Polycarbonates for Smarter and More Sustainable IoT Applications

From the Internet of Things to the Intelligence of Things

The Internet of Things offers polycarbonates numerous potential applications – for example, in housings and sensor components, or displays. In applications like these, the engineering materials help to make better use of resources, in the fields of agriculture, transport and construction, for example. The potential they open up is demonstrated by current applications and new design concepts for future IoT devices.

The UV-stable housing protects the inside of the base station against impacts, even at very low temperatures, while at the same time, ensuring stable signal transmission. © Covestro

Many areas of life are set to become "smart". Smart city, smart home, smart healthcare and smart logistics, are just a few examples. Behind them is the global trend toward digital networking of devices in the "Internet of Things" (IoT). This is increasingly permeating public and private life and blurring the boundaries between sectors in the economy. As early as 2021, the number of active IoT connections worldwide was estimated at over 14 billion [1]. It is expected to double as early as 2025. The global market for IoT sensors alone, is expected to grow by around 28 % per year, over the next few years, reaching USD 142 billion in revenue by 2030 [2].

The major advantage of digitally networked devices is that the broader network of connected devices can generate greater added value than isolated devices, which usually perform only one function. If the IoT is combined with AI (artificial intelligence) technologies, the Internet of Things can quickly evolve to the "Intelligence of Things", where "things" become intelligent. Thus, IoT applications can also make a major contribution towards accelerating the achievement of the United Nations´ sustainability targets. Potential areas of application, in this sense, include intelligent temperature and lighting control in

Fig. 1. Together with partners, the concept of a streetlight for smart cities was developed. Among other things, it integrates a PC-based LED light, a security camera, environmental sensors, a 5G cell and an electric charging station. © Covestro

buildings, to save energy, smart parking and traffic control, to reduce greenhouse gas emissions, or smart agriculture, where sensors for field monitoring can control soil moisture, save water or report pest infestations. IoT systems can also optimize predictive maintenance of machines and enable fully automated processes in industry and logistics with the help of robotics. In healthcare, IoT devices could help improve safety and care for the elderly.

Functional, Aesthetic and More Sustainable

High-tech thermoplastics are necessary for the success of a network of devices that permeates daily life. They are already established in the production of digital devices, because, among other things, they can be economical in large-scale production of lightweight filigree components with complex geometries. In addition, they can be recycled at end of life, thus enabling material cycles, to conserve resources. Polycarbonate (PC) and its blends, both as injection molding and film materials, offer numerous advantages for IoT components. Their impact resistance makes housings robust when it comes to impacts and other mechanical stresses. Their glass-like transparency makes them ideal for the manufacture of displays and enables the integration of lighting and backlighting elements, as well as hidden light and display functions, which are only visible when activated.

However, PC materials also have high transmission for other electromagnetic frequencies of the electromagnetic spectrum (e.g., infra-red, or radar). They are therefore suitable for applications such as for optical distance and speed measurement by 3D laser scanning with infrared beams (Lidar). These are used for robotic vacuum cleaners, for example, to navigate through apartments. PC materials are also transparent at frequency bands in the gigahertz range, used for IoT and extended reality (XR) applications, as well as for 5G wireless technology and other wireless networks.

Functional Integration through Printed Electronics

Another important advantage, especially for IoT applications, is that PC can be printed with conductive traces and thus represents a good substrate for printed electronics. This is particularly important in the production of small electronic components, such as hearing aids, or wearables. In the smart home and office sector, in particular, an attractive appearance of the IoT devices is also required. PC is very well suited for this, as it can be easily colored, rendered light-stable, and can display an opaque, matte, translucent, or high-gloss finish. It can also be given fine surface textures, or combined with other thermoplastics, in multi-component injection molding (such as hard-soft technology or in 2-component parts with thermally conductive PC).

The globally active PC manufacturer Covestro, has an extensive portfolio of injection molding and film materials for the IoT industry. The company has »

Fig. 2. In addition to capacitive touch control functions and an OLED display, the Nighthawk demonstrator, which is only 3.5 mm thick, also integrates functional lighting elements and ambient lighting. © Covestro

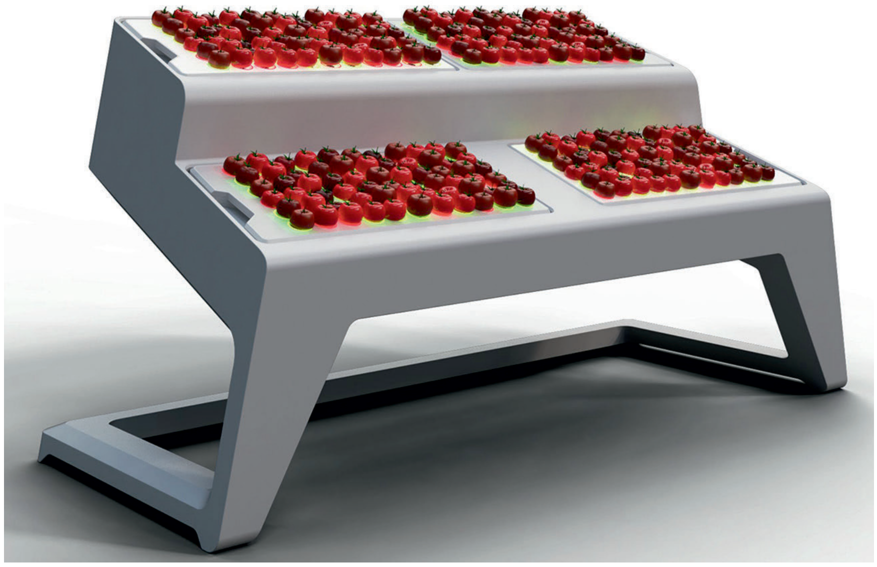

Fig. 3. The smart freshness detector determines the degree of ripeness of fruits and vegetables and communicates this via lighting. The concept comes from designer Maya Peled. © Covestro

built on know-how gained over decades of collaboration with the electrical, electronics, automotive and healthcare industries, as well as in development work for digital technologies, such as 5G mobile communications.

Implementing Miniaturization

For various sensor applications, for example, flame-retardant and weather-resistant PC blends, very tough and thermally durable PC compounds and PC grades with high IR transmission have been developed. For applications in the thermal management of equipment – such as ribbed heat sinks – thermally conductive materials from the Makrolon TC range are available. With these products, the manufacturer is responding to, among other things, the trend toward miniaturized electronic components, which often generate heat during operation.

An example of an IoT application which uses Makrolon materials is a 5G millimeter-wave base station from Baicells (**Title figure**). A PC enclosure solution with very good performance under harsh outdoor conditions was developed for this purpose. It offers stable dielectric properties at low to high

Fig. 4. The smart medication dispenser ensures greater safety for users. The digital prototype was created using rendering software and digital materials from the CMF database. For example "Apple Green" and "Glowing Orange" were used for designer Sharon Libster's concept. © Covestro

Info

Text

Dr. Niklas Meine is a marketing specialist in the Engineering Plastics segment of Covestro Germany. There, he is responsible for the electrical and electronics industry in the EMEA region. Meine has been with the company since 2012.
John Skabardonis, PhD, works in the Engineering Plastics segment of Covestro LLC, where he is responsible for technical marketing to the electrical and electronics industry in the Americas region. He has been with the company since 1999.

Service

Further information:
www.covestro.com

References & Digital Version

You can find the list of references and a PDF file of the article at
www.kunststoffe-international.com/archive

German Version

Read the German version of the article in our magazine ***Kunststoffe*** or at
www.kunststoffe.de

frequencies, including the millimeter band of 20 GHz and above, thus reducing signal losses.

Low-Emission PC Compounds

Like other plastic applications, IoT components must offer the highest level of sustainability, by having the lowest possible carbon footprint. Covestro is gradually converting its production to utilize renewable energy and alternative raw material sources. The company is embracing the circular economy and aims to become climate-neutral in the future. For the IoT industry, for example, the plastics manufacturer offers compounds with recycled content from post-consumer (PCR) and post-industrial (PIR) plastic waste.

An exciting addition to the portfolio are the low-carbon-footprint PC grades in the Makrolon RE range. They are produced proportionately, with raw materials allocated via mass balance from biowaste and residual materials, and partly with green electricity. As a result, they have an approximately 80 % lower carbon footprint than PCs made from fossil raw materials. Some of the RE grades are already cradle-to-gate climate neutral (in accordance with the ISO 14040 standard, verified by TÜV Rheinland). The origin of the raw materials is certified according to ISCC Plus and mass balancing. The RE grades are chemically and physically identical to their purely fossil fuel-based counterparts and therefore meet the same technical specifications and certifications. The first commercial applications have already been implemented; Deutsche Telekom, for example, has developed a modern fixed-network device made of Makrolon RE.

A Makrolon RE grade is also used for the housing of the smart EVBox Livo wallbox (EV charger), which is made from over 70 % mass-balanced, biocircular raw materials and is UL-certified. The box can be connected via Wlan, 4G LTE-M or Ethernet to download software updates and activate smart features, such as dynamic load sharing.

Covestro is specifically seeking cooperation with research institutions, companies and design institutes, among others, in order to open up new IoT application areas for its materials (**Fig. 1**).

Suitable manufacturing technologies are also being optimized in the process. One example, is the Nighthawk demonstrator, developed jointly with the company TactoTek (**Fig. 2**). It was manufactured using IMSE (In-Mold Structural Electronics) technology and illustrates the possibilities of this process. It allows interconnected electronic functions and components such as circuits, sensors, control surfaces and lighting elements applied to films, to be integrated directly into molded 3D plastic housings. This results in thin, space-saving and mostly jointless assemblies with a smart surface and a significantly reduced number of individual components. The technology offers great potential, for example, for optical user interfaces for IoT applications in the automotive industry, as well as in consumer and industrial electronics.

Smart Designs with PC

One example of cooperation with a design school is Covestro's collaboration with the Shenkar College of Engineering, Design and Art in Israel. In one project, students used engineering plastics, such as PC and thermoplastic polyurethane (TPU), to develop concepts for smart IoT applications that will shape modern life and at the same time, contribute to the UN's sustainability goals.

These include an intelligent freshness detector for food, which uses IR spectroscopy and just-walk-out technology (cashier-less payment). Sensors are used to detect the degree of freshness and ripeness of fruits and vegetables and this is displayed by means of illumination (**Fig. 3**). An intelligent medication dispenser with smartphone connection, which can provide acoustic and visual warnings, has also been developed (**Fig. 4**). It dispenses the relevant medications at the appropriate time, warns of drug interactions and is connected to the patient's pharmacy, or doctor. Other design ideas include a field robot that determines the optimal harvest time and plant irrigation needs, and a walking stick that, not only increases the user's mobility, but also monitors their vital signs (**Fig. 5**).

In addition to materials, Covestro supports developers and manufacturers of IoT devices and systems with a comprehensive range of services to accelerate product development. Customers benefit from the fact that the broad product portfolio has been digitized and each material is available as a digital twin. Through the use of rendering software, photorealistic 3D images of the application can be generated from this, without the need for time-consuming and costly mockups (**Fig. 4**). These virtual prototypes are visually very close to the final product and can save the time and cost to build an expensive injection mold. Customers receive the digital materials via AXF files.

Great importance is also attached to integrating sustainability into application development from the design stage and through the use of recycled materials, or bio-based and mass-balanced raw materials – and ideally, as mono-material solutions. The aim is to use "design for sustainability", to build up material cycles and minimize the carbon footprint of networked devices. ■

Fig. 5. The interactive walking stick also enables communication with relatives. The concept comes from designer Prielle Haddad.