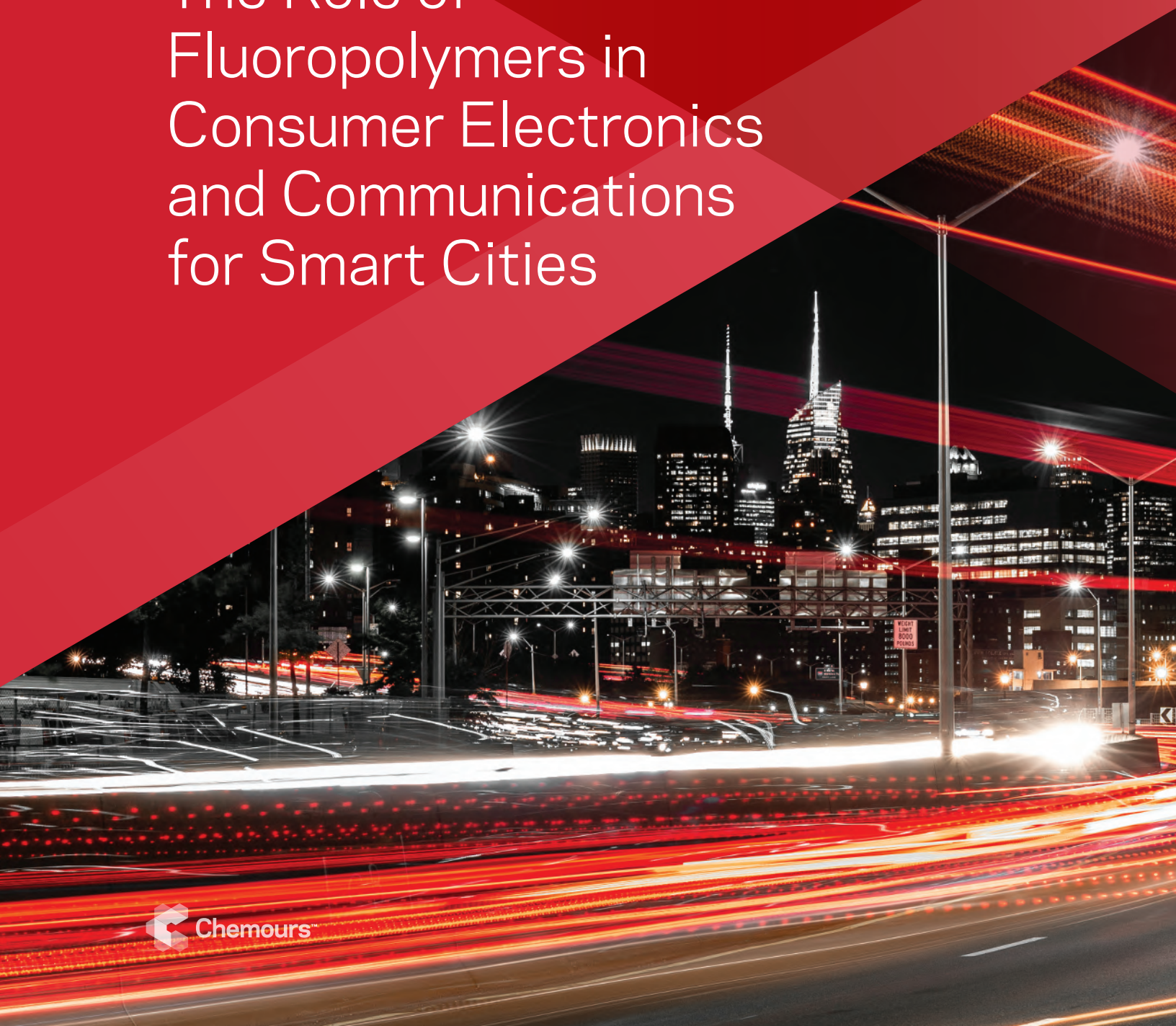
Teflon™ fluoropolymers

The Role of Fluoropolymers in Consumer Electronics and Communications for Smart Cities



Chemours™

Empowering Society by Merging Our Technology and Environment

As the world's population grows, resources become limited. In places like cities—where career, education, and cultural opportunities attract many people already—further congestion can make day-to-day logistics feel cumbersome and inefficient.

Fortunately, smart electronics and communications devices have helped increase people's access to tools and services, inform more efficient decisions, and keep people connected while physically away from their social circles. Since these devices help organize, connect, and streamline aspects of people's lives, it only makes sense to merge them with the enriched epicenters in cities. Making cities more adaptive to the people in them is necessary since experts estimate that 68% of the world's growing population will live in urban areas by 2050.

This introduces the idea of a Smart City, where buildings, cars, appliances, and infrastructure connect and communicate like smart devices. This expansion of the Internet of Things (IoT), or the number of connected devices, will help influence and enhance the performance and logistics of urban life. It's no longer a future-thinking aspiration and is more of a realistic feat, as the network needed to support Smart City bandwidth, 5G connectivity, is on the horizon.

Societal Benefits of the IoT, 5G, and Smart Cities

For a Smart City to truly be interconnected, it depends on fast mobile wireless networks,the latest in-building wireless technologies, and a network that can process and store millions of pieces of data at a type. That data will be generated by a vast network of IoT devices—whether it's a cell phone, kitchen appliance, traffic light sensor, or remote medical device. Analysts believe that we'll see over 26 billion connected devices globally[3] by 2020.

These networks and devices will collect and analyze data that can help improve societal safety, health, and efficiency. Smart Cities have many ways to apply this data and make major improvements for people's wellbeing and general productivity, such as:

Making safer environments:

- Prevent building catastrophes by monitoring the structural health of buildings, bridges, and monuments
- Provide increased security by accessing restricted areas and finding people in these nonauthorized areas
- Increase travel safety by monitoring climate and weather conditions affecting roads or traffic

Contributing to good health:

- Measure air quality and pollution by identifying things like forest fires, increased radiation levels, and water quality
- Improve wellness at work by adapting lighting to conditions

Saving money, time, and other resources:

- Reduce energy waste by measuring energy radiated from cell stations or WiFi routers
- Make commuting more efficient by monitoring traffic congestion and recommending alternate routes
- Monitor sound in public spaces or centric zones in real-time
- Increase efficiency of waste disposal by managing waste along trash collection routes
- Automate building environmental systems to conserve energy
- Save on utilities by tracking home energy automation systems and consumption

The International Data Corporation (IDC) reports that Smart City spending will increase to $135B by 2021[1]. The market is expected to include 600 global cities and generate 60% of the world's GDP by 2025[2]. The market alone reflects the world's expectations for Smart City potential and their ability to deliver meaningful and sustainable solutions for society through data-driven decision-making.

A Closer Look at How Smart Cities Work

Understanding Smart Cities and why they're demand is rising starts by understanding the many industries and applications that make them work.

First off, Smart Cities use sensors, actuators, cables, and other technologies to connect components throughout a city—from up in the air to below the streets. Sensors gather information, cables transfer the information, and actuators use the information to complete an action. A person could also be on the receiving end of information, gathering insights that help them act to make their city a better place to live and work.

While this description sounds overly simple, the logistical applications themselves are highly sophisticated. Sensors will gather specialized information; one specific example being travel or traffic related data. With this information, people can learn about real-time public transit information

and predicted maintenance on transportation infrastructure. Various types of actuators and microchips can control intelligent traffic signals, direct autonomous ride-sharing vehicles or micro-transit buses, and guide smart parking.

While data-driven decisions between machines is appealing, there are still several data-driven decisions people can make with ample Smart City data. A primary example is in security and law enforcement. Officials can improve their cities' security using that same interconnected technology for predictive policing, real-time crime mapping, gunshot detection, smart surveillance, emergency response optimization, disaster early-warning systems, personal alert applications, home security systems, data-driven building inspections, and crowd management[5].

Critical Smart City Applications That Depend on High-Performance Materials

A nearly endless list of possibilities exist for Smart Cities, but the technology and infrastructure that support them must be composed of efficient, durable, and reliable materials to perform at a satisfactory level for people. Fluoropolymers enable the materials—which make up sensors, cables, and actuators—to function as expected.

Office Space

The workplace of the future demands high-speed Ethernet cabling, Wi-Fi networks, and data centers that support The Cloud. Fluoropolymers support the high bandwidth and extreme performance requirements of today's networks through jacketing and linings for cabling and wiring.

Cell Towers

As 5G networks come online globally, high-performance fluoropolymers support high speed/high-frequency communications in 5G radio heads. Fluoropolymer resins and coatings ensure that communications equipment—from cell towers to distributed antenna systems to the cabling that connects them—achieve the speeds, capacity, and low latency that 5G protocol requires.

Mobile Phones

Today's mobile phones are pocket-sized supercomputers with more power than the computer that landed Apollo 11 on the moon (that same computer had 1,300 times less processing power than the iPhone 5s). High purity, high performance fluoropolymers are a critical component in the powerful semiconductor chips and advanced USB cables in 21st century advanced mobile device technologies.

Wearable Devices

Smart devices have been made more accessible and more convenient with wearable technology. Wearables won't stop at watches; we can expect new variations in other forms of apparel in the future. Fluoropolymers used in sensor technology and chip miniaturization advance the performance and reliability of wearable devices.

Smart Lighting and Building Controls

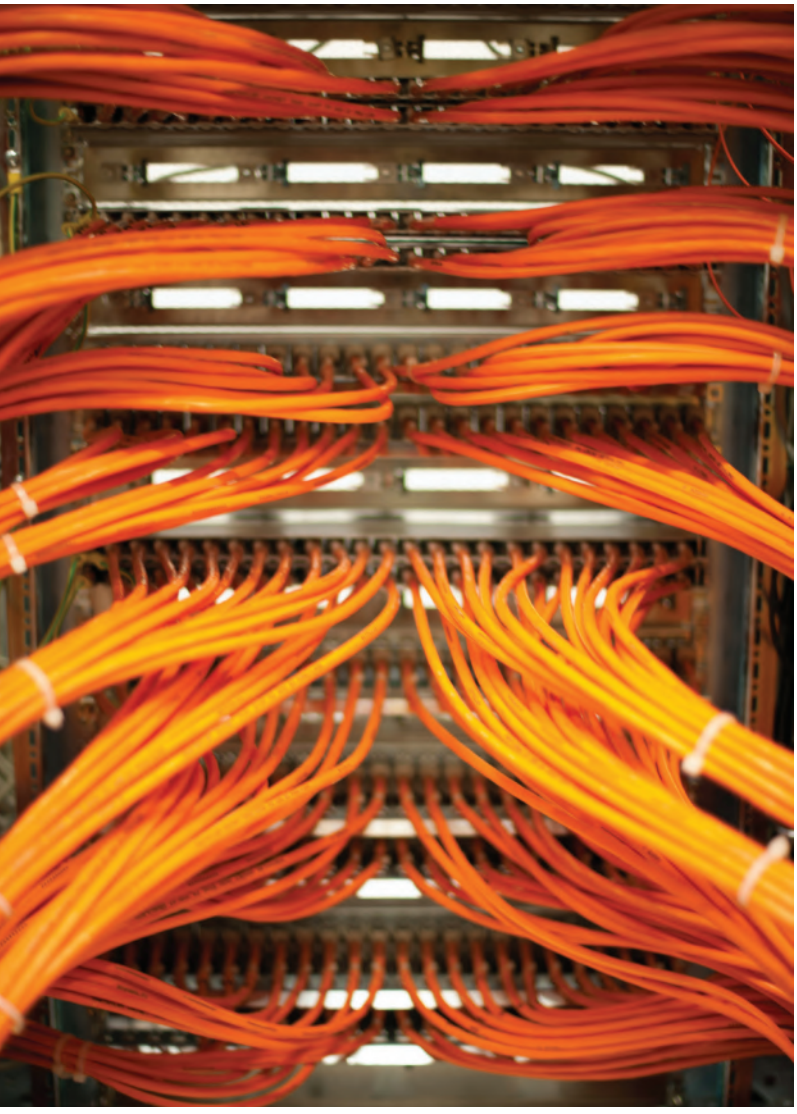
Buildings have evolved to become a network of connected systems that learn from each other and adapt to maximize energy efficiency. The performance and reliability of fluoropolymers have revolutionized how technologies, such as smart lighting systems and environmental controls, are connected, managed, and powered.

Fluoropolymers: Connected to Consumer Electronics and Communications

Smart Cities depend on information and communication technology (ICT) to meet operational demands. When the right fluoropolymer resins and materials are used, ICTs operate more reliably and efficiently. Fluoropolymer resins and coatings are used in the manufacture of cables, chips, processors, and sensors, data/telecom/LAN cables, extruded and wrapped cable insulation, and connectors. This wide range of components is used in many different technologies, which fluoropolymers enable and enhance in many ways:

Sensors in Resistance Temperature Detectors (RTD)

As consumer electronics continue to shrink, RTD coated with fluoropolymers are enabled with high dielectric strength and protection against temperature fluctuations and corrosion. This construction enables these devices to reliably transmit data faster.



Data Communications

These special types of cables are used in phones, internet, cable television, and computer networks. Ordinary wires aren't equipped to handle the high-power consumption and high frequencies of 5G radios and cells. Fluoropolymer resins increase 5G reliability by insulating and protecting cables from fire and heat and allowing for quick data transmission and flexibility.

Sensors, Silicon Wafers, and Filters

Fluoropolymer resins and coatings prevent contamination and offer temperature and pressure resistance in the manufacture of semiconductors with higher tolerances to power AI, robotics, and 5G infrastructure.

Chips and Processors

Servers that analyze data, sensors, and other embedded devices used in chips and processors, rely on the characteristics inherent in fluoropolymers, which offer durability, require less power, and aren't bothered by the shrinking sizes. Manufacturing requires high purity without contamination and high yield. Fortunately, the right fluoropolymers ensure that purity remains and impacts the effectiveness of the final product.

Printed Circuit Boards

Nearly every element involved in a Smart City's technology relies on printed circuit boards (PCB), especially as tens of billions of devices connect to IP networks. Manufacturing multi-layer PCBs with high-quality fluoropolymers will help ensure purity during fabrication, eliminate cross-talk when operating at high-frequencies, and enable reliable performance in high-temperature ranges.

Cabling

Smart Cities use cabling everywhere to connect antennae, sensors, data centers, and other IoT devices to networks and the cloud. Now, cabling is expected to carry much greater volumes of data at higher data rates[9]. LAN cables must meet many specifications and comply with codes for fire safety and performance, including resistance, capacitance, crosstalk, return loss, and propagation delay as set forth by the Electronic Industries Association/Telecommunications Industry Association (TIA/EIA). Twinax cable featuring fluoropolymers has become the cable of choice in the high speed data centers for the back panels

Fluoropolymer resins are engineered and manufactured for use in extreme environments and conditions, with a range of melt flow index, low friction, particle size, melting

point, stress, and flex life. Their inertness, high chemical stability, electrical properties, and weatherability make them excellent for use in high speed wire insulation and cable jacketing. They work well in wire insulation/cable jacketing applications that require low flammability and smoke emissions, high stress-crack resistance, extreme chemical resistance, extended thermal cycling capabilities, and best-in-class dielectric properties.

Cables made with poor quality fluoropolymer resins can crack or break, taking down a critical link or causing electrical/crosstalk interference that affects the data link's quality. Any imperfections that might result from a low-rated fluoropolymer resin can potentially introduce structural or electrical problems.

Antennae

These tools collect and share data while providing conduits for data flow throughout a Smart City. As the world completes its transition to 5G technology—a key enabler of innovative Smart City applications and uses—antennae will play an even greater role in facilitating that connectivity.

These networks are bringing faster speeds and denser small cell deployments to account for distance limitations with millimeter wave technology and ultra-low latency applications[10]. 5G technology offers increases in bandwidth and coverage ubiquity to drive innovations—but it will rely on cables for transporting data to and from the rest of city networks[11].

Fluoropolymers: Helping to Tie Smart City Infrastructure Together

Fluoropolymers are integral components in the manufacture of antennae, circuit boards, mobile devices, building wire, and cables for LAN networks and so much more. Infrastructural nodes (or links) that exchange data with autonomous vehicles, urban systems, public transit, healthcare and social services, and municipal processes depend on infrastructure build with fluoropolymers.

Embedded sensors, cameras and beacons, networked smartphones and operating systems that link everything together for unprecedented efficiency and connectivity rely on materials and fluoropolymers' chemical inertness, dielectric properties, wide temperature ranges, and stability through the manufacturing process to operate at the highest levels so that they can deliver the maximum benefits to smart city residents and visitors.

What Differentiates Teflon™ Fluoropolymers From Other Brands

Over the past 80+ years, we've improved upon the polytetrafluoroethylene (PTFE) polymer discovered by DuPont scientist Dr. Roy Plunkett, and developed a whole portfolio of Teflon™ fluoropolymers that fulfill multiple applications in diverse industries. We've capitalized on the properties of fluoropolymers, like their:

- Nonstick and friction-reducing properties
- Stability that results from multiple carbon-fluorine bonds
- Outstanding thermal, electrical, and chemical resistance
- Low coefficient of friction
- Low melting points and crystallinity
- Thermo-physical properties

Smart thinking and engineering expertise continue to fuel our scientists' curiosity and passion for innovation, making Teflon™ fluoropolymers the best "ingredient" for the technology demands—from IoT to 5G—of smart cities worldwide.

In the fast-moving and even faster-changing technology and telecom industries, Chemours has the infrastructure to support an agile supply chain, expertise for rapid prototyping, and the flexibility to adapt to updated and accelerated product development cycles. Driven by the qualities of Teflon™ fluoropolymers—from circuit boards

to antennae, wireless charging solutions to AR/VR applications—we're ready to support rapid development.

Smart cities require modular and scalable technology infrastructure. We've prepared Teflon™ fluoropolymers to support the processes that combine technology into an interface with smart city services that will transform people's lives, increase efficiency, and improve the quality of life through interconnectivity.

About Teflon™ Fluoropolymers

From developing technology and a growing market demand for more sustainable, higher performing products to evolving customer needs, Teflon™ fluoropolymers enable businesses to innovate and bring value to customers.

A wide range of industries—aerospace, automotive, communications, industrial manufacturing, consumer electronics, cookware and bakeware, energy, food processing, medical, military, and semiconductors—rely on Teflon™ fluoropolymers because of their diverse characteristics which include:

- Electrical properties: Teflon™ coatings, films, and resins exhibit very low dielectric and dissipation factors that provide superior signal insulation to data transmission networks.
- Nonstick properties: Very few solids stick permanently to Teflon™ industrial coatings. Nearly all substances release easily—important for commercial food preparation, chemical processing, and other applications.
- Chemical resistance: Teflon™ coatings, films, and resins impart permeation resistance, important for many many industries that require high-purity environments.
- Non-wetting properties: Teflon™ coatings, films, and resins are hydrophobic (water resistant) and oleophobic (oil resistant)—critical properties for textiles and other applications that must remain dry or contaminant-free.
- Corrosion resistance: Teflon™ fluoropolymers perform well in corrosive environments, like offshore drilling and chemical processing, to protect components from damage caused by oxidization and other chemical reactions.

For more products and information, visit Teflon.com or call a Teflon™ fluoropolymer expert: https://www.teflon.com/en/contact

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