MANUFACTURING

# Engineering and production of novel sandwich radomes for 5G applications

4a manufacturing’s white paper for sandwich radome engineering up to series production processes

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## Introduction

We are experiencing a time of breathtaking new developments in wireless communications and digitalization industries. Upcoming wireless technologies are going to play a key role for further emerging fields like robots, drones, self-driving vehicles, medical devices, high-speed low latency satellite communication and long-range power transfer (Goasduff, 2019). Most of the new applications are based on the new 5G radio standard – the next generation of wireless networks. Major keys of 5G are high achievable bandwidth, low latency - which enables very short response times - and the high density of new radio infrastructure that allows up to 100 times more devices to be connected compared to today (Cooley, 2020). Ingeniously enough it is also possible to upgrade satellite infrastructures using 5G. The satellite and terrestrial interworking is going to play a key role in establishing seamless networks everywhere on our planet (Hassanaly, 2019).

A key to reach high bandwidth for all new applications, is the use of higher transmission frequencies. In the case of 5G the millimeter wave spectrum (starting from 30GHz up to 300GHz and beyond, also known as mmWave) is used to carry a huge amount of data very quickly (O‘Donnel, 2019). In the case of satellites, the operators are more and more switching to Ka band (26GHz to 40GHz) which offers even higher signal bandwidth (Kodheli, Lagunas, Maturo, Sharma, & Shankar, 2020).

The increasing use of higher frequencies leads to the necessity of using sandwich radomes (radiation domes) as antenna covers instead of monolithic materials. For the multitude of upcoming high frequency applications, sandwich radomes are capable to combine a maximum of flexibility regarding electromagnetic design freedom and mechanical stability at the same time. This makes them a perfect choice for 5G small cell antenna radomes and flat panel phased array antennas e.g. for satcom (Griffiths, 2008).

## mmWave Challenges

Especially for telecommunications, mmWave poses some difficulties. It is estimated that approx 3 times the amount of signal deployment sites are required to achieve the same outdoor coverage as sub-6GHz signals have today in urban areas. That number further increases if indoor coverage is desired. The reason is that outdoor to indoor coverage is unrealistic due to the transmission losses (IWPC, 2019). This entails a higher need for low cost, high performance radomes with addition of new parameters such as industrial design for example.

## Sandwich Radomes

The radome is a protective cover, that forms a barrier between the environment and the antenna structure. This function must be accomplished with minimal impact on the electromagnetic performance of the antenna. Therefore, the ideal radome would be electrically transparent. Thus, the performance is determined by the matching of its materials and geometry to the application and required frequency range.
Moreover, an optimized radome can improve the overall system performance by (Griffiths, 2008):

- eliminating wind load on the antenna
- allowing all weather operation
- protecting antenna from environmental influences (wind, hail, sand, salt spray, temperature fluctuations)
- extending the antenna and system lifetime

Compared to monolithic radomes, multilayer radomes achieve more bandwidth and a larger scanning range. Furthermore, they achieve high bending stiffness and a higher strength-to-weight ratio, which makes them the radome of choice for many applications (QAMAR, ABOSERWAL, & SALAZAR-CERRENO, 2020). Especially for higher frequencies in the millimeter wave range existing monolithic radome structures cannot deliver the desired combination of electrical and mechanical properties. (IWPC, 2019)
Two important sandwich radome configurations are the A-Radome (Figure 1) and the C-Radome (Figure 2).



Figure 1: A-Radome configuration.

two rigid skins at the outside and an internal rigid layer, that can be the same material as the outside skin or another appropriate rigid, dielectrically beneficial material. In between there are two thin dielectric low-loss foam cores most often of the same foam type. The C-Radome is also called double A-Radome (QAMAR, ABOSERWAL, & SALAZAR-CERRENO, 2020).
The outer side of the radome realizes the protection against environmental influences and is therefore covered with a coating shown in Figure 3.




Figure 3: A-Radome configuration protected with specific coating.

## Electromagnetic wave propagation

Sandwich radomes are generally made from electrically isolating materials. The dielectric constant of a material relates to its permittivity ε. The relative permittivity εr of a material is the ratio of its own permittivity to the permittivity of vacuum ($\varepsilon_0$) (Zulkifli, 2012).
When an electromagnetic wave hits an interface between two materials, then a part of the wave is reflected (in phase or shifted by 180°, depending on the dielectric constants) and a part is transmitted through the material (Griffiths, 2008). Figure 4 shows this behavior in a simplified way, expressing the electromagnetic waves (EM-waves) as arrows. While being a gross simplification, it helps in building a basic understanding for the following design guidelines.