LTCC patch antenna array with embedded air cavities for 5G mobile applications

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Keywords: LTCC, patch antenna, array, 5G, laser structuring

Abstract

Specifications on 5G network frequencies worldwide up to millimeter waves and aspired data rates up to several Gbit/s were followed by higher investigations in hardware developments for high speed mobile communication systems directly. A steady increase of data rates in digital communication networks is essential to handle the growing amount of data traffic caused by mobile media applications and the progressive development of the internet of things mainly. Therefore, very agile mobile systems are required which offer high speed and real time communication. The 5G network concept and architecture offering different frequency spectra and increased bandwidths, compared to former mobile communications standards, and can fulfil these requirements. Robustness, a significant increase of data rates and coeval agile communication links in wireless networks can be realized using dual-polarized patch antenna arrays in the system concept. Moreover, these arrays can be used for beamforming and spatial power combining suitable for 5G base stations or other MIMO applications.

The LTCC technology benefits an excellent electrical performance up to millimeter wave frequencies and 3D capability. Passive components, Monolithic Microwave Integrated Circuits (MMICs) as well as antennas can be integrated which supplies compact high performance RF systems in one LTCC package, also well suited for future 5G mobile communication systems. Furthermore, the LTCC technology enables the manufacturing of embedded air cavities which can be beneficial for passive RF structures as well as antennas. The local decrease of substrate permittivity for the aperture improves some parameters (e. g. efficiency, gain and bandwidth) of the antenna performance essentially.

Therefore, a 2x2 dual-polarized patch antenna array featuring embedded air cavities was designed and fabricated using the LTCC multilayer technology in Du Pont 951 as well as was characterized during RF measurements. The measured center frequency of the antenna is about 29.7 GHz and a bandwidth of nearly 1 GHz was achieved. Each antenna patch is fed by a vertical via transition connected with a microstrip (MSL) feeding line on substrate surface and a Mini-SMP connector from Rosenberger. A further improvement of the RF performance was achieved during optimizations of the Mini-SMP to MSL transition as well as the vertical via feeding using the 3D field simulator HFSS.

This contribution will present simulation results of the transitions, the manufacturing in LTCC technology as well as measurement results of the patch antenna including transitions. The main challenge during the technological realization was to achieve adequate and stable embedded air cavities as well as a vertical via transition feeding featuring further reduced tolerances to each antenna patch. Each air cavity including partial vertical via transition was fabricated using carbon inlays which were mechanically punched and filled with gold paste from Du Pont. A high accuracy alignment of the inlay and green tape was mainly achieved by precise laser cutting of both materials and inlay assembly steps during tape stacking process. Therefore, the final paper will primary focus on the technological realization of the antenna array in LTCC technology, especially the fabrication of embedded air cavities used for the antenna aperture and feeding network as well as resulting free-standing gold vias in the air cavities. Samples of the manufactured antenna arrays are currently under measurement. The Mini-SMP to MSL transition in a back to back configuration is scheduled for the next LTCC run. After successful implementation in LTCC technology and connector assembly step, this transition will be also presented in the full paper including measurements.