WHAT'S NEW?

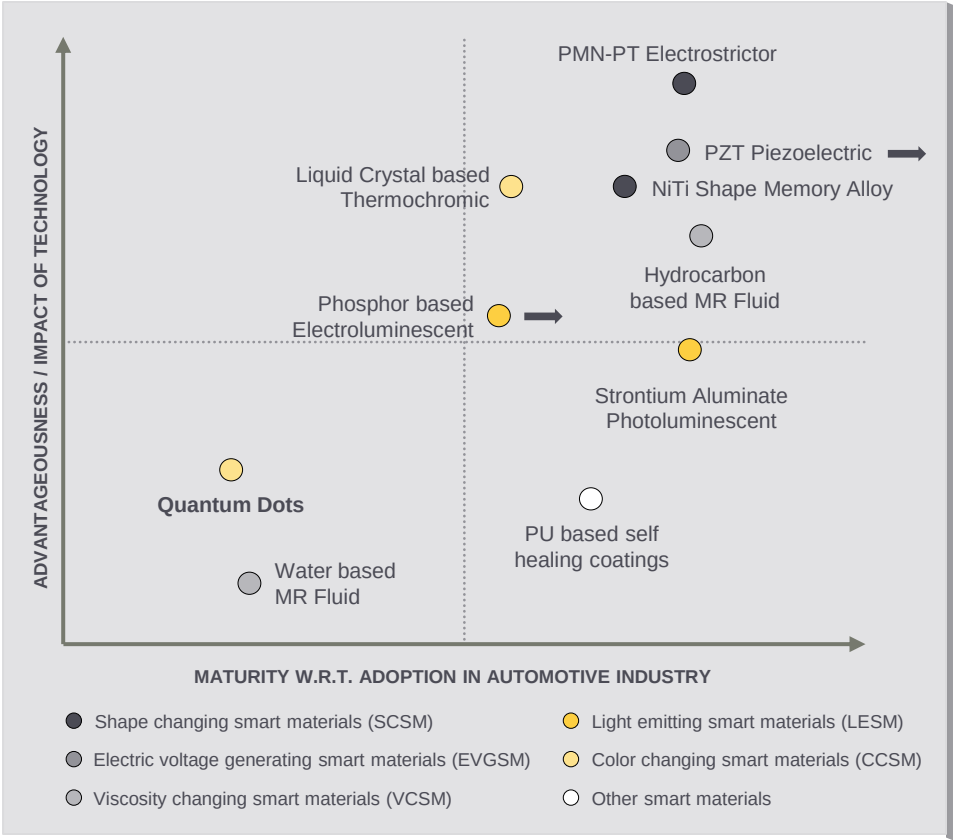
H1 2020

EXECUTIVE LENS

Summarized insights for Smart Materials w.r.t. trends in technology, market, and players

State of the Trend

Energy harvesting, passenger comfort and aesthetic features driving forward the adoption of smart materials



Key developments in last 6 months

- Electro chromic, Thermo chromic materials are widely used for enhanced vehicles interior features, such as new head up displays, curved screens instead of dashboard etc.,
- Suppliers such as Covestro and BASF are expanding their sustainable material portfolio to meet the OEMs' demand for light weight, durable and recyclable parts
- Upcoming car models are going to implement large area displays. OEMs such as Cadillac and Mercedes-Benz are announced their new models with large-area OLED displays
- Players are developing new materials that can protect the car interiors from pathogens as the COVID-19 has changed consumers' perception about hygiene risks. Nanox developed new material for car interiors that guards against viruses. Ultraleap and JLR are developing touch-less interfaces in order to avoid risk associated with touch screens

Electrochromic materials	Leading OEM's and Tier 1 suppliers are integrating electrochromic based smart glass technology into vehicles across the automotive sector.
Thermochromic materials	Automotive designers are replacing flat screens with conformable and shapeable OLCD/OLED displays .

Read more in Benchmarking section

Emerging trends

Tomorrow's mobility ecosystem, with fleets of autonomous and/or electric vehicles, may require a new catalog of materials to make everything from batteries to simplified powertrains and customizable interiors. Players are developing new technologies and increasing their competency.

Color changing smart materials, smart sustainable polymers and piezoelectric materials are finding numerous applications in automotive sector

Players diversifying their portfolio with sustainable smart materials for automotive

- Covestro has developed a wide range of thermoplastic polycarbonate and thermoset polyurethane composite >>
- BASF announced a large sum of investment for the capacity expansion of water-based polyurethane dispersions >>
- Audi to use 89% of the fabric from recycled PET (polyethylene terephthalate) plastic bottles >>

Read more in Q1 2020 Pulse - SM

Advanced piezoelectric sensor technology for smart cockpit

- Mercedes-Benz developed new steering wheel technology with capacitive sensors >>
- Bosch developed new MEMS sensor that ensures uninterrupted navigation >>
- Ultraleap developed gesture based mid-air haptic technology >>

Read more in Q2 2020 Pulse - SM

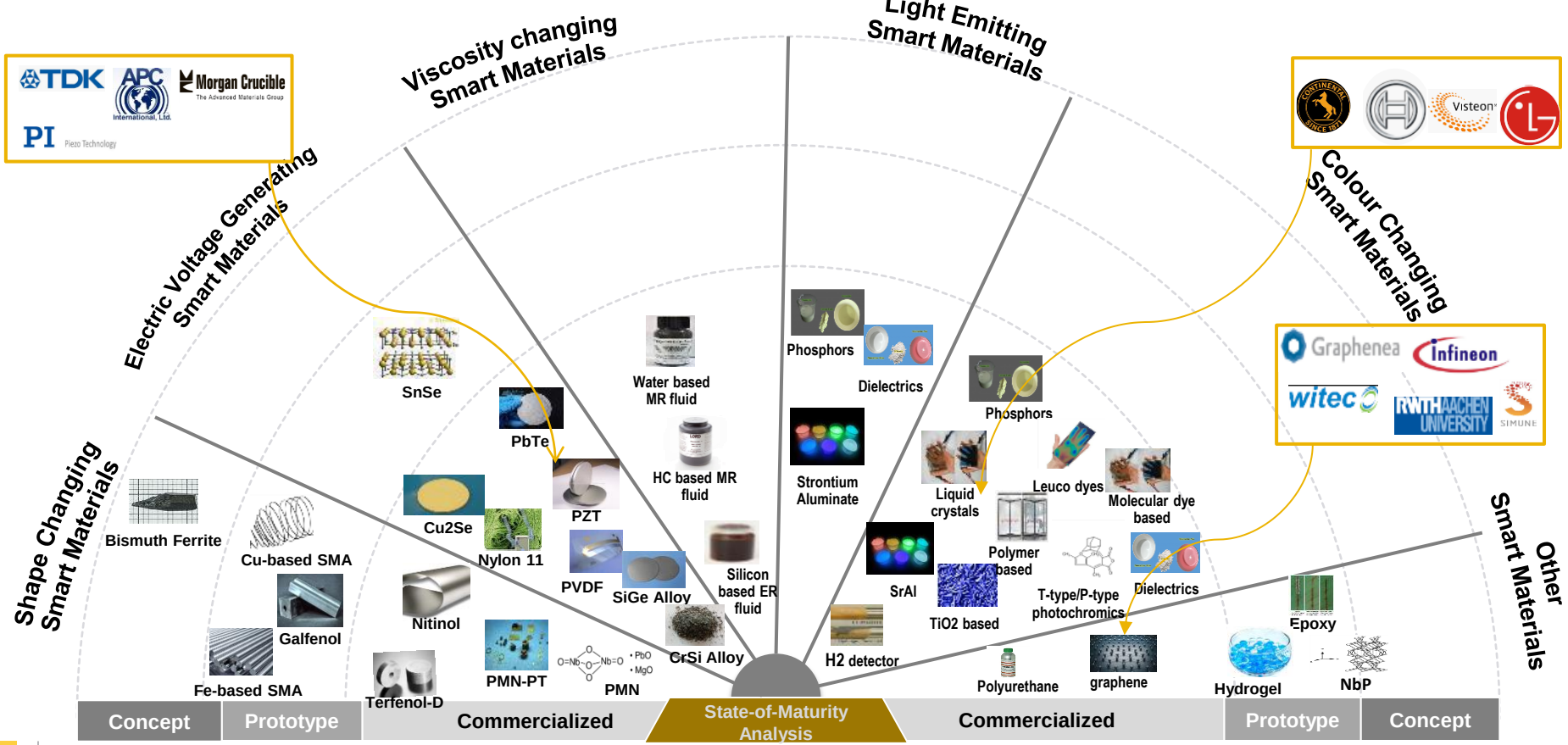
OEMs embrace large OLED Smart displays in upcoming models

- Mercedes-Benz S-class to implement LG's large OLED screens >>
- Rightware collaborated with LG Electronics to power graphics for the 38-inch OLED display in 2021 Cadillac Escalade >>
- LG got GM innovator of the year award for its P-OLED cockpit technology in 2021 Cadillac Escalade >>

Read more in Q2 2020 Pulse - SM

Maturity Fan Diagram

Although majority of the solutions are commercialized, and only few are on prototype/research phase



Impact of Megatrends

		Upcoming requirements	Opportunities for smart materials
Safety & Autonomy		• Increased passenger comfort, new seating configuration and dynamic positions, seat-integrated safety systems • Enhanced safety features to comply with regulations utilizing clever sensor integration • Increased communication with pedestrians	• Smart fabric in seats allows features to only be deployed when needed reducing screen or button need • Magneto rheological materials for damping in interiors • Integration of safety features in interiors and crash protection in exterior using shape memory alloys • Electroluminescent display features on exteriors
Electrification		• Vehicle to grid infrastructure • Improved battery thermal management solutions • Battery self diagnostics systems and inspection sensors	• Photovoltaic as source for charging stations or in vehicle roofs • Thermoelectric based energy recovery systems • Electrostrictive material in batteries to account for volume changes when charging/discharging • Use of graphene for EV applications
Connectivity		• Passenger monitoring on cloud • Increased number of display devices, HUDs • Sensors for driver health monitoring	• Piezoelectric material-based fatigue drive monitoring • Electro-chromic materials enhancing display devices by changing intensity based on surroundings

Impact of Megatrends

		Upcoming requirements	Opportunities for smart materials
Shared mobility		• comfortable seats and blunt edges are needed since the interior space is being largely utilitarian. • Reduce wear and tear of tires due to continuous usage • Autonomous ride sharing services	• Thermoelectric fabrics on seats , anti-bacterial coatings and OLED/LCD displays • Nitinol based shape memory alloy is on testing phase to reduce wear and tear of vehicle tires • Photochromic tinting on windows to maintain inside cabin temperature in order to make it comfortable when passengers enter the vehicle.
	Reduction in weight	• Electrification and autonomy will increase the demand for weight reduction in vehicles.	• Adoption of light weight , high performance polymers, advanced composites, and aluminum and lightweight steel alloys. e.g.: Polycarbonate films in future automotive cockpits • Graphene / graphene composite based car body panels

Front Running Technologies – Adoption & Industry development

Piezoelectric and thermochromic materials gaining momentum, high industrial and research activity observed in 2020.

Thermochromic Material – Large area OLED displays

Read more in Q2 Pulse SM

Cadillac — Large area OLED display from LG

Mercedes-Benz — Mercedes-Benz S-Class to get five large OLED screens

BYTON — Byton's 49" wide OLED display

NISSAN — Nissan's curved two-screen display

Key Research Activities

- Reflective liquid crystal display with fast response time and wide viewing angle >>
- Experimental and modeling studies of automotive-qualified OLEDs under electrical stress >>

Piezoelectric Material – Sensors for smart cockpit

Read more in Q2 Pulse SM

Henkel — Henkel functional material solutions

Mercedes-Benz — Touch-sensitive steering wheel

ultraleap — Interfaces with mid-air haptic technology

MICROCHIP — smallest automotive controllers

BOSCH — semiconductor chip with MEMS sensor

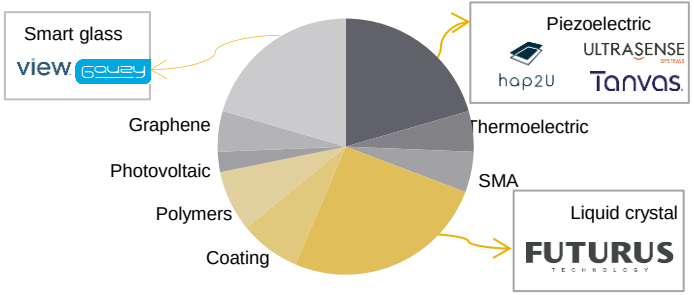
Key Research Activities

- Piezoelectric pressure sensor for harsh-environment and high-temperature applications >>
- Pressure induced structure distortion in ferroelectrics with enhanced piezoelectric properties >>

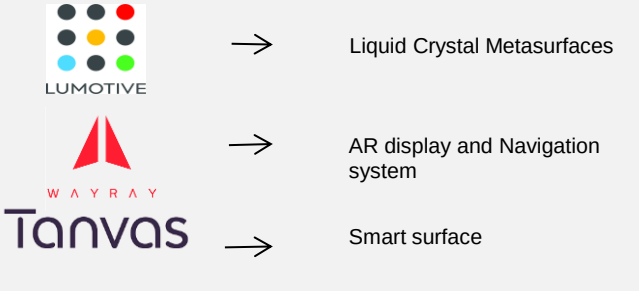
Startup Activity Summary

Startups captured in 2020 contains more number of startups in color changing smart materials. More startups are emerging in piezoelectric sector as the consumer demand is rising for in-vehicle comfort and convenience features.

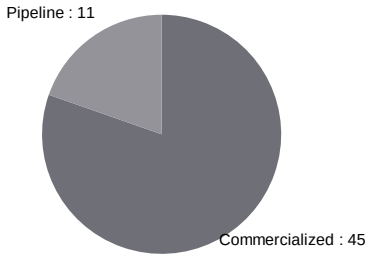
Startups in SM by technology



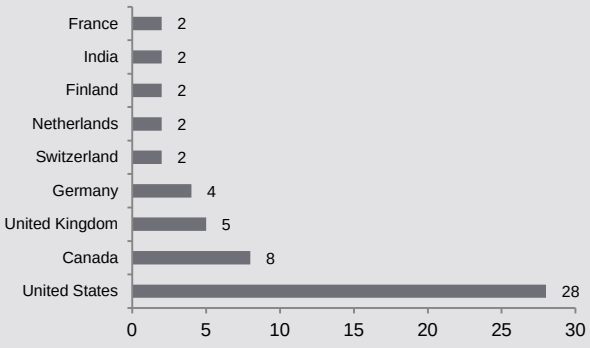
Some key startups active in 2020



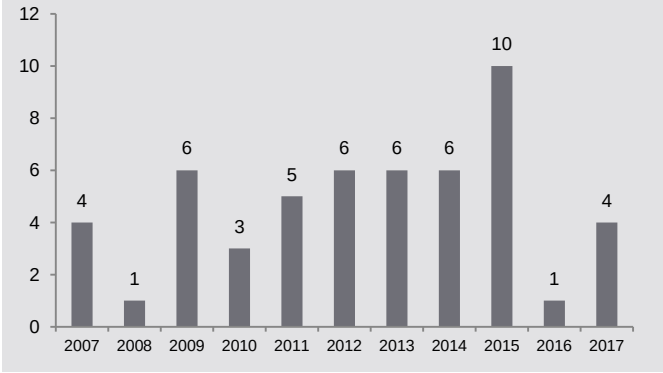
Startups by state of maturity of products



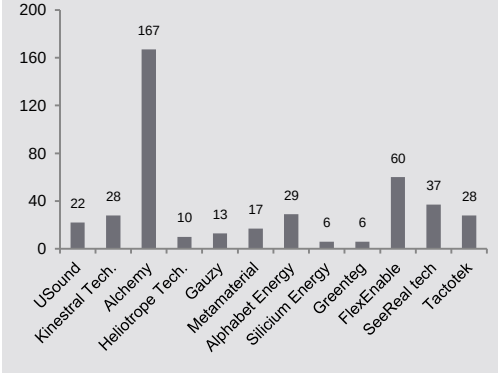
Startups by geography



Startup incorporation



Number of patents by startup



Exteriors Applications

Increased adoption of smart materials in dampers and energy recovery; innovative uses in bumper help enhance safety

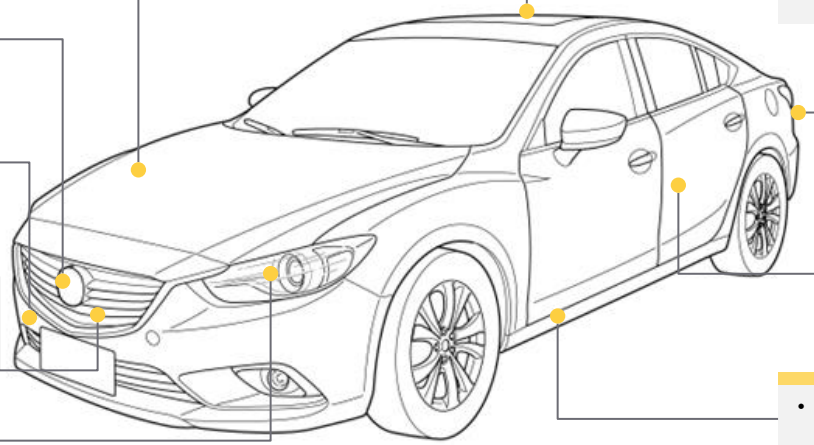
- **Shape Memory Alloy**
  Controlled vibration to reduce aerodynamic drag

- **Electroluminescent**
  Illuminated vehicle emblem

- **Shape Memory Alloy**
  Smart bumpers

- **Thermoelectric**
  Radiator heat exchanger

- **Shape Memory Alloy**
  Headlamp vibrations damping



- **Electro chromic Material**
  Vehicle Sunroofs

- **Photovoltaic Material**
  Solar panel sunroofs

- **Thermoelectric**
  1. Exhaust energy recovery
  2. EV battery Cooling

- **Self healing material**
  1. Coatings/paints
  2. Paints for easy detection

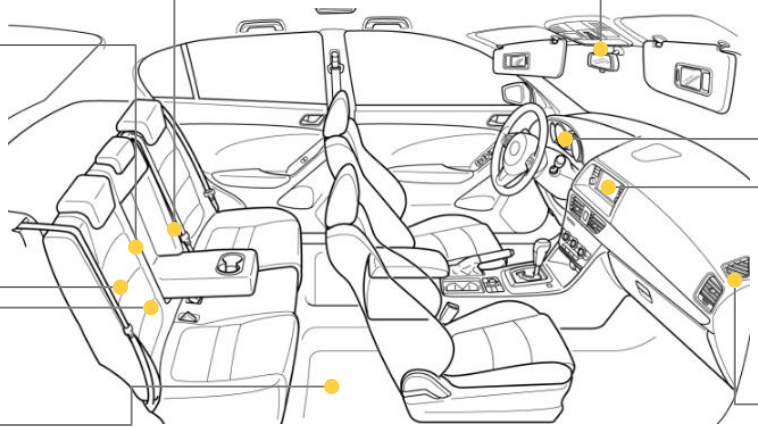
- **Magnetorheologic fluid**
  Dampers

- Thermoelectric heat exchanger in radiator & exhaust, photovoltaic sunroof make vehicle adept in energy harvesting capabilities
- Shape memory alloys enable dynamic projection on the exterior surface to reduce drag
- Electrochromic sunroof and electroluminescent emblem add aesthetic features to exteriors

Interior Applications

Ability to get miniaturized enabling smart material to penetrate in seats; electroluminescent and Electrochromic materials enhance user experience

- **Shape Memory Alloy**
  Variable support in seat
- **Shape Memory Alloy**
  Massage systems in seat
- **Electrostrictive**
  Lumbar support
- **Thermoelectric**
  Heating/cooling vehicle seat
- **Electroluminescent**
  Interior panel surface light



- **Electro chromic Material**
  Rearview mirrors
- **Electro luminescent**
  Instrument clusters
- **Electrochromic**
  Display panels, HUDs
- **Electrostrictive**
  Lumbar support

- With the ability to form miniaturized components, smart materials are enabling safety and comfort features integrated in the seats
- Electroluminescent features add aesthetics features to the interior which could unlock further vehicle personalization
- Display panels and mirrors adopting Electrochromic materials to enhance view according to ambient light

Supplier activities on smart materials for future mobility

Players are diversifying their smart material portfolio for future automotive applications. The continuous demand of innovative products for future mobility is forcing the suppliers to enhance their already existing smart-material solutions.

Future mobility smart material solutions from Covestro

BASF future campervan concept with advanced materials

Apple research on mood lights, smart fabric

Metamaterial functional films that replace LCD/LED displays

Gauzy's LCG® smart glass windows for future cars

Bosch AI-powered LCD sun visor

Continental's Intelligent Glass Control

Cadillac Escalade 2021 with LG pOLED display

COVID impacts on smart material industry

The coronavirus epidemic is likely to harm general markets. Global GDP is going to take at least a minor hit. Display industry is facing huge loss, as most of the regional hubs are affected by the pandemic.

Display Market Down in Light of COVID-19 : expected to plunge by 11.1% in 2020 as the coronavirus crisis >>

16 April 2020

05 April 2020

UVeye has developed contact-free, emergency-vehicle inspection systems equipped with thermal sensors that can identify drivers and passengers with fever through vehicle windshields >>

Wuhan: major hub for display manufacturing with LCD and OLED fabs, badly hit by Corona outbreak >>

29 Jan 2020

13 Feb 2020

Covid-19 outbreak boosting LCD panel prices: A decline in supply and a rapid rise in LCD panel prices are occurring in the wake of factory shutdown in China attributable to Covid-19. >>

Future Outlook

Near Term → **Medium to long term**

Technology	Near Term	Medium to long term
Viscosity Changing Fluids	• Use cases of magneto-rheological and electro-rheological fluids in damping and vibration control apparatus in suspension and exteriors	• Adopting active collision protection systems for controlling stiffness of exterior support structures
Color Changing Materials	• Flexible OLED/OLCD displays, Large area displays • Thermochromic material to help indicate temperature of components • Photochromic window tinting for passenger comfort	• Ultrathin, foldable, customized and low cost flexible displays • Interior light intensity control • Curved OLED screens on dashboard
Shape Changing Materials	• Shape memory alloy enabling smart comfort features in the interiors and vibration control • Magnetostrictive sensors in drivetrain	• Features such as smart bumper, protective shield system using SMA • Accounting volume change in battery
Voltage Generating Materials	• Energy recovery systems using thermoelectric generators (heat energy) and piezoelectric (vibrations energy)	• Smart interior sensing capabilities and comfort features using piezo and thermo-electrics

Things to watch out for!

- Increasing interest in light-weight and high-performance smart materials leading to significant research activity in the area of polymers and composites
- Upcoming vehicle models are implementing large area/flexible OLED, OLCD displays
- COVID-19 has dramatically changed consumers' perception of the hygiene risk of touchscreens. Players such as Ultraleap is developing gesture-based solutions
- Smart glass is rapidly becoming the smartest choice for dynamic shading and temperature control in the transportation sector. Players such as Continental, and Apple are in the forefront of the technology

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