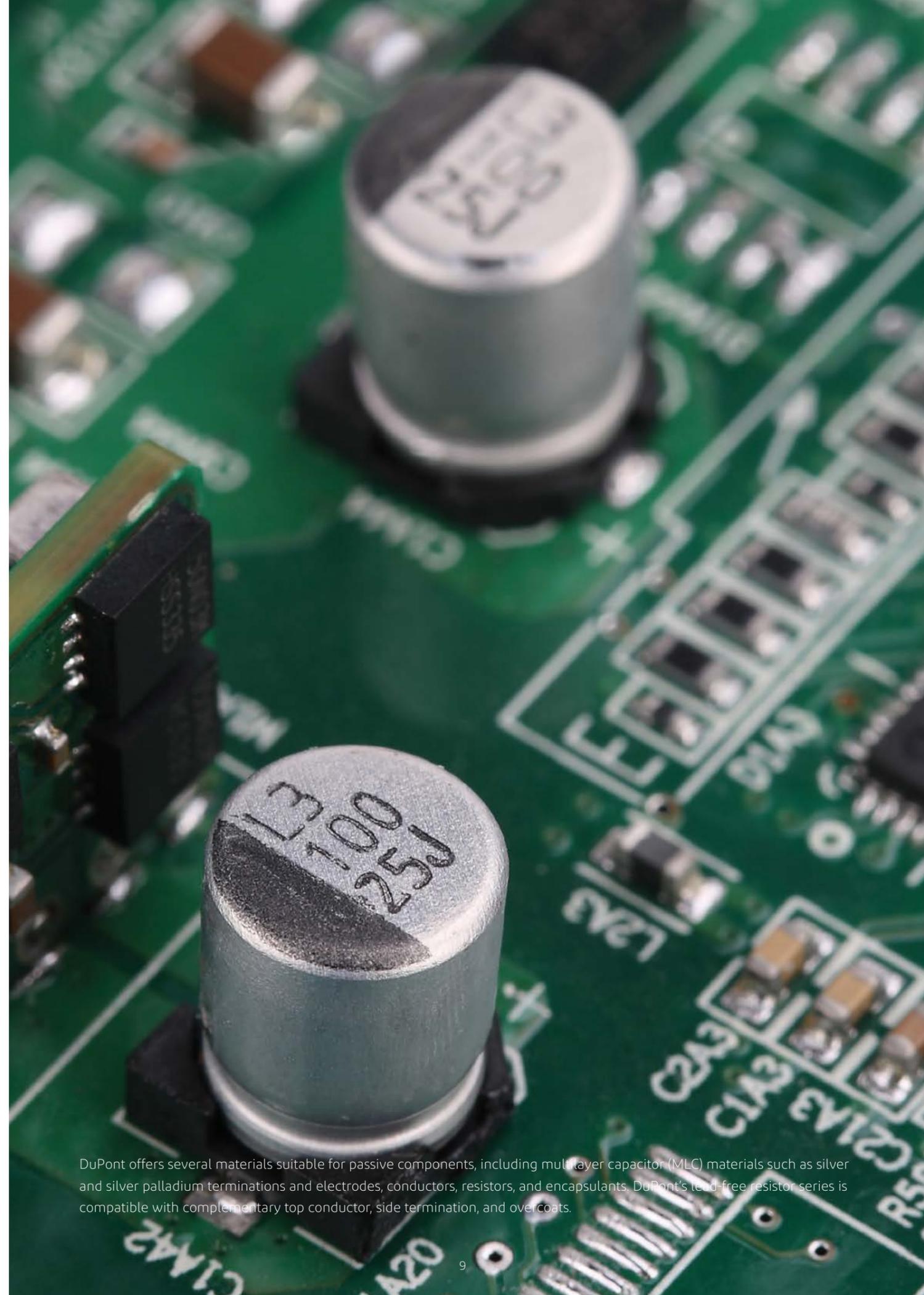
The performance of everything electronic—from autonomous cars and manufacturing processes to telecommunications and toys—depends on reliable passive components. **DuPont's product portfolio gives you access to innovative materials that free your designs so you can make resistors, capacitors, and inductors smaller, more complex, and more powerful than ever.**

DuPont multilayer capacitor materials provide:

- Excellent green strength, solderability, and adhesion
- Dip cosmetics
- Plateable materials which do not require tumbling or burnishing

Our resistive materials feature:

- Wide process window including firing temperature and resistor size
- Tight resistivity and TCR control on small chip sizes
- Excellent power handling performance
- Electrostatic discharge
- Anti-sulfuration conductors
- Polymeric conductor options
- Lead-free systems



DuPont offers several materials suitable for passive components, including multilayer capacitor (MLC) materials such as silver and silver palladium terminations and electrodes, conductors, resistors, and encapsulants. DuPont's lead-free resistor series is compatible with complementary top conductor, side termination, and overcoats.

DuPont silver/silver chloride and carbon inks are ideal for blood glucose and blood coagulation test strips. DuPont low-temperature curing gold ink for highly inert electrode surfaces enables reliable immunodiagnostic and blood gas sensors.



eHealth Products

Advanced devices and garments that use electronics give consumers more control over their health and help keep healthcare providers better informed. **As the applications for eHealth products grow by the day, DuPont leads the way with printed electronics materials for biomedical sensors, patches, and test strips.**

DuPont's flexible and reliable electronics solutions enable:

- Remote patient monitoring for long-term chronic conditions
- Post-surgical monitoring
- Accurate testing, including EKG, heart rate, blood glucose levels, temperature, and more
- Delivery of heat and neuromuscular stimulations
- Miniaturization of devices
- Low cost of ownership through high-throughput printing
- Exceptional lot-to-lot consistency

Our highly conductive inks, dielectric, and fine line printing solutions enable multilayer stacking and miniaturization, opening up new possibilities for designers of eHealth products. Plus, novel stretchable and washable solutions for advanced smart garment sensing.

Primary applications

From miniaturization of circuits and boards and colorful, vibrant displays to furthering 5G, AI, wearables, and overall connectivity, DuPont materials enable technology advancements today for tomorrow.



Electronics for EVs & ICEs

Extreme heat and other harsh environments can push electronics to their limits. **DuPont manufactures a wide variety of materials and solutions for a host of sensor applications that withstand the toughest EV and ICE conditions**—including innovations in automotive control, motion control, touch, and fluid level sensors.

Our extensive portfolio includes:

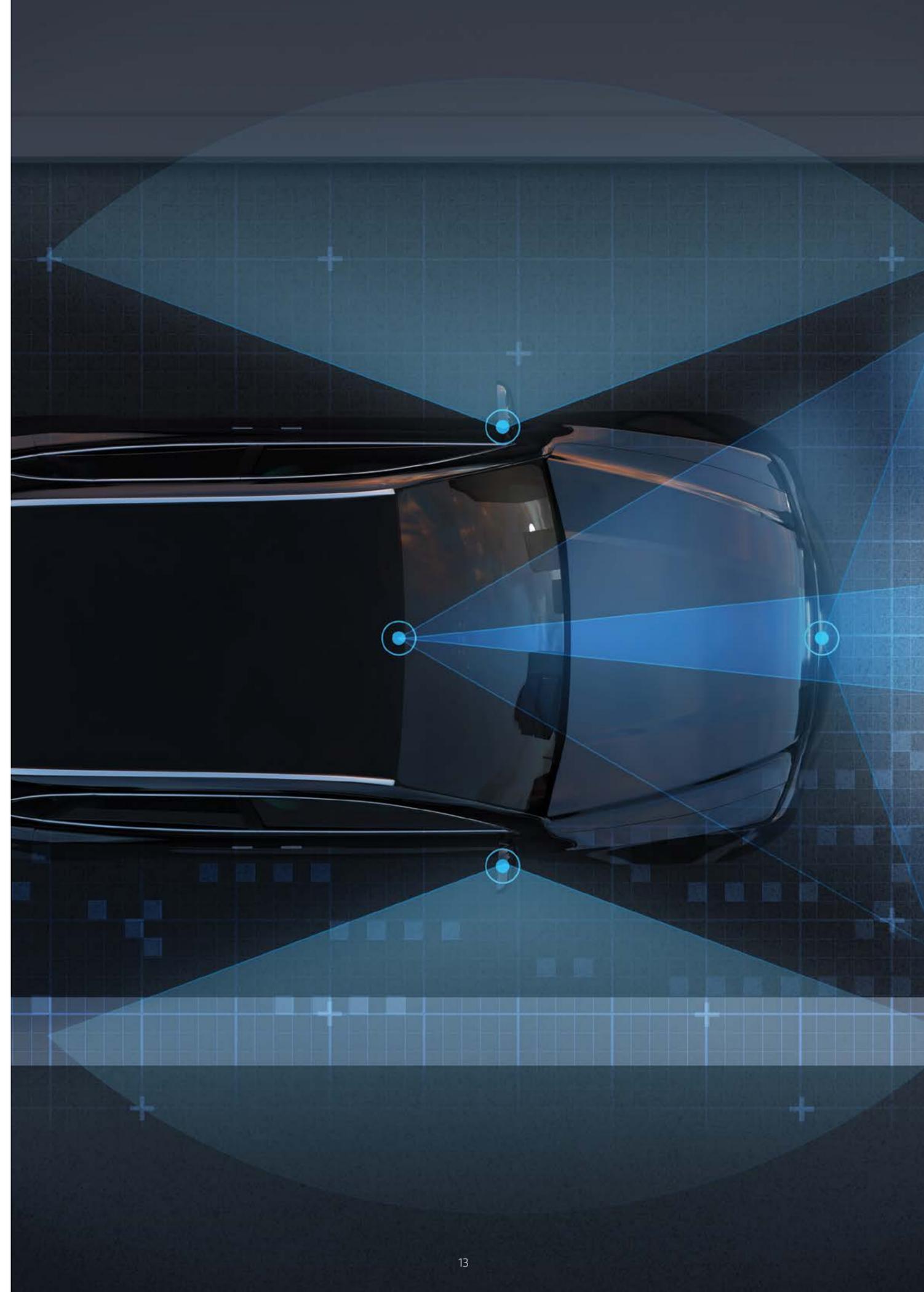
- Ceramic hybrid materials that are ideal for sensor applications that require a small footprint, high levels of reliability, and top performance in the most challenging environments
- Low-temperature co-fired ceramic (LTCC) material systems that combine the benefits of multi-layer ceramic and thick film technologies to meet the increasing demand for EV electronics that function reliably in extreme temperatures and other harsh conditions
- Printed polymer sensor materials that provide strong adhesion and high conductivity that are also light-weight and fast curing

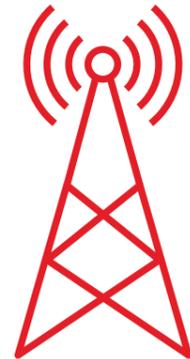
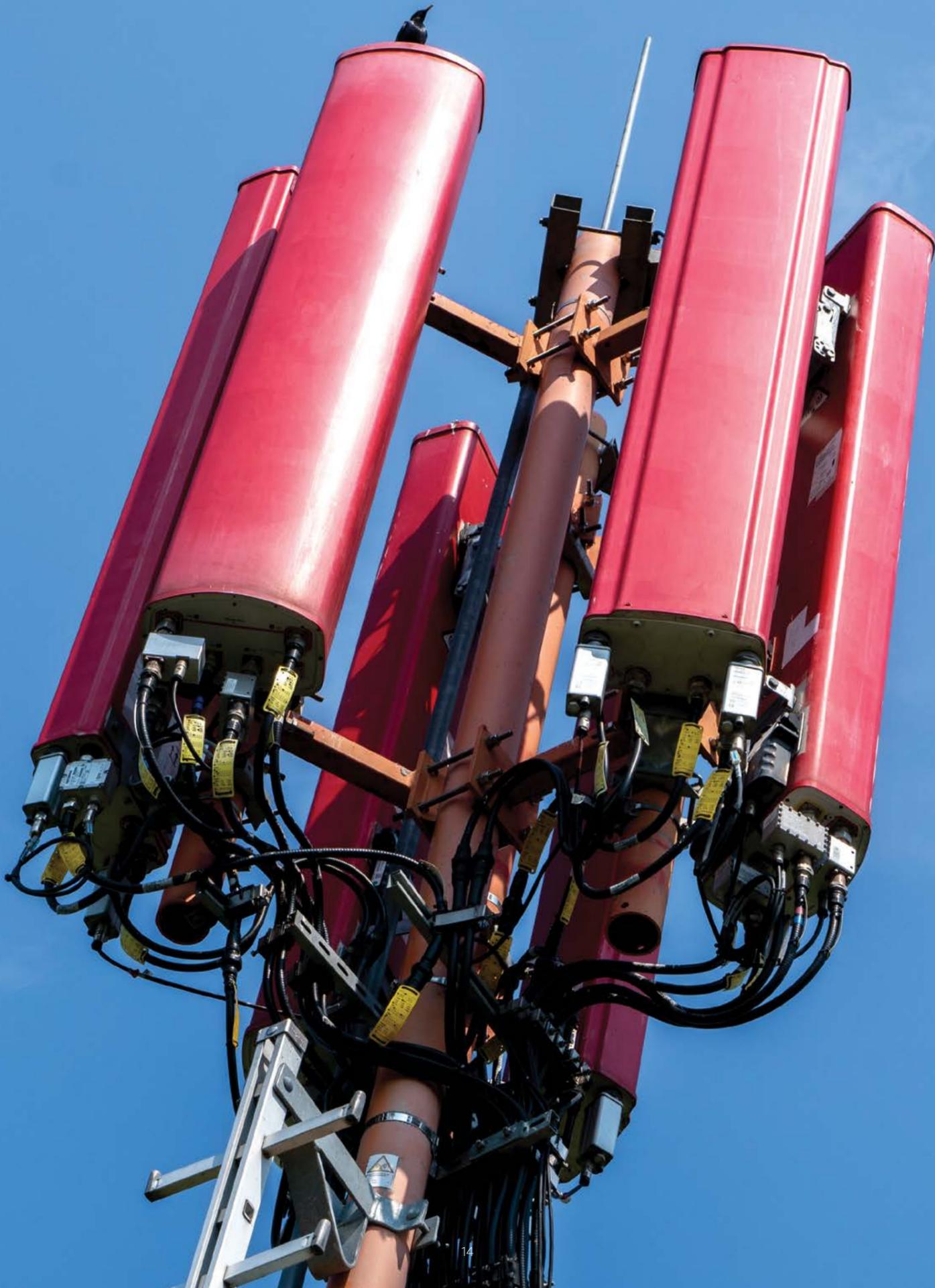
DuPont printed electronic materials that enable smaller, faster, thinner, and more reliable automotive electronics are ideal for a broad spectrum of automotive applications, including:

- Advanced driver assistance systems (ADAS)
- Electronic control unit (ECU)
- Millimeter radar
- Human-machine interface (HMI)
- Battery conditioning
- Automatic transmission control
- Cabin and steering wheel heating
- LED light demister
- Window defogger and transponder
- Rear lights
- Seat occupation sensor
- Mirror heating
- Interior heating, seat heater, rear window heating

The low-loss characteristics of DuPont LTCCs make them an ideal choice for high-frequency applications and enable more efficient circuits. Plus, DuPont LTCC materials allow for a cost-effective system design that incorporates direct die attach, high-density circuitry, compact design, and great thermal management.

Polymer and ceramic thick film technologies from DuPont offer automakers the advantages of creating sensors that enable high density, high reliability and excellent performance. And when used for defroster and defogger applications, DuPont materials offer the best cost per backlight due to a much thinner fired trace, higher process yields, and manufacturing versatility.





5G & High Frequency Communications

DuPont's hybrid circuit materials are relied upon every day in 5G and satellite communications, automotive electronics, guidance systems, aerospace, defense, homeland security, telecommunications, and consumer electronics.

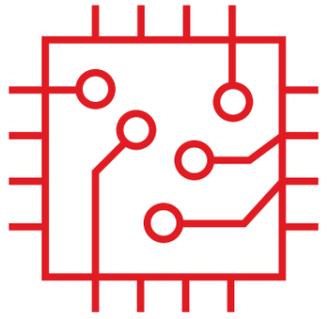
DuPont solutions for high frequency circuits include:

- Ceramic packaging materials
- Proprietary processing technology
- Design knowledge covering 1-120 GHz frequency spectrum
- LTCC and thick film on alumina / aluminum nitride / beryllium oxide substrates

Our extensive offering consists of material systems with proven compatibility including a full line of conductors, dielectric materials, resistor materials, encapsulants, DuPont™ GreenTape™ ceramic tapes, and Fodel® photo-imageable materials.

GreenTape™ 9K7 is a low-loss glass ceramic dielectric tape for high-frequency applications— up to 100 GHz and beyond—that includes compatible gold and silver conductors, plus co-fired embedded resistors. This dielectric tape is both cadmium and lead free and is ideally suited for advanced high-frequency applications, wireless and mobile communications, and high-density multilayer interconnects for high-speed digital applications.

DuPont thick films maximize design flexibility in terms of substrate compatibility— ranging from low-temperature curable pastes suitable for PVC, polyethylene, polypropylene and PET substrates, to high-performance pastes that can perform up to 250°C on high-temperature flexible substrates like PEN and DuPont™ Kapton® polyimide films. DuPont hybrid circuit materials are also compatible with other polymer, glass, metal, and ceramic substrates.



In-Mold Electronics (IME)

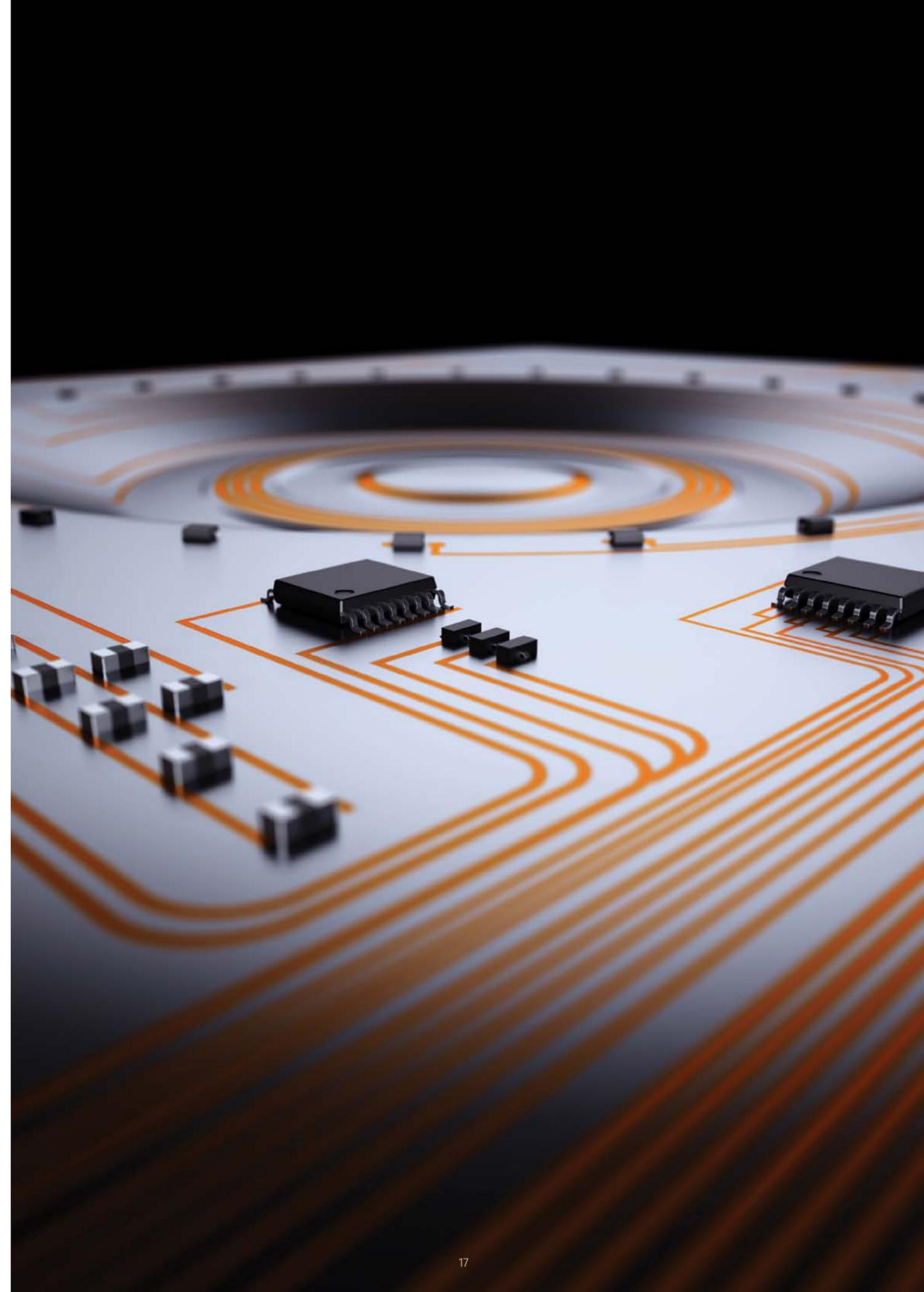
How do you make products more beautiful while simplifying their assembly? With DuPont's unique line of in-mold electronic inks that enable touch controls to be directly embedded inside of plastic parts. Our materials allow manufacturers to print circuits directly onto plastic sheets which can then be thermoformed and injection molded.

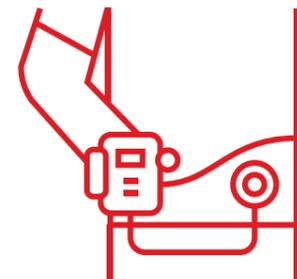
DuPont offers the only suite of IME inks designed to withstand the intense stretching and high temperatures of thermoforming and injection molding, opening up new design possibilities for appliance, automotive, aerospace, and consumer electronics applications.

DuPont IME inks can be used to construct true 3D circuits with capacitive switches and LED lighting for applications such as controls in automobiles and domestic appliances. Use of IME eliminates the need for bulky wires and switches which means components take up less space and weigh less than traditional switching components. In a typical application:

- Weight is reduced 70%
- Part assembly time is cut by 40%
- Manufacturing costs are reduced 30%

Plus, DuPont IME inks offer unlimited design freedom because they can be thermoformed to create any shape designers imagine.





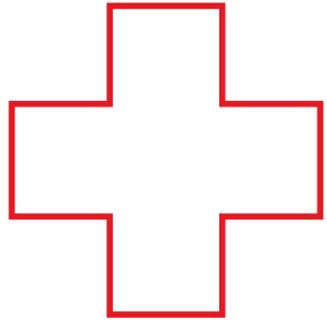
Printed Electronics

Design options abound with printed electronics, especially when it comes to making ordinary objects smart and interconnected. Printable sensors, antennas, biosensors, touch screens, touch switches, and printed heaters are helping advance everything from automobiles and telecommunications to consumer goods and health devices.

DuPont's printed electronic materials include a selection of conductive silver, carbon, and silver chloride inks, all formulated to strike the right balance between performance and cost. By combining these conductors with other printed electronic elements including dielectric inks, we offer the ability to form conductive traces, capacitors, and resistors. For touch panels and smart glass, DuPont fine-line, high-resolution silver pastes are suitable for grid lines and busbars with good adhesion to ITO and low-contact resistance. This additive technology simplifies production of touch panels and functional glass such as self-dimming windows.

DuPont conductive ink technologies are compatible with many substrate surfaces including polyester, glass, and ceramics, and can be applied using screen printing as well as a variety of other processes. Some of our other functional inks include:

- **DuPont™ Kapton®**—these polyimide inks are ideal for high-temperature printed electronic applications such as heaters because they're capable of operating continuously at temperatures up to 230°C.
- **DuPont™ Low-temperature Inks**—DuPont inks that can cure at temperatures as low as 60°C open possibilities for printed electronics because they can be used with less expensive plastic films such as PVC, polystyrene, high-density polyethylene, and acrylic polymers.



Wearables for Health and Fitness

Wearables advance to the next level with **DuPont™ Intexar™ ink and film that integrate seamlessly into textiles to transform materials into smart wearables.** In addition to providing an effective way to sense and transmit biometric signals and deliver heat, Intexar™ is soft, thin, lightweight, and stretchable.

Intexar™ is ideal for:

- **Wearable health monitoring and therapy**—when placed directly on skin, Intexar™ Health has sensors that detect the body's natural electrical signals. It can also be used for gentle on-body heating and mild electrostimulation for pain relief to targeted areas
- **Fitness performance clothing**—with sleek designs that eliminate bulk, Intexar™ Fitness can track and monitor pulse, breathing rate, muscle tension, and form

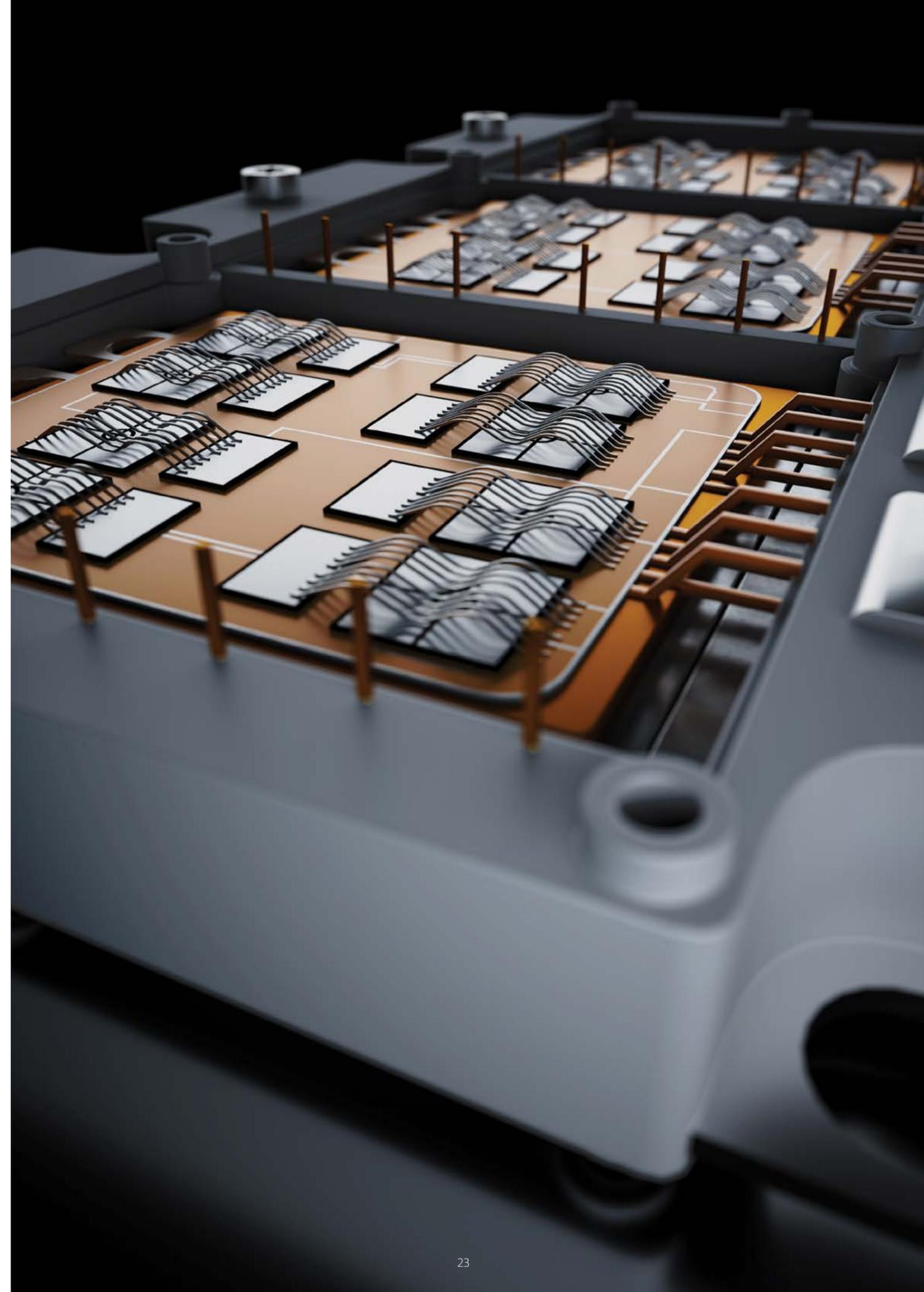
- **Heated smart clothing**—Intexar™ Heat eliminates bulky wires for ease of movement while providing temperature control and fail-safe engineering that eliminates the possibility of overheating

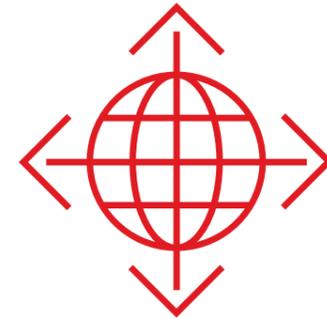
All grades of Intexar™ are compatible with standard textile lamination processes and can be cut to any shape. Plus, Intexar™ is durable and maintains signal strength for more than 100 washes.



DuPont Printable Inks, Pastes, and Tapes for Microcircuits

| Solution | Key Properties |
|--------------------------------------|--|
| AS Series Paste System for Aluminum | <ul style="list-style-type: none"> Prints directly on aluminum substrates and heat sinks |
| Biomedical Sensor Inks | <ul style="list-style-type: none"> High-performance electronic materials for glucose test strips and next-generation medical diagnostic devices and skinpatches |
| Copper Pastes | <ul style="list-style-type: none"> Photonic technology enables high-speed, low-temperature curing High conductivity on many substrates, including FR4, PVC, and Kapton® Excellent printed line/space resolution Long lamp life for photonic systems |
| Laser Structurable Pastes | <ul style="list-style-type: none"> Provide fine line capabilities and superior resolution to screen printing with sub-100 micron pitch |
| Low-temperature Curing Pastes | <ul style="list-style-type: none"> Cure at temperatures as low as 60°C with optimal performance at 80°C Enable printing on polymers like polyolefins and PVC |
| Dielectric and Encapsulant Materials | <ul style="list-style-type: none"> For cross-overs, co-fireable and sequentially fired multi-layer applications |
| Inkjet Ag | <ul style="list-style-type: none"> Superior resistivity values tested at all temperatures High print height with a single pass Fine line resolution and ultra-smooth surface Good adhesion to multiple substrates |
| Thick Film Resistor Materials | <ul style="list-style-type: none"> For hybrid applications including chip resistors and networks |
| Fodel® Photoimageable Pastes | <ul style="list-style-type: none"> Photoimageable, thick film ceramic system featuring dielectric, silver, and gold conductors Enable the creation of high-density/fine-line/fine-geometry circuits, ideal for the most challenging applications and toughest operating environments Doesn't require dedicated processing equipment |
| GreenTape™ LTCC Glass Ceramic Tape | <ul style="list-style-type: none"> Low-loss glass ceramic dielectric tape for high-frequency applications—up to 100 GHz and beyond—that includes compatible gold and silver conductors, plus co-fired embedded resistors |
| Intexar™ | <ul style="list-style-type: none"> Stretchable and washable Thin, lightweight, and conforming Senses biometrics, delivers powered heat, provides monitoring |
| Kapton® | <ul style="list-style-type: none"> Maintains mechanical and electrical properties for applications with extreme heat and vibration |





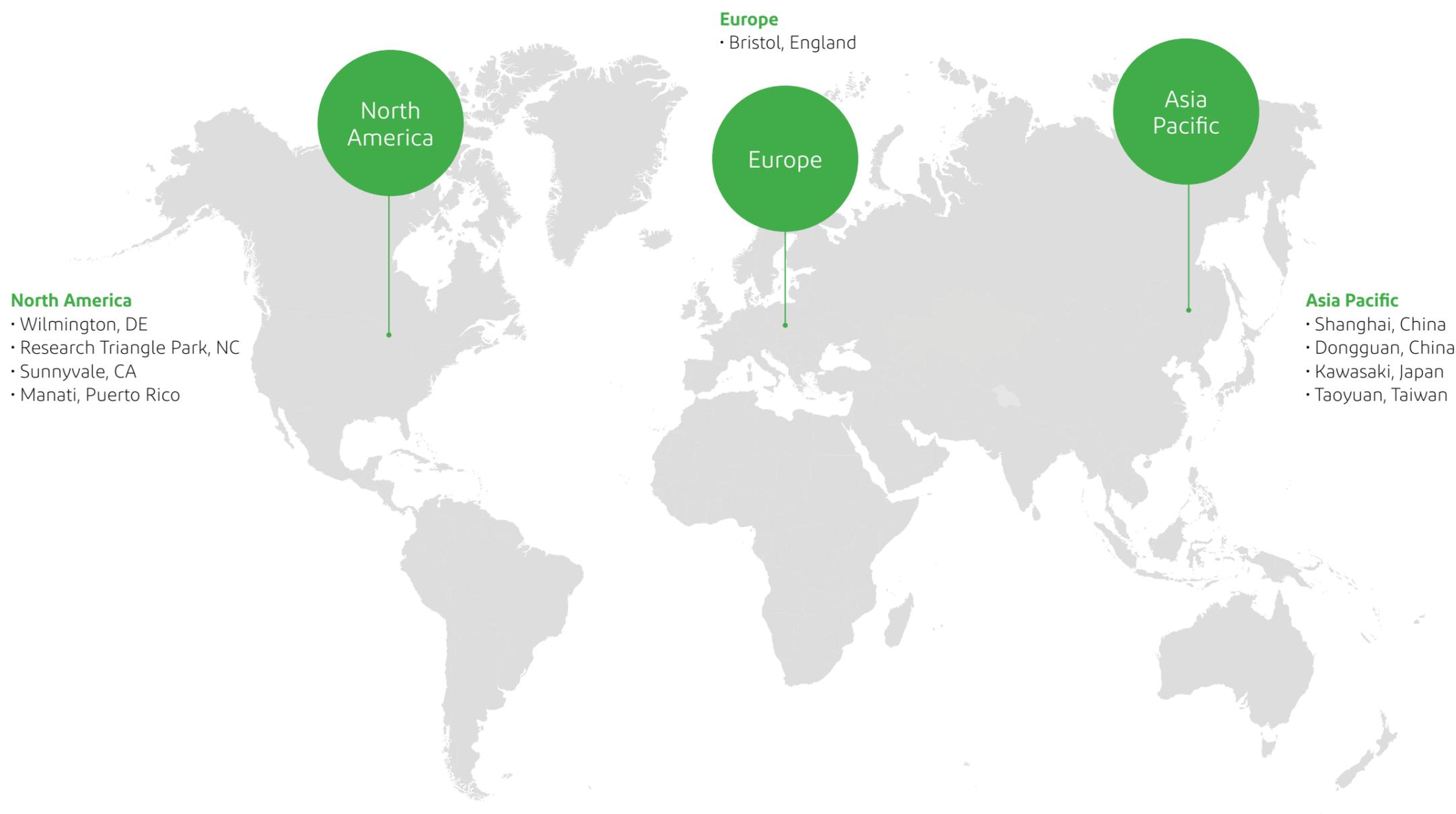
Worldwide Support and Supply

When you choose DuPont microcircuit materials, you get access to worldwide support and supplies.

Our product development team innovates by combining the most advanced materials and formulation science with:

- Expertise in metals, glass, and ceramic chemistry
- Application engineering
- Inorganic chemistry

With daily air shipments to Asia Pacific, Europe, and the U.S., DuPont is a supplier you can depend on for printed microcircuit materials. Turn to us for dielectric materials, resistor materials, encapsulants, thick film, pastes, GreenTape™ LTCC glass ceramic tapes, and Fodel® photoimageable materials.



Applications for DuPont microcircuit materials include but are not limited to:

- Thick film, hybrid and LTCC
- In-mold electronics
- Printed electronics
- Wearables, including stretchables
- Chip components
- Hybrid integrated circuits
- Ceramic packaging solutions
- Satellite and flight hardware
- Airborne radar and flight avionics
- High-frequency transmitters and receivers
- Bluetooth RF modules
- Signal processing filters and switches
- Membrane touch switches (MTS)
- RFID and membrane touch switches
- Electroluminescent materials
- Sensors / flexible sensors
- EMI shielding
- Wireless charging coils
- Self-limiting, flexible heaters
- Large-area flexible LED foils
- Printed biosensors
- Force-sensing resistors
- Emerging photovoltaics
- Touch screens and smart glass
- Smart packaging
- OLED lighting
- Printed photodetectors

What microcircuit materials do you need?

We help customers advance their products with flexible, reliable microcircuit materials so they can build the next thing that changes everything. Plus, our research and development team partners with customers on product development and customized solutions.

Contact us at dupont.com to learn more about DuPont printed electronics products, request a sample, or get a quote.



<https://www.dupont.com/mobility-materials/thick-film-materials.html>

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