Multi-band Integrated RF/Wireless Functions in Liquid Crystal Polymer (LCP) System-On-Package Technology

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Cost, electrical performance, integration density, and packaging compatibility are variables that are often at odds with each other in RF designs. Few material technologies are able address these considerations simultaneously. LTCC is a technology that has excellent electrical performance, dense multilayer integration, and good barrier properties, but it is relatively expensive. Most other substrate and packaging materials do not have low enough water absorption properties in tandem with multilayer construction capabilities to be considered for vertically integrated designs. Liquid Crystal Polymer (LCP) is a material that offers a unique all-in-one solution for high frequency designs due to its ability to act as both the substrate and package for multilayer constructions. LCP's very low water absorption (0.04%), low cost, and high performance (ε_r=2.9-3.0, tanδ=0.002) make it very appealing for many applications. And using vertical space allows the passive elements in RF front-ends to be efficiently integrated. However, processing challenges such as LCP-metal adhesion and bond registration have delayed widespread LCP implementation. Metal adhesion has recently been solved, and bond optimization is under active pursuit. Once the process is commercially available, LCP will be situated as a prime technology for enabling system-on-package RF designs. This paper explores several filter, antenna as well as module designs on LCP to demonstrate its capability for integrated RF and mm-wave front ends.

Several filters have been designed, fabricated, and measured on LCP substrates. A Single-Input-Single-Output (SISO) dual-band filter using the novel “dual behaviour resonators” technique will be shown. The WLAN operating frequency bands, ISM 2.4-2.5GHz and UNII 5.15-5.85GHz, have been targeted because of the ever growing number of services allowed to operate in this part of the spectrum. Exploiting the strong second resonant frequency of the resonators to realize the filtering response, allows for achieving the asymmetric shape and the good rejection between the two bands. The insertion loss and return loss at the central frequency are 2.4dB and 15dB for the 2.4GHz band, respectively, and 1.8dB and 8dB for the 5GHz band, respectively. To avoid harmonic spurious response above 6 GHz, compact low pass filters (3mmx4mm) have been designed, basing on the m-derived method. Similar filters designs have been performed for C and V-bands.

A dual polarization, dual frequency 2x1 antenna array on LCP will also be presented. The frequencies of operation are 14 and 35 GHz. The 14 GHz antenna array is placed on the top layer of the LCP substrate, while the 35 GHz antennas are “sandwiched” in between the 14 GHz array and the ground plane on an embedded layer. Both arrays are fed by microstrip lines printed on the same layer as the corresponding array. The control of polarizations can be realized by the use of two small gaps in the feed lines, which introduces a small capacitance in each gap. Each array has been simulated and measured, separately. The simulated results show a return loss of approximately -26 dB and -40 dB for polarizations 1 and 2 of the 14 GHz structure and approximately -20 for each polarization of the 35 GHz structure. The measured results for polarization 1 and 2 are as follows: -22 and -50 dB for the 14 GHz antennas and -43 and -30 dB for the 35 GHz antennas. This design exhibits a high efficiency and a low cross-polarization level.

Finally an example of WLAN IEEE 802.11a compliant module on LCP will be also shown to demonstrate the power of this technology. A wireless transceiver system has been implemented, exploiting the capability of LCP to enable for low loss interconnections as well as for integration of embedded passives. It includes up-converting and down-converting stages, image canceling BPFs, PA module and variable gain LNA on the receiver side. The transmitters overall P1dB above 24 dBm allows for transmission of up to 18 dBm of linear power (6dB back-off). The receivers overall NF is lower than 8 dB in order to enable for proper RF reception and then demodulation of signals as low as –70dBm.