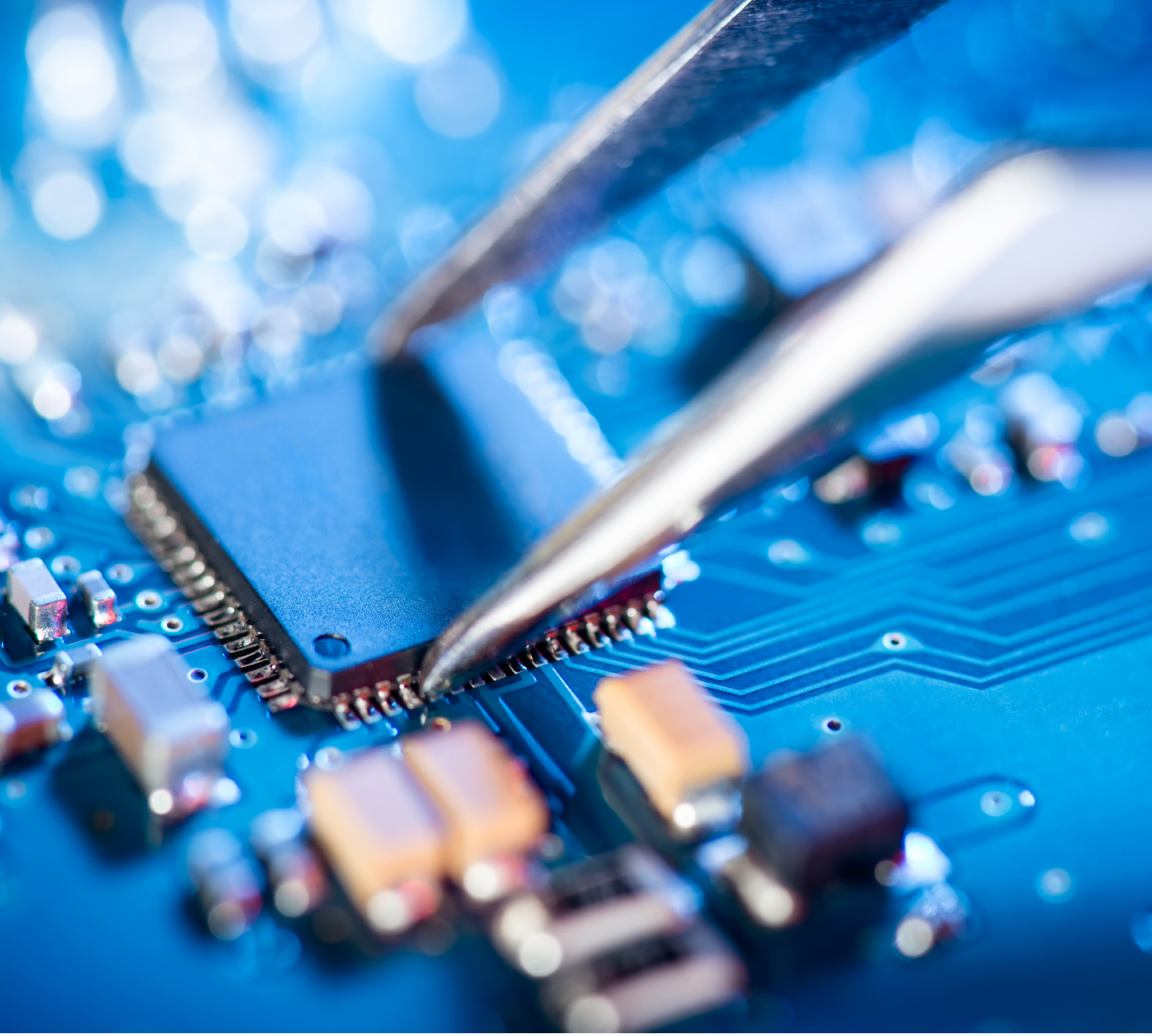

Trends Shaping the Electronics Industry

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What distinguishes electronics from electrical products is how their electricity is conducted. In electrical products, the conductor is metal, such as copper wire, whereas in electronics, it is non-metallic, namely gases, liquids, superconducting materials, in a vacuum, or silicon. Most electronics have long relied on the silicon crystals in semiconductors for their electrical circuits, although other materials are continually being investigated to improve future performance.

Electronics are used daily in thousands of applications by businesses and consumers across the world. This white paper focuses on the largest segments and those that are driving growth in both sales and technology.

Industry Segments

Major segments of the electronics industry mirror the global end use markets for semiconductors:

- 32.3% PC/Computer
- 31.2% Communications (including smartphones)
- 12.0% Consumer
- 12.0% Industrial
- 11.4% Automotive
- 1.0% Government

100.0% Global Semiconductor Sales ($440 billion in 2020)

Source: 2021 World Semiconductor Trade Statistics, Semiconductor Industry Association

In the electronics market, two other major segments are:

- Semiconductor manufacturing*
- Electronic components

* *The semiconductor industry is not covered in detail in this paper. For more information about semiconductors, see the companion white paper titled, Trends in Semiconductors.*

Industry Trends

The following industry trends are predicted for the short term by New Electronics, a U.K. website and journal for electronics design engineers: https://www.newelectronicsco.uk1

- Growth of COVID-accelerated **medical technology** (Ex: smart watches for consumers that monitor illness, as well as fitness)
- Advances in **social care/home care technology** (Ex: technology that unobtrusively monitors and provides emergency responses)
- Machine learning will fuel growth in **connected health** (Ex: remote diagnostics of illnesses; greater deployment of machine learning)
- Wider deployment of **gesture recognition technology** (people using gestures instead of touchscreens on systems and devices)
- Volume increase in **speech recognition** (Ex: more speech – activated systems in public spaces)
- **Global supply crunch of electronic components** (stock levels have not sufficiently recovered to keep pace with demand)

- **Smart home gym equipment** will expand (Ex: smart workout assistants that employ AI)
- **ARM Laptops** market race will heat up (with ARM processors, based on RISC architecture – see RISC-V below; ideal for students and general-purpose laptop users)
- **Smart homes** will further increase their appeal (Ex: smart meters for utilities, with focus on climate change and managing energy)
- **AR/VR** (augmented reality/ virtual reality) will further evolve (Ex: Remote learning in educational systems; remote shopping)
- **Nature and outdoor leisure apps** and the "IO Tree" (trees with IoT sensors attached to help combat climate change)
- **Retail technology** to herald cashless society (more technologies for contactless payments)
- **RISC-V** will edge further towards the mainstream (RISC-V ISA, the open standard instruction set architecture (ISA) based on established reduced instruction set computer (RISC) principles)
- Improved **remote working solutions** (Ex: teleconferencing software, such as smoother video generated by AI)

Selected Growth Segments

Consumer Electronics

Consumer electronics are devices and equipment designed for everyday home and/or personal use, primarily for entertainment, communication, home office and recreation.

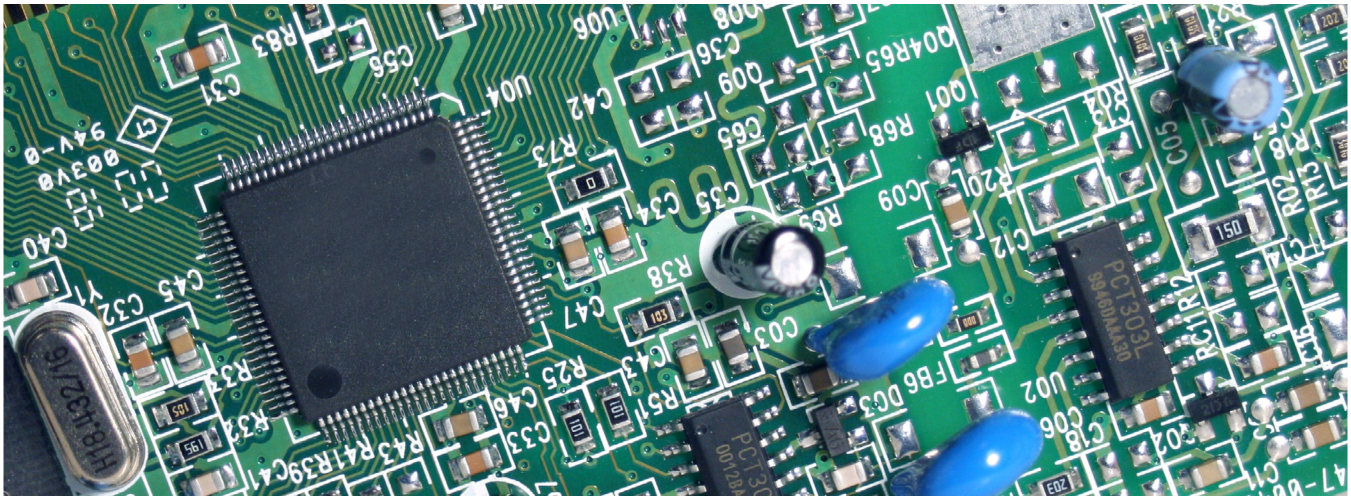
The Consumer Technology Association (CTA) predicts that U.S. sales of consumer electronics will grow to $461 billion (retail spending) in 2021, up 4.3% from $422 billion spent by consumers in 2020. Growth in 2021 continued being driven by Americans working from home and home schooling during the pandemic. These two years were characterized by a leap in technology adoption, particularly of laptop computers and other work-from-home tools.

CTA forecasts strong U.S. growth for consumer electronics in 2021, driven by streaming services, 5G connectivity, and digital health devices:

- **Streaming services and software,** up 11% to $112 billion in 2021 (a new record) following 31% growth in 2020
- **Smartphones,** up 4% to 161 million units to $73 billion; 42% of these will be 5G
- **Digital health products,** up 34% to $845 million, following a massive 73% increase in 2020 to $623 million; sales will grow from 2022 through 2024 by 14%/year, reaching $1.25 billion in 2024

Other consumer electronics forecasts by CTA for 2021 are:

- **Gaming,** including software and hardware, up 8% to $47 billion
- **Video,** up 15% to $41 billion
- **Audio,** up 19% to $10 billion
- **Wireless headphones and earbuds,** up 32% to 91 million units
- **TV sets,** dropping 8% to 43 million units in 2021, but 2020 had the second largest sales volume ever recorded



Electronic Components

Electronic components comprise a vast number of parts for a wide number of functions. Major categories include:

- Passive components
- Active devices
- Semiconductor memory
- Connectors
- Logic IC families
- ASICs (application-specific integrated circuits)
- FPGAs (field programmable gate arrays)

Shortages of electronic components began in the United States in 2018 when the federal government imposed tariffs on nearly two-thirds of all Chinese imports. Then, in 2020 and 2021, the pandemic resulted in a severe, worldwide electronic components shortage, particularly semiconductors. This was caused by a combination of factors, primarily the surge in consumer demand for electronics to support people having to move their work, school, shopping and entertainment to their homes. Bulk electronic component shortages were further exacerbated by the disruption of Asian supply chains, including both manufacturing and shipping.

While not quite as severe as in 2020, shortages continued in 2021, with mounting demand driving up prices. A number of forecasts have predicted the semiconductor shortage will ease in the second quarter of 2022. More recent reports suggest these supply chain problems could persist through 2023.

According to the Electronic Components Industry Association (ECIA), lead times for all electronic components have significantly lengthened since September 2020, including those for electronic component procurement groups. ECIA concludes that if the global economy continues to improve, electronic component supplies will continue to be pressured by market demand.

A U.K. supplier of global electronic manufacturing services recently stated, "electronic products have shorter lifecycles than ever before." This is the result of rapid technology advances and frequent shifts in consumer behavior. The company added that this has led electronics manufacturers to hesitate about investing in longer-lasting products.

Automotive Electronics

The Center of Automotive Research in Ann Arbor, MI, identifies four technology megatrends that are transforming the automotive industry: Autonomy, Connectivity, Electrification, and Shared Services – aka "ACES." (Shared services refers to on-demand transportation through shared-service platforms, such as ride-hailing apps and robo-taxis.) These trends are driving the growth of automotive electrical and electronic components (E/E). McKinsey & Co. predicts this market to grow by 6.5% annually in the coming decade, from $205 billion in 2020 to $385 billion by 2030.

The major E/E automotive segments in 2020 were:

- **Electronic control units** (ECUs) and domain control units (DCUs)
- **Sensors**
- **Power electronics** (excluding battery cells)
- **Other components** (harnesses, controls, switches, displays)

The market for **electronic control units** is forecasted to shift from 98% ECUs and only 2% DCUs in 2020 to 57% ECUs and 43% DCUs in 2030. Currently, numerous

ECUs each controls a vehicle's discrete electrical subsystems, such as passenger seat movement. Each DCU controls a group of subsystems. which is more cost-effective for OEMs. Autonomous vehicle (AV) adoption will accelerate DCU growth because the complexity of having separate ECUs controlling individual functions in an AV system would be too great.

The automotive sensor market is expected to grow by 8% annually through 2030. The highest growth, at 13% per year, will be experienced by ADAS (advanced driver assistance systems) and AD (autonomous driving) sensors. Three key factors drive this segment: an increasing adoption rate, higher demand for cameras and radars and the introduction of LIDAR sensors to the mass market.

Other sensor categories include:

Body sensors, which are tied to driver and passenger comfort and convenience, will experience 5% annual growth. These measure the state of numerous vehicle functions, such as the doors, trunk, windows, wipers, heating and cooling, seats, and mirrors, to name a few.

Chassis sensors are expected to grow by 4% annually. These monitor functions such as steering, braking, and suspension, which are being increasingly incorporated into ADAS and AD safety systems.

The number of **sensors tied to the powertrain** are expected to decrease in the coming decade because of increasing use of electric vehicles. Fully electric vehicles require fewer powertrain sensors than those with internal combustion engines because EVs have a simpler powertrain with fewer components. These sensors in electric vehicles also cost less, which will continue as they become commoditized.

The **automotive power electronics segment** is forecast to experience the highest growth rate to 2030, at 15% annually. This is primarily due to the increased adoption of electric vehicles, which require significantly more of these electronics than vehicles with internal combustion engines. Major EV components driving growth in power electronics will be 40 to 150kW inverters, DC/DC converters, battery junction boxes, onboard chargers, and e-motors. The rapid growth of power electronics will more than double its share of the total E/E segment from 10% of the total automotive electronics and electrical market in 2020 to 21% in 2030.

As of mid-2021, global semiconductor lead times ran between 16 and 50 weeks, with chip makers working at full capacity just to supply the surging demand for consumer electronics. With new car demand once again on the rise, to what extent they can also supply the remains a question.

The global semiconductor shortage caused automakers in Europe, North America and Japan to announce new production cuts for the second half of 2021. On a positive note, German manufacturer Bosch, the world's largest car parts supplier, opened a new, €1 billion chip factory in June 2021, which should help ease shortages. The fully automated plant, which incorporates AIoT (artificial intelligence combined with the Internet of Things) will focus on automotive microchips built on the latest 300-mm wafers.

Power Electronics

Power electronics, a branch of industrial electronics, refers to using electronic devices with semiconductors to control the flow of electric current and voltage and convert it, through a control circuit, to the required form for the user's electric load.

Some common devices and applications are:

- AC voltage controllers
- AC-to-DC converters (rectifiers)
- DC-to-AC converters (inverters)
- DC Link converters, also known as AC-DC-AC converters
- DC-to-DC converters
- Power optimizers
- AC-to-AC converters

Power electronic devices are needed by the growing number of renewable energy sources supplying power to the electrical grid. They are used to convert AC voltages generated by wind and hydroelectric turbines into HVDC (high-voltage direct current), which is further converted into the three-phase power of the local electric grid. For power generated by photovoltaic cells, solar inverters convert their DC power to the AC power required for homes. On solar farms, a central solar converter performs the DC-to-AC conversion for the whole system.

Another long-term growth industry for power electronics is transportation electrification. The global trend of electric vehicles is expanding to other forms of transportation, including trains, ships, and airplanes. Increasingly strict environmental regulations on fuel emissions have propelled this shift. Vehicle electrification uses power electronics to connect the electric propulsion and energy storage systems, and the electrical grid.

Electronics Protection

EMI Shielding

Protecting semiconductor devices and printed circuit boards (PCBs) from both externally and internally generated electromagnetic and radio frequency interference (EMI/RFI) has become increasingly challenging. This is due to the ongoing trend of smaller, faster, more powerful and more densely packed PCBs in operating electronics, as well as their growing number of frequencies. Without this shielding, EMI can reduce an electronic device's performance, cause a malfunction, or lead to complete failure.

EMI shielding essentially blocks the electromagnetic field with barriers made of conductive or magnetic materials. The most common shielding materials are pre-tin plated steel, copper and copper alloy 770, and aluminum. All absorb transmitted signals before they can reach a device's circuits. This creates a current within the shield where a ground connection or ground plane absorbs the current.

Shielding is made in many forms, depending on the type and configuration of the electronics and the frequencies involved. The following popular shielding products, each have their advantages:

- Gaskets
- Foil tapes
- Carbon foam
- Film
- Mesh metal screening/ Faraday boxes

Many EMI shielding gaskets are made of silicone filled with metallic particles, such as nickel-graphite. This conductive material effectively blocks radio frequencies between 20 and 10,000 Hz. With its ability to perform well in harsh environments, EMI shielding silicone has been used in the electronics and automotive industries.

Thermal Management

Like EMI, excessive heat threatens to the performance and service life of electronic devices and components. Electronic products are often insulated from hot components by materials made of glass, plastic, and layers of air.

The amount of energy it consumes is directly proportional to the amount of heat it generates. This means that fast, powerful computers get hotter than smaller mobile devices.

In computers, only a few components produce most of the heat, primarily the microprocessor, graphics processor, a calculating chip, and the computer's screen. To prevent damage, this heat must be transferred away from its sources, often to a heatsink, a component specifically designed to absorb and dissipate heat.

A thermal interface material (TIM) is used to fill the gaps between the heat source and the heatsink in order to maximize the efficient heat transfer. TIMs vary according to device configurations and other factors and include:

- Thermal gels
- Gap-filler pads
- Phase-change materials
- Thermal tapes
- Potting and underfill materials
- Dielectric pads
- Heat spreaders
- Thermal greases

To protect electronic circuits from overheating, thermal fuses, PTC thermistors, and voltage regulators are frequently used. These temperature-sensitive devices will either limit the amount of current flowing through the circuit or disconnect when unsafe conditions are detected. Resettable thermal fuses will automatically reconnect the circuit when they again sense normal temperatures.

Researchers are examining ways to develop combined TIM- and EMI-absorbing materials as a single solution. One example, from a university in Korea, is thermally conductive ceramic and magnetic powders as fillers in PDMS (polydimethylsiloxane) polymers.

Many of the latest power devices use chips made of GaN (gallium nitride) and SiC (silicon carbide). These wide-bandgap semiconductors (WBGs) allow higher power density in electronic devices, which enables their miniaturization. Thermal management of WBGs differs from that of silicon-based chips because they operate at higher temperatures and in some applications, higher voltages. These trends pose challenges for electronics package designs, which drive the use of CAD/CAE simulation modeling for choosing optimum thermal materials solutions.

Stretchable Electronic Circuits

Some next-generation electrical devices will include electrical circuits capable of stretching. These include wearable technologies, soft robotics, and biomedical applications, such as on-body, on-skin and implants. A major technical challenge has been successfully connecting stretchable conductors with rigid electronic components, such as resistors, capacitors, and LEDs. Researchers at Yale University have recently developed a stretchable circuit board assembly with an interface made from a new form of gallium-indium nanoparticles called bGain (biphasic Ga-In). The result is a fully stretchable circuit, shown to work in multiple applications, including an amplifier circuit, an LED array, and a multilayer conditioning circuit board with a stretchable sensor attached to the user's shirt.

Light-based Applications

Future electronic devices will be needed to produce or process light efficiently for applications like inexpensive solar cells and infrared sensing. These will require semiconductor electronics with non-silicon conductors. Silicon is inefficient at exchanging light for electricity (and vice versa), for example, in solar panels and camera sensors. Gallium arsenide (GaAs) is used in some devices, including lasers, but it is costly. Combinations of other elements have worked effectively but are brittle and difficult to fabricate. Silicon photonics has been found to perform better with light, as does adding tin into silicon or germanium.

Emerging Technologies

New Material for EMI Shielding

Researchers at Drexel University recently developed a uniquely effective EMI shielding material called titanium carbonitride from a family of two-dimensional metal carbides and nitrides called MXenes. Traditional shielding materials, like copper, either cover the whole circuit board or wrap individual components with foil shielding that contains and deflects electromagnetic radiation. Drexel's new material, which can be applied as an extremely thin coating, blocks electromagnetic waves, not by deflecting them but by absorbing them. This prevents the shielded device's emitted EMI from potentially damaging other nearby, unshielded devices.

Ultra-thin Heat Shields

At Stanford University, researchers have created ultra-thin heat shields for electronic devices from four stacked layers of atomically-thin materials. The new shielding material is two to three nanometers thick and includes a layer of graphene. It provides the same insulation as a sheet of glass 100 times thicker. Heat shields this thin would enable next-generation products to be even more compact and protect them from the heat generated by their electronic components.

High-conductivity Polymer Ink

Swedish researchers, alongside colleagues in the United States and South Korea, have developed a stable, high-conductivity polymer ink that can be used to manufacture organic electronic devices. Called BBL:PEI, it is an "n-type" polymer conductor, meaning it conducts electricity by the motion of negatively charged electrons. P-type polymer conductors, which conduct electricity by the motion of positively charged ions, are already used to make solar cells, LEDs, transistors and batteries. Many electronic devices, however, require both p- and n-type conductors to function, thus BBL:PEI, the first n-type polymer conductor, may enable the development of new electronic circuits that were not possible before.

Conclusion

The global pandemic caused a leap in technology adoption, spurring growth for a wide range of electronic device categories, particularly consumer electronics. Going forward, multiple studies indicate these changes in consumer behavior will likely continue. In addition, megatrends like climate change and IoT will continue driving new applications for electronics, such as the electrification of transportation and renewable energy sources supplying power to the electrical grid.

The trend of computing and communications devices getting more powerful, with greater functionality in smaller packages, has presented challenges. These include greater electromagnetic interference (EMI) and higher heat levels within devices, which continue to drive new research and solutions.

Ultimately, the greatest factor dampening growth in electronics is the global shortage of semiconductors, which may not return to normal levels until 2023.

Source:

1. https://www.newelectronics.co.uk/electronics-blogs/electronic-industry-trends-for-2021/234272/

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