Compact Wilkinson Power Divider Design and Fabrication Using IPD Technology

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Abstract : In this paper, presents the Wilkinson power divider used integrated passive device (IPD) technology with excellent performance for personal communication services (PCS). The insertion loss of this power divider is 0.4 dB and the port isolation greater than 25 dB over the entire band. Return losses input and output ports are 18 dB and 19 dB, respectively. The power divider based on SI-GaAs substrate is designed within die size of about 0.775×0.83 mm^2.

Key Words : Integrated Passive Device (IPD), GaAs, Wilkinson Power Divider

1. Introduction

Integrated passive devices (IPDs) have attracted much attention in recent years, primarily due to the needs of handheld wireless devices to further decrease in cost and size and increase in functionality [1]. Many function blocks in the RF modules, such as impedance matching circuits, harmonic filters, couplers, baluns, and power combiners/dividers, can be realized by using IPD technology.

Because IPDs are generally fabricated using standard wafer fab technologies such as thin film and photolithography processing, they can be manufactured with low cost and small size with excellent reproducibility.

With the rapid progress of wireless communication and strong requirement of miniaturization and multi-function design, power divider have become important components for multi-band wireless communication products at microwave frequencies. For example, a global system for mobile communications (GSMs) operate at both 900 and 1800 MHz, Personal communication services (PCS) operate at 1800MHz, IEEE 802.11b and IEEE 802.11g wireless local area network (LAN) products.

In this paper, we present a Wilkinson power divider that covers PCS radio band application. The Agilent ADS2008 with IPD design kit developed by NanoENS Inc. is used to guarantee the proposed design.

2. GaAs IPD Process

In this paper, RF passive devices (such as MIM capacitors, thin film resistors, high Q inductors) and a dual-band filter are fabricated using SI-GaAs IPD process with 6 masks. Figure 1 presents a cross-sectional view of GaAs integrated passive devices. To achieve cost and size reductions, a low cost manufacturing technology for RF substrates and a high performance passive process technology are developed for RF-IPDs.

The substrate used for the fabrication is a 6 inch SI-GaAs wafer, which is advantageous to avoid the capacitive and inductive loading of a conductive substrate, with thickness of 0.625 mm, permittivity of 12.85, and a loss tangent of 0.006. The process features two levels of plated Cu/Au metal; for the first metal with thicknesses of Cu 4.5 μm and Au 0.5 μm, for the second metal with thicknesses of Cu 3.0 μm and Au 2.0 μm. PECVD Si_3N_4 of 1000 Å was used as the capacitor dielectric layer. Air-bridges were used for the metal layer cross over between inductor winding sand the under passes. After thinning the wafer toits final thickness, back side metallization was applied.

3. Power Divider Design

The basic divider layout circuit is shown in Figure 2, which consists of π lumped-element equivalent networks, and a 100 Ω isolation resistor. The circuit is designed for application to PCS band and the design has input and output impedance of 50 Ω. This design used 4.8 nH inductor, appropriate 0.76 pF and 1.25 pF capacitors which are selected through optimization with Agilent's ADS for the π lumped-element equivalent networks. The power divider is tuned using EM simulator. EM simulation is essential, particularly as die size is reduced by compacting components to meet the targets, since coupling effects of compact components can't capture by the ADS.

4. Wilkinson Power Divider RF Characterization

The Wilkinson power divider as presented above is implemented in π lumped-element circuit. EM simulation results are superimposed in Figure. 3, respectively. The detailed simulation results compared with the specifications are shown in Table 1. The Wilkinson power divider is fabricated using the aforementioned IPD technology on a Si-GaAs wafer.

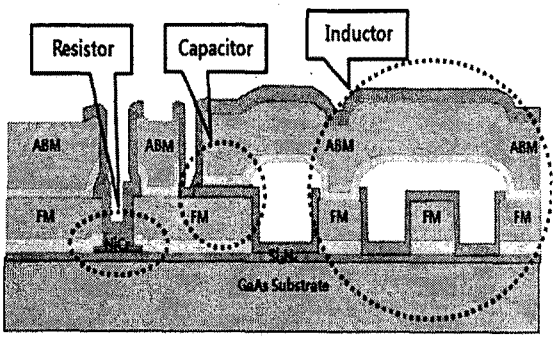

Figure 1. Cross-sectional view of GaAs IPDs

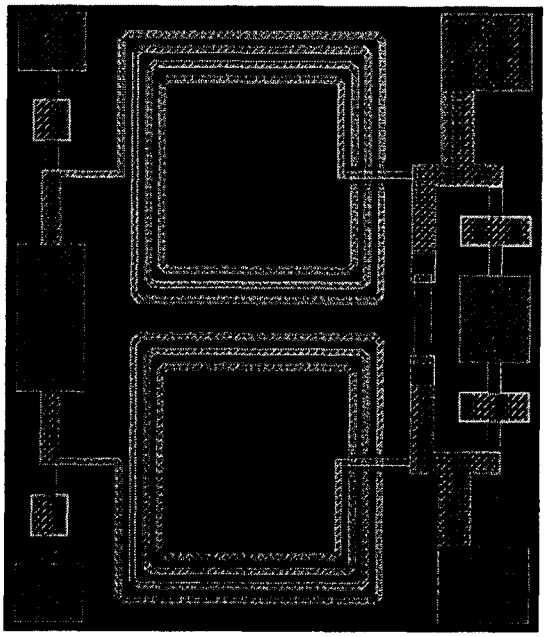

Figure 2. Layout of power divider

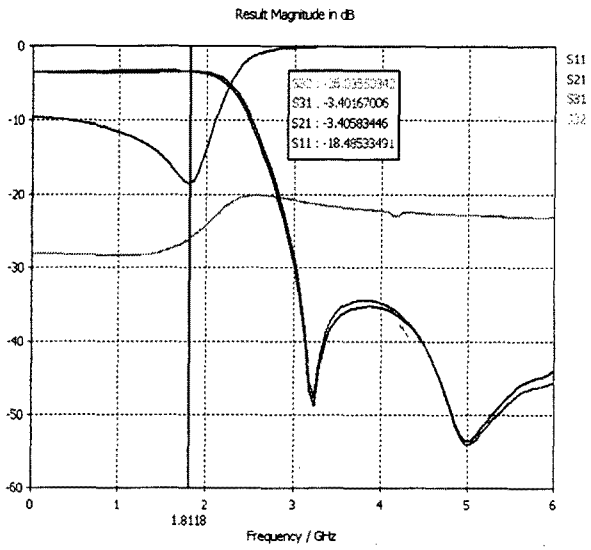

Figure 3. EM simulation of S-parameters

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References

[1] H. Clearfield, S. Wijeyesekera, E.A. Logan, A. Luu, D. Gieser, C.M. Lim, J. Jing, "Integrated passive devices using Al/BCB thin films", Proceedings of the 7th international Conference on Multichip Modules, Denver, Colorado, April, 1998, pp. 501-505. 7.

Table 1. Summary of the results

Requirement	Standard	Simulation	EM simulation
Center Freq.	1.8 GHz	1.8 GHz	1.8 GHz
Insertion loss	0.5 dB	0.46 dB	0.40
Return loss (Input)	15 dB	16 dB	18 dB
Return loss (Output)	15 dB	20 dB	23 dB
Isolation	20 dB	26 dB	-26 dB
Port Impedance	50 Ω	50 Ω	50 Ω