

Material Knowledge Shapes Advanced Antennas

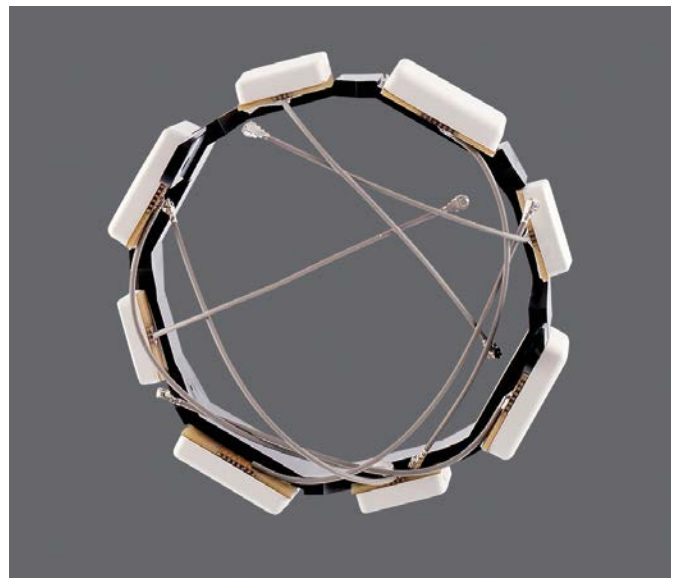
By combining a geometric approach using polymer-based dielectric materials, one company is literally changing the face of high-frequency antenna design.

Antennas will be needed everywhere if a Fifth-Generation (5G) future unfolds with “wireless everywhere.” To help meet the present and future demands for compact antennas at RF/microwave frequencies, the aptly named Antenna Company is poised and ready with an innovative approach to antenna design, drawing on extensive knowledge of materials to achieve the best antenna performance in the smallest footprints possible.

Compact printed-circuit-board (PCB) antennas are traditionally based on resonant transmission-line circuits, such as microstrip, which are straightforward to fabricate and test. Microstrip patch antennas based on circuit materials with low dielectric constant, for example, are capable of developing the fringing fields needed for good directivity using relatively small circuit structures.

Consistent and repeatable antenna directivity is a function of the consistency of the dielectric constant across the antenna substrate material, as well as the mechanical tolerances of the microstrip transmission lines in the resonant circuitry. Recent work with advanced composite materials, often referred to as metamaterials, has shown the potential performance enhancements possible when using selectively engineered circuit materials.

In this vein, engineers at Antenna Company sought ways to develop high-performance, form-fitting antennas that can be designed into modern wireless communications equipment (rather than simply adding them to a system). Their research culminated in the creation of dielectrically loaded polymers and an efficient computational approach to the design of two-dimensional (2D) and three-dimensional



1. The ring shape of this Wi-Fi directional AP/router antenna was made possible through the use of SuperShape technology.

(3D) shapes to be used as form-fitting single-band and multiple-band wireless antennas. This new class of materials makes it possible to produce smaller and lighter antennas with high performance levels, essentially reinventing traditional dielectric resonator antennas (DRAs).

THE SUPERFORMULA...

Work by one of the company's founders, Johan Gielis, and his Gielis Superformula allows the calculation of complex radiating circuit shapes using a simplified set of computational parameters. Gielis serves as vice president of

research/materials for the firm, founded in 2013. He is joined on the management team by Chief Executive Officer David Favreau, a wireless industry executive who led Qualcomm's wireless connectivity business for the past 10 years; Dr. Diego Caratelli, chief technology officer; and Dr. Thomas Wilhelm, VP of manufacturing, who has more than 20 years of polymer manufacturing experience.

By combining the Gielis Superformula with the company's polymer expertise, the end result is what the company calls a "geometry-based antenna technology." The technology ultimately delivers smaller antenna form factors with extended frequency coverage and improvements in gain, efficiency, directivity, and polarization. Through detailed system-level computer simulations, the company works with customers to determine optimal antenna placement and orientation for the best possible radiation patterns for a given application, whether in a fixed or mobile system.

...LEADS TO THE SUPERSHAPE

The company's SuperShape DRA antennas (SDRAs) replace the ceramic materials of traditional DRAs with a proprietary polymer material that can be shaped according to the Gielis Superformula to achieve excellent electrical performance within defined mechanical limits. Use of polymer technology allows for simple and cost-effective integration of SDRA solutions into embedded applications, where size and cost are important considerations. Measurements have shown that SDRA antenna systems are capable of stable radiation patterns over wide frequency ranges. In addition, they achieve high isolation, enabling systems with closely spaced multiple antenna structures without interference.

The SuperShape Antennas represent examples of the new antenna design approach, constructed as form-fitting shapes for indoor and outdoor wireless communications applications like Wi-Fi routers and public access points (APs). Wi-Fi networks, whether using public gateways or in-home systems, are notoriously guilty of lost coverage due to blind spots and interrupted service, requiring a reset of the wireless device to regain Internet access.

Some wireless connectivity problems stem from antennas with low gain and efficiency that fail to provide the required system signal strength due to propagation losses and reflections from walls and other barriers. Unwanted coupling between multiple antennas in a mobile device can also lead to



2. SuperShape technology was instrumental in creating the unique shape of this Wi-Fi directional outdoor router antenna.

interference and disruption of service.

By developing highly directional antenna reference designs (Fig. 1, ring) for multiple-input, multiple-output (MIMO) system configurations from 2×2 to 8×8 in array size, Antenna Company improved Wi-Fi antenna performance, such as increased coverage areas under line-of-sight (LOS) and non-LOS conditions. On top of that, it dramatically reduced the size of the antenna arrays compared to conventional microstrip antenna technologies.

ANTENNA APPS SHAPE UP

In addition to outdoor wireless hotspots, the antennas (Fig. 2) are finding good fits within wirelessly connected homes and in increasingly miniaturized mobile electronic devices, such as notebook computers.

The "smart home," for example, is expected to contain any number of Internet of Things (IoT) sensors that almost instantly provide data on temperature, humidity, whether appliances are on or off, or even home security, using wireless links to a centralized gateway with internet access. For owners of mobile communications devices, such as a smart cellular phone, IoT technology will provide the convenience when checking on the home and its electronic devices from anywhere with cellular/wireless-internet access.

Antennas of many different shapes and sizes will be needed to make these smart homes a reality—not just to provide required performance, but to coexist with other wireless devices within the home, including Bluetooth devices and cellular telephones. For these connected devices in a smart home, key antenna design requirements include small size

and low power consumption (for “always on” access). To meet those needs, Antenna Company developed small on-board antennas that offer excellent coverage and performance while minimizing output power to save on battery life.

For mobile-computing applications, the company crafted a polymer-based DRA for high-performance IEEE 802.11ac MIMO notebook designs (Fig. 3). The antenna is designed for reliable mechanical integration into the notebook hinge location while covering dual IEEE 802.11ac frequency bands with high gain, high efficiency, and high isolation (more than 20 dB) between antennas. The DRA features a more than 40% reduction in size compared to laser-direct-structured (LDS) antenna designs. As mobile devices evolve, the reduced antenna size will prove crucial to the further integration of other wireless technologies into these devices.

Antenna Company’s work is not just here on Earth. Together with Space Engineering and Airbus, the company was awarded a two-year contract by the European Space Agency (ESA) to develop advanced antenna array



3. This Wi-Fi 2x2 11ac notebook antenna is designed to fit into the tightest of spaces.

architectures for conformal host platforms on low-earth-orbit satellites (LEOS) and medium-earth-orbit satellites (MEOS). The contract, which began in November 2015, seeks sparse arrays with improved aperture efficiency and scanning capabilities without excessive cost or complexity.

Based on its current body of work and its SuperShape reference designs, the firm is well-positioned to achieve the antenna performance levels needed for present and future wireless requirements, while also developing innovative shapes that fit shrinking system-design footprints.