3D Printed Antennas for mmW / Sub-**THz (100GHz−500GHz) Applications**

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Inexpensive 3D printing technology can be used to build antennas for RF sensing solutions for food safety, health, security, industrial and many more applications. By using a 3D printer, we can rapidly prototype inexpensive plastic based antennas; providing the required radiation system performance.

Until recently, it remained difficult to realize low cost and miniature solutions in the mmW / sub-THz band; the lower end of this frequency band was difficult to reach with CMOS technology, while relatively large and expensive sources and detectors were required at the higher frequency end of the band. Today, though, given recent advances in integrated circuit technology (IC), the mmW / sub-THz band is at the forefront of sensing and imaging. At CSEM, the M3TERA [1] and TeraExplore [2] projects address the subject of THz sensing. They share a common objective: to develop heterogeneous integration platforms that enable manufacturing of compact, reliable and advanced-performance mmW and THz systems at reasonably low cost. Possible applications of the M3TERA and TeraExplore platforms include:

- Food safety – remote sensing of impurities in dry food: metal, plastic, glass
- Health / security – stress sensing via skin reflectance, remote sensing of respiration and heart rate
- Industrial – radar for level measurements
- 3D imaging

The focus of the discussion that follows is on the design and implementation of low-cost antennas implemented using 3D printing technology for the M3TERA and TeraExplore platforms.

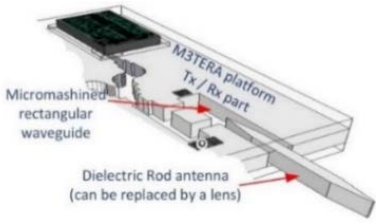

Figure 1: General drawing of the M3TERA miniature platform module.

A conceptual illustration of the miniature M3TERA platform is provided by Figure 1 (telecom and sensing applications). The M3TERA sensing prototype is focused on operation in the 122-123 GHz ISM band. The sensor relies on the use of either FMCW radar or RF signal reflectance techniques. In order to help meet the M3TERA target of miniature, low-cost solutions, and improve the manufacturability of the antennas, while maintaining acceptable performance, printed plastic (dielectric) antennas have been designed and developed (Figure 2). The size of the antenna is nominally around 8 λ and the gain is about 20 dBi. The antenna is well matched to the target 122-123 GHz band, as well as to the 145 GHz M3TERA telecom band. New antennas, designed to meet the needs of different applications (gain, directivity, frequency of operation) can be rapidly prototyped. In the future, such antennas are envisioned for use as part of a versatile RF sensing platform, where the antennas may be readily removed and changed for another suited the application in a manner analogous to the changing of the "head" on a probe, and where the sensing technique may be also be adapted and optimized as required for the application (as well as to control the antenna beam) via real-time algorithms running on a software defined radio (SDR).

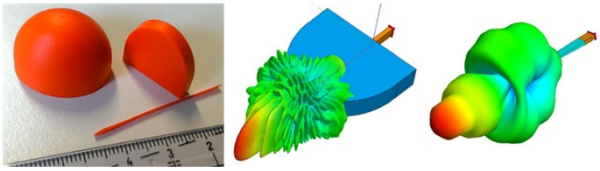

Figure 2: Prototyped 3D plastic antennas (left) and corresponding HFSS computational models with theoretical radiation patterns (right).

The TeraExplore active multi-color imaging THz detector operates in the 0.3 THz−0.5 THz frequency range and is used for inspection of composite materials and solar cells. The THz detector to be developed is based on the “direct detection method”, i.e. it consists of a UWB antenna and a CMOS based RF receiver. An UWB antenna (0.3 THz−0.5 THz) is being prototyped at CSEM with resolution of about 80 μm (Figure 3). The antenna will be co-integrated with the IC to meet system requirements.

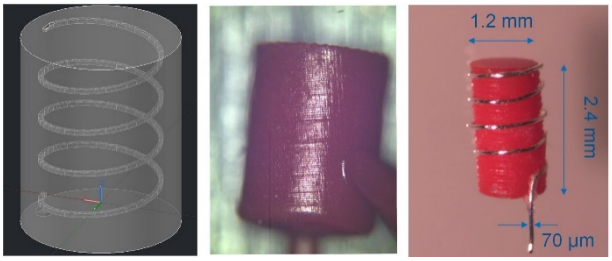

Figure 3: Helix antenna (from left to right): antenna model, realized 3D solution with helix inside and helix wire outside (TeraExplore project).

In summary, low-cost 3D printing technology is able to fulfil the needs of the RF sensing applications in the mmw / sub-THz frequency band. Through the use of 3D printing technology, we can rapidly prototype different, miniature, plastic antenna heads (e.g. lens antenna for an industrial application). The prototyped antenna "heads" can be readily attached to the test platform boards, providing the required radiation pattern needed in support of tailoring and optimization of the performance of the RF sensor to the target application.

[1] M3TERA (EU project under GA No 644039) www.m3tera.eu

[2] E. Le Roux, *at al*., “TeraXplore–Single Detector for Multi color Terahertz (THz) Imaging”, in this report, page 20.