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5G and IoT communication

60GHz technology for WiGig® and 5G applications

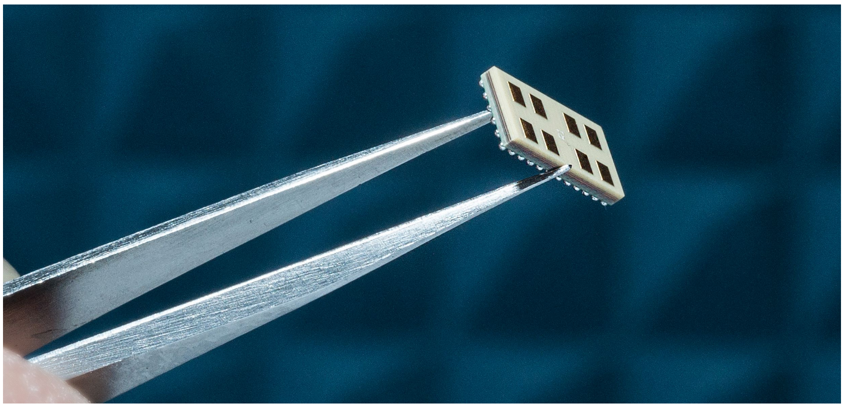
Imec's prototype 60GHz transceiver is suitable for both indoor WiGig® applications (such as video distribution in the home) and outdoor 5G applications (e.g. fixed wireless access).

The 5th generation of mobile networks (or 5G) promise higher data rates and lower latency, and will support a higher density of mobile broadband users than the current 4G standards. Wireless communication radios that operate at frequencies around 60GHz have large potential to support these 5G communication networks. An example is imec's prototype 60GHz transceiver, suitable for both indoor WiGig® applications (such as video distribution in the home) and outdoor 5G applications (e.g. fixed wireless access). Companies can access imec's 5G technology through various business models. And going even a step further, imec researchers are also developing ATTO cell technology for data-intensive industrial applications that require even higher bitrates, higher density and lower latency than what 5G can offer...

60GHz technology for indoor data-intensive applications

Today's wireless indoor applications typically use Wi-Fi compliant devices to support wireless network connectivity. These devices are based on the IEEE 802.11 standards and deploy the 2.4 and 5GHz radio bands. But the next generation of wireless technologies is expected to face spectrum scarcity in the frequency band below 10GHz. This is due to the exploding number of users and products, and to the increasing number of data-intensive applications running on today's consumer electronic products. On top of that, a whole range of new applications comes in sight, including video distribution in the home, fast exchange of GBytes of data between tablets and smartphones, immersive gaming and wireless docking of laptops. To cope with the upcoming spectrum scarcity, bandwidth is being sought at millimeter-wave frequencies – ranging from 24 to 100GHz. An interesting option is to use the 57-66GHz unlicensed band which is available throughout the world. This band promises speeds of multi-Gb/s with low latency, in line with the 5G requirements. Frequencies around 60GHz however come with challenging propagation characteristics, due to the significant absorption of the signals by oxygen and other materials. On the plus side, these frequencies consequently allow a spatial reuse by using highly directed beams. In other words: two or more neighboring links can share the same frequency channel at the same time, without signal interference. But the propagation attenuation also comes with a downside, as it results in high path loss and signal blockage – limiting the wireless propagation distance to about 500 – 1000m.

Access to the uncongested 60GHz band is enabled by the IEEE 802.11ad standard, also known as WiGig®. WiGig® is a new standard for indoor scenarios, expanding the Wi-Fi experience for virtual reality, multimedia streaming, gaming, wireless docking, etc.



Prototype of imec's multi-Gb/s 60GHz wireless transceiver

A low-power WiGig® compliant 60GHz transceiver

Imec has developed a small, low-power 60GHz transceiver chip that is compatible with the WiGig® standard for high-speed, data intensive wireless indoor applications. Imec's prototype chip (called Phara) features beamforming, a signal processing technique using phased antenna arrays for directional transmission or reception. The chip consists of a phased-array transceiver IC and a small 4-antenna module. The transceiver IC is implemented in 28nm CMOS technology and measures only 7.9mm2. Its architecture features direct down-conversion, and the beam steering (phase shifting) happens in the analog baseband. This allows the radiation to be steered in the right direction. The 28nm CMOS technology has a very high switching speed and allows the realization of the millimeter-wave radio with performances competitive to a millimeter-wave radio in SiGe BiCMOS technology. The transmitter (Tx) consumes only 425mW and the receiver (Rx) 350mW peak dc current.

The 4-antenna module with chip has an antenna-in-package configuration, with ultra-low loss antenna interface (0.5dB @ 60GHz). The antenna array is designed for beam steering in an azimuth scan range from -45° to 45° and an elevation scan range from -30° to 30°. The transmitter-to-receiver EVM (a measure for the modulation quality and error performance of the transceiver) is better than -20dB in all the four WiGig® frequency channels (58.32, 60.48, 62.64 and 64.8GHz), with a transmitter equivalent isotropic radiated power (EIRP) of 24dBm. This allows for QSPK as well as 16QAM – two modulation techniques commonly used for wireless applications. The chip has been validated with a IEEE 802.11ad standard wireless link and has demonstrated 4.5Gb/s data communication over 1 meter, and 1.5Gb/s over 10 meters.

5G fixed wireless access and small cell backhaul

By scaling up the number of antennas, the range of the 60GHz radio can be increased to a few hundreds of meters, making the technology attractive for 5G small cell backhaul applications and fixed wireless access (FWA) – which will probably become the first 5G use case. With FWA and small cell backhaul, multigigabit per second connections can be brought to the home without the need for fiber in the last kilometer. For FWA, two fixed locations are required to be connected directly. The base station can be put on e.g. a street lamp or a roof top, while the radio link towards the end user is preferably located outdoors for minimal signal loss (e.g. in a box next to the window). Each of the FWA devices is configured to be in line of sight for better signal reception. Millimeter-wave FWA can be combined with millimeter-wave backhaul to wirelessly carry the data traffic deeper into the communication network – towards the mobile network operator's core network. One option is to use in-line streetlights for deploying the small cells.

Combining 5G FWA and small cell backhaul is ideal in an urban scenario where it would be more expensive or too slow to set up fiber optic backhaul connections. Wireless point-to-point backhaul links can easily be put on street lights or house facades, whereas an alternative fiber optic solution would require more time due to regulation or the need for obtaining approvals for the installation. Or think of a scenario where extra high bandwidth is needed only for a short period of time – such as a concert, an important cycling race or a disaster zone.

Imec's radio solution consists of multiple Tx-Rx phased-array (Phara) transceiver chips, with a large antenna array as needed for longer range 5G backhaul. For example, a 16-antenna array with 4 (Phara) transceiver chips features a 1.5Gb/s data communication over 150 meters. For longer distances, a 32-antenna array with 8 transceiver chips can be used, providing 1.5Gb/s over 300 meters.

Beating the 5G targets through ATTO cell technology…

Going even a step further, researchers at imec - Ghent University are working on ATTO cell technology, which can be considered an evolution of the wireless small cells technology. In small cell technology, large quantities of antennas are being installed and each of them covers a limited area (or cell) to enable high-speed wireless broadband. The smaller the cell becomes, the higher the speed that can be accommodated, and this process takes us to ATTO cells. ATTO cell technology combines broadband antennas integrated in the floor with dedicated hardware to allow short-range high-speed wireless connectivity. The team in Ghent aims to beat the 5G targets with a factor 100 in delay (less than 10 microseconds) and a factor 1000 in density. And to interconnect the different ATTO cells with the hardware, an RF-over-fiber network is envisaged which provides sufficient bandwidth to continue to increase ATTO's data rates towards a dedicated 100Gb/s per user – which is ten times the speed of the upcoming 5G technology. To reach their goal, the team will leverage the 7GHz available bandwidth between 57 and 64GHz. Possible applications include robots in industrial environments that need to be capable of sending and receiving very high volumes of data. To investigate and develop the disruptive wireless ATTO cell technology, Professor Demeester and his team (imec – Ghent University) received a European ERC advanced grant of 2.5 million euro [2017 - 2021].

Take a lead in the development of 5G

The 60GHz technology development relies on imec's long-time experience with IC design, antenna module development and system modelling. Imec's antenna research for example aims at improving antenna efficiency, bandwidth and scan range for a better user experience. Different technologies are employed to deliver the optimal cost/power/area trade-off. Imec also developed complete IEEE802.11ad signal processing models, including for example algorithmic solutions for synchronization, channel estimation, equalization, tracking and detection. An innovative beamforming algorithm gives high performance, even in multi-path environments.

Imec's millimeter-wave R&D is offered to companies through various business models. Firstly, interested companies can join the full three-year program. This program uses an open innovation model and targets semiconductor vendors. Partners can get a worldwide commercial license to all the results. Secondly, system vendors can enter the application program, a subset of the full program without access to the IC design database. Thirdly, the technology is offered through a white-box IP license. This includes a transparent technology transfer of the prototype IP, including the schematics, layout, measurement results and simulations. Following this business model, the licensee tunes and commercializes the imec prototype, with support of the imec team. And finally, interested companies can collaborate with imec through dedicated projects.

Want to know more?

Interested? Contact Nora.Maene@imec.befor more information. Or visit the demo at the imec Technology Forum 2017.