Low Noise and Power Amplifier Modules for 60 GHz Wireless Personal Area Network Applications

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Abstract

In this paper, we present the feasibility of a multilayer low temperature co-fired ceramic (LTCC) technology as the substrate as well as packaging material for millimetre-wave 60 GHz wireless transceiver module. The designed conductor backed coplanar waveguide (CBCPW) transmission line exhibits low insertion and return losses of -0.26 dB and -22.7 dB at 60 GHz, respectively. The fabricated LNA and PA modules exhibited only a little degradation of chip performance (S_{21}<-0.5 dB for LNA and S_{21}<-0.1 dB for PA at 60 GHz) after interconnect using ribbon wire-bonding technique and CBCPW transmission line. This indicates that the LTCC is a promising solution for millimeter-wave module applicable to 60 GHz wireless communication systems.

1. INTRODUCTION

The increasing demands for high-speed (>1Gbps) multimedia data communications, such as a huge data file transmission and real-time video streaming, stimulated the development of 60 GHz-band wireless communication systems. For successful use of these systems especially in consumer markets, low-cost high-producible RF module technologies are required. Miniaturization, portability, cost and performance have been the driving forces for the evolution of packaging and system-on-package (SOP) approach in RF, microwave and millimetre-wave applications. Low temperature co-fired ceramic (LTCC) technology is one of the most promising candidates for an SOP up to millimetre-wave bands. Using this technology, we can obtain high integration density by embedding passive elements in the layers while active devices are mounted in the surface cavity and achieve miniaturization and cost effectiveness of the system.

The main purpose of this work is to investigate the feasibility of a multilayer LTCC technology as the substrate as well as packaging material for millimetre-wave 60 GHz wireless transceiver module. This requires access to low-dielectric (and conductor) sheets for such applications. The Ferro A6-S LTCC material sheet was chosen because of its low loss tangent (<0.002 up to 100 GHz), low insertion loss of transmission line and low-cost for mass production. In spite of the advent of new packaging and interconnection technology like a flip-chip bonding, a wire-bonding technology has been extensively used as a chip interconnection method because of its simplicity of assembly and reduction of final manufacturing cost [1]. Moreover, the low noise amplifier (LNA) module exhibited only a little degradation of chip performance (S_{21}<-0.5dB at 60 GHz) after interconnect using ribbon wire-bonding technique and conductor backed coplanar waveguide (CBCPW) transmission line and details will be given in the conference. Therefore, we adopted LTCC and wire-bonding interconnection technologies as a promising solution for millimetre-wave 60 GHz wireless transceiver module.

In this paper, we present low-cost LNA and PA modules based on the multilayer LTCC technology and LNA and PA MMICs developed in ETRI using 0.12 ㎛ AlGaAs/InGaAs/GaAs pHEMT library[2-3]. These modules will be used as a building block of optical/electrical transceiver for 60 GHz wireless personal area network (WPAN) system. The 3-dimensional module structure was designed using an Ansoft's HFSS™ simulator. The designed module was manufactured using 5mil thick layers of Ferro A6-S, internal Ag and external Au conductors.

2. TRANSCEIVER BLOCK DIAGRAM

Fig. 1 illustrates the transceiver block diagram of millimetre-wave 60 GHz WPAN system. The transceiver is composed of transmitter and receiver for RF signal. Normally, the medium power amplifier is used to drive up to dynamic range of the power amplifier in the transmitter branch and low noise amplifier is used to minimize noise parameter and amplify the signal in the receiver branch. Since the gain and output power of the developed LNA are enough to drive power amplifier in the transceiver module, the LNA is used as common building blocks in both branches and the PA module is also used in the transmitter branch, as shown in Fig.1.

3. LTCC MODULE TECHNOLOGY

Fig. 2 shows the schematic cross-sectional view for LNA and PA modules developed in this work. In the fabrication process, via holes were filled with silver conductor and embedded ground planes and backed conductor were also printed with same conductor. However, the RF signal line and coplanar ground plane on the top layer were made of gold conductor to reduce