same tendency. The difference between the peak values of the measured result and that of the calculated result for TE wave is due to the available measurement range in an anechoic chamber. Moreover, the absorption of 25 dB or more is obtained at the incident angle ranging from 5° to 45° for circularly polarized waves and it also satisfies Type A. Therefore, realization of the thin wave absorber for improving ETC environment can be confirmed.

4. CONCLUSION

A thin wave absorber based on EPDM rubber sheet combined with flaky magnetic powder of Fe_3Si is designed, fabricated, and measured. In the design result, it is confirmed that the absorption of 20 dB or more can be realized when the loadings of Fe_3Si is 80 phr and the thickness of absorber is set to be 2.39 mm. Absorber sample is fabricated based on this design result and the absorption characteristics are measured. We clarify that the absorption of 25 dB or more can be obtained for circularly polarized waves and it also satisfies commercial requirement of ETC. Therefore, the thin wave absorber satisfying commercial requirements can be realized when the thickness of absorber is controlled.

ACKNOWLEDGMENT

This work was partially supported by grant-in-aid for 21st COE Program from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of the Japanese Government.

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GAIN ENHANCEMENT TECHNIQUES FOR CMOS LNA AND MIXER

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Received 12 March 2006

ABSTRACT: *Two major techniques for gain improvement of the CMOS low noise amplifier (LNA) and mixer are presented. First, the inductive interstage matching is applied to design a cascode amplifier for increasing the power transfer between the common source (CS) and common gate (CG) stages. Second, a super source follower (SSF) is utilized in a P-type micromixer for increasing the conversion gain of the mixer. A series of investigations are performed for demonstrating the feasibilities of the proposed techniques. The LNA and mixer designs based on the proposed techniques are realized using 0.35 ìm 1P4M CMOS technology. Then their measured results are compared with those of a preliminary design, which fully integrates a conventional cascode amplifier and a P-type micromixer. The gain of the LNA is increased 2.1 dB and the noise figure is maintained at the same value of the preliminary design. On the other hand, the conversion gain of the super source follower (SSF) of the micromixer output is improved about 9.5 dB. Such improvements reveal great potential of the proposed design techniques on the gain enhancement for the LNA and mixer. Then, the measured results of the preliminary design show the return-loss of 25 dB, the isolation of better than 30 dB, and the conversion gain of 4.8 dB in the 2.4 GHz ISM band.* © 2006 Wiley Periodicals, Inc. Microwave Opt Technol Lett 48: 2067–2070, 2006; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.21838

Key words: *CMOS; LNA; cascode amplifier; interstage matching; mixer*

1. INTRODUCTION

The trend of wireless devices into human lives has been a global phenomenon. One key factor for such success of wide acceptance of wireless products is the advancement of device technology, thanks to the continuing improvement of semiconductor processes. The advance in digital CMOS technology has made a reality the integrated circuits operating at microwave frequency bands [1]. This paper reports two approaches to increase the gain of the CMOS LNA and mixer. The circuits, which are designed based on the proposed techniques, are realized using 0.35 ìm CMOS technology and tested by on-wafer measurements. The measured results are also compared with those of the preliminary design. Section 2 explores a preliminary design, which consists of a low noise amplifier (LNA) constructed by a cascode structure and a P-type micromixer. The design considerations and measured results of the preliminary design are also presented. Next, section 3 presents two design techniques for the gain improvement. The inductive interstage matching is designed for improving the power transfer in the cascode amplifier. Also, a P-type micromixer utilizing a super source follower (SSF) is presented. Both approaches are verified by the experiments and show good agreements between the predictions and the measurements. Section 4 concludes the paper.

2. CMOS CASCODE AMPLIFIER AND MICROMIXER—PRELIMINARY DESIGN

Figure 1 shows the schematic, which includes a CMOS cascode amplifier and a P-type micromixer. The cascode architecture is believed to be one of the most promising candidates for reducing the Miller effect and increasing the output impedance to achieve high reverse isolation [2–6]. Although the mixer shown in Figure 1 is a stacked structure, which requires high V_{DD}, the current injections, composed of M_1 and M_2 in Figure 1, are mainly applied to bias the Gilbert cell for resolving the head room issue. Additionally, the current injection with high impedance creates a negligible effect to the Gilbert cell. Notably, the unbalance-to-balance transformation between the output of the cascode amplifier and RF input of the Gilbert cell is established by $M_6 - M_8$ and $R_1 - R_3$ (i.e. active balun) for converting a single-ended signal to a differential one [7]. A resistor network (R_1, R_2, and R_3) is designed to establish the biasing conditions and impedance matching of the mixer.

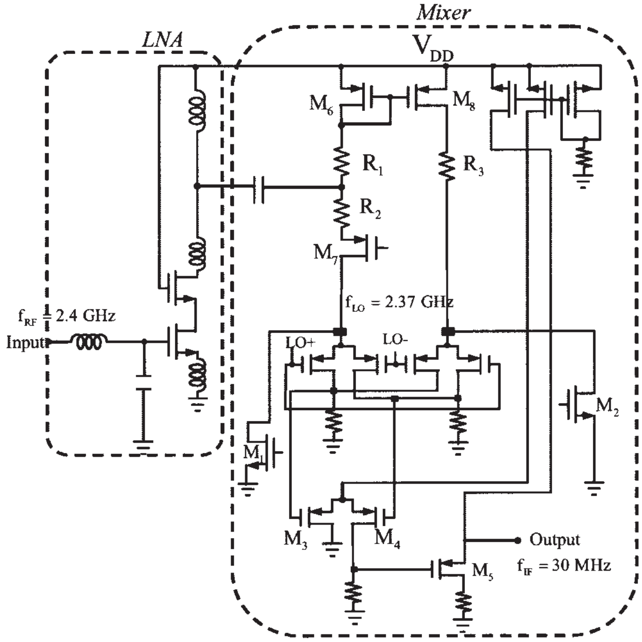

Figure 1 The preliminary design of a 2.4 GHz CMOS LNA and a mixer

Figure 2 shows the photograph of the fabricated chip. The chip (1500 ìm by 1500 ìm) includes a conventional cascode amplifier, a micromixer, and pads. Figure 3 shows the experimental result for the input reflection coefficient of the circuit shown in Figure 2, with the supply voltage of 3.3 V. As shown in Figure 3, the measured input return loss, which includes the effects of the pads, is better than 25.0 dB from 2.0 to 2.6 GHz based on 50 ohm system. Additionally, the minimum value of the curve shown in Figure 3 is about 33.8 dB at 2.4 GHz, revealing that the device under test (DUT) shown in Figure 2 can receive the 2.4 GHz ISM band signal with minimum power reflection.

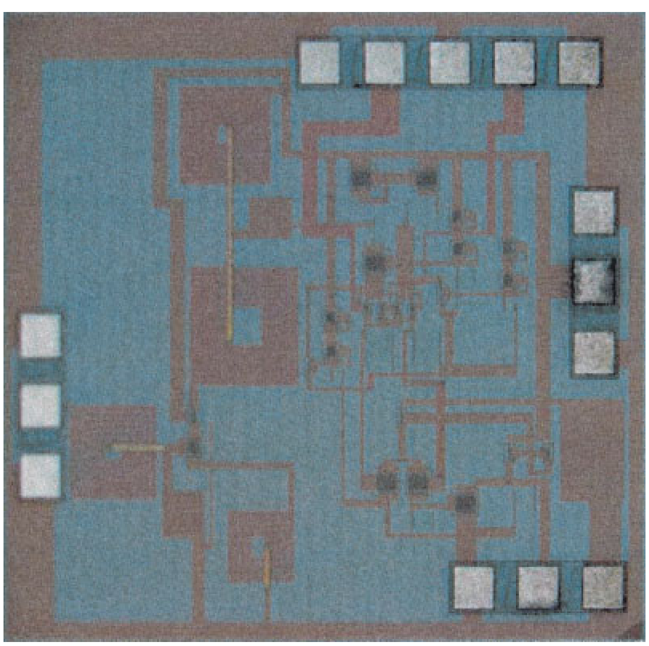

Figure 2 Photograph of the preliminary design shown in Fig. 1. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

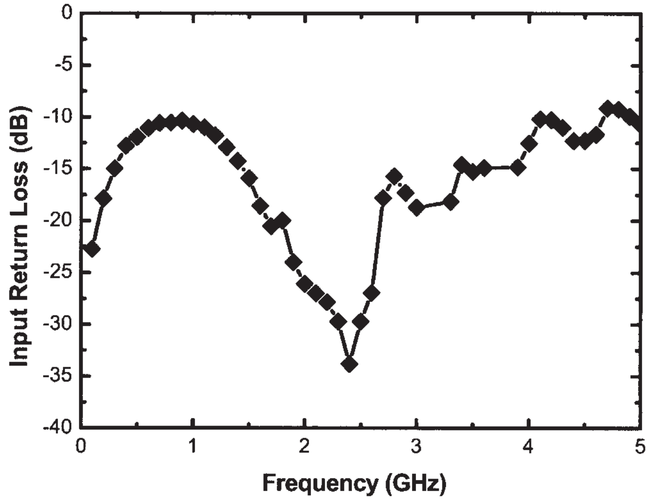

Figure 3 Measured input reflection coefficient of the preliminary design shown in Fig. 1

The isolations of the mixer are investigated by measuring the power spectrums in the adjacent ports. The RF-IF isolation is higher than 27.0 dB and the minimum value is 36.7 dB at 2.4 GHz. Second, the LO-RF and LO-IF isolations are both higher than 30 dB from 2.0 to 3.0 GHz and the minimum values are 43.9 and 45.9 dB at 2.37 GHz, respectively. Figure 4 shows the composite plot of the measured results for both the conversion gain and output power versus the input power of the RF signal for the DUT. During the measurements, the frequency and power of the LO signal are set at 2.37 GHz and 8.0 dBm, respectively. The frequency of RF signal and the supply voltage of the chip are 2.4 GHz and 3.3 V, respectively. As shown in Figure 4, the conversion gain of the preliminary design keeps nearly a constant value of 4.8 dB.

Furthermore, the conversion gain falls to 3.5 dB below when the input power of RF signal is higher than −2.5 dBm. Notably, the conversion gain reported in Figure 4 is the power ratio between the RF signal and the IF signal based on the 50 ohm system. On the other hand, the linearity of the preliminary design shown in Figure 1 is investigated by measuring the input 1-dB compression point. Figure 4, which plots the output power of IF signal versus the input power of RF signal, shows the input 1-dB compression point of −3.5 dBm.

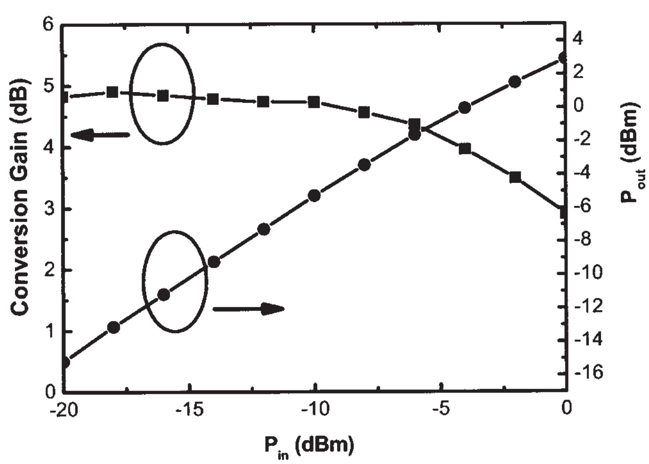

Figure 4 Measured results of the conversion gain and the 1-dB compression point of the preliminary design shown in Fig. 2

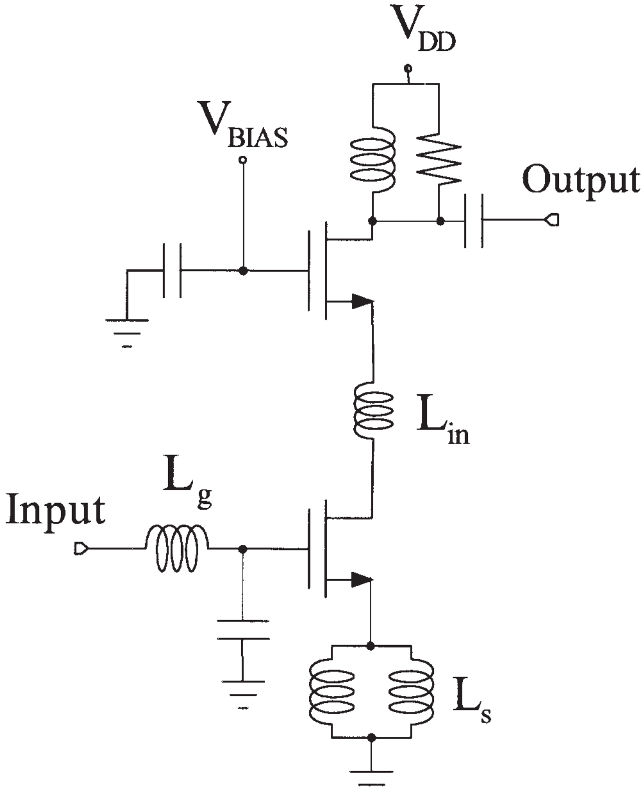

Figure 5 A cascode amplifier incorporating with inductive interstage matching and source degeneration

The preliminary design, which is fabricated by 0.35 ìm 1P4M CMOS technology, is characterized, revealing high isolation, low input reflection, and high linearity. In the following section, the gain enhancement techniques are reported. The techniques cover two main parts. One is the cascode low noise amplifier (LNA) with inductive interstage matching and the other one is the P-type micromixer with a super source follower (SSF).

3. GAIN ENHANCEMENT TECHNIQUES

3.1 The Cascode Amplifier With Inductive Interstage Matching

Figure 5 shows the schematic of a single stage cascode amplifier with inductive interstage matching. A negative feedback network, so-called inductive source degeneration (L_s), is utilized into the design of a common source (CS) amplifier for minimizing the channel thermal noise of the amplifier [5]. Additionally, the L_g and L_s are designed to improve the input matching condition of the CS stage. Since the output impedance of the CS stage and the input impedance of the common gate (CG) stage are both capacitive, a proper series inductor (L_{in}) can be inserted between two stages to form a series resonator with the capacitive parasitic produced by two amplifiers. Therefore, the power transfer between two stages (CS & CG) can be improved at the resonant frequency of the series resonator.

Two identical cascode amplifiers except the inductive interstage matching are designed, fabricated, and tested based on the same conditions for investigating the effects of the interstage matching. Figure 6 shows the gain and noise comparisons of two cascode amplifiers based on the measured results. The gain of the amplifier with interstage matching is about 6.0 dB at 1.8 GHz and 2.1 dB higher than that of the conventional cascode amplifier. Furthermore, the noise figure of the amplifier with interstage

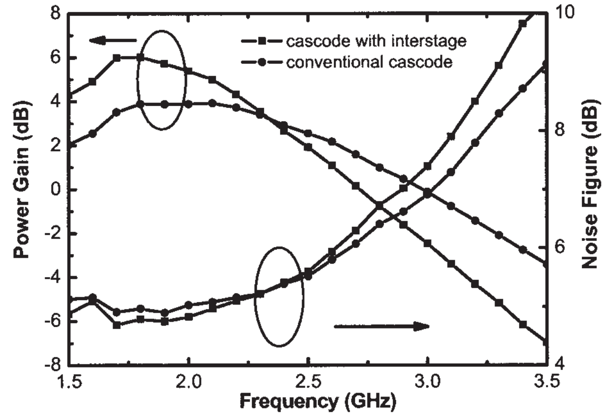

Figure 6 A low noise cascode amplifier with gain improvement

matching, which is about 4.8 dB at 1.8 GHz, keeps almost the same as that of the conventional cascode amplifier from 2.2 GHz to 2.5 GHz. In other words, the inductive interstage matching not only improves the gain but also produces a negligible effect to the noise figure of the amplifier. The input 1-dB compression point of the amplifier with interstage matching is about −5.0 dBm and 5.0 dB lower than that of the conventional cascode amplifier. Besides, the IIP3 of the cascode amplifier with interstage matching is about 0.55 dBm and 5.6 dB lower than that of the conventional one.

3.2 P-Type Micromixer Incorporating With Super Source Follower

In this section, a super source follower (SSF) is designed for the output of the mixer reported for improving the conversion gain of the micromixer. The SSF can reduce the impedance of the output, assist the micromixer in delivering more power to the next stage, and finally improve the conversion gain of the mixer.

Figure 7 shows the gain comparisons for the two types of micromixers based on measured results. The P-type micromixer with a SSF and the P-type micromixer with a common drain (CD) stage have the conversion gain of −1.0 dB and −10.5 dB, respectively. The curves shown in Figure 7 reveal more than 9.5 dB improvement of conversion gain for the micromixer design based on the proposed methods mentioned earlier. Consequently, the input 1-dB compression point of the P-type micromixer with a SSF is −8 dBm and 8 dB lower than that of the P-type micromixer with a CD. Additionally, the IIP3 of the P-type mixer with a SSF and of

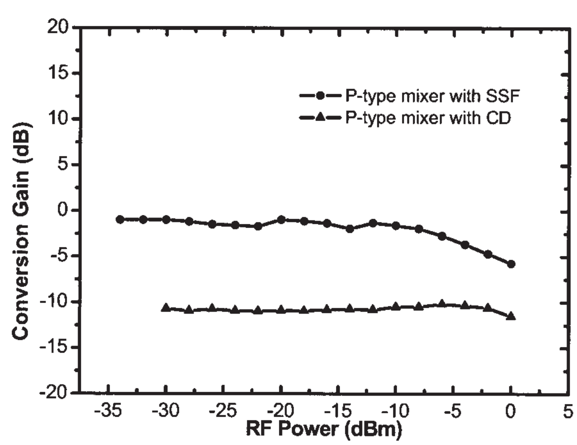

Figure 7 Measured conversion gain of the micromixers

the P-type mixer with a CD are 2.0 dBm and 5.5 dBm, respectively.

4. CONCLUSION

In this paper, two major techniques for gain improvement of the CMOS low noise amplifier (LNA) and mixer are presented. One is inductive interstage matching, which increases the power transfer between the common source (CS) and common gate (CG) stages. The other one is the design of the P-type micromixer utilizing a super source follower (SSF) at the output of the mixer. The SSF can reduce the impedance for the output of the mixer and assist the P-type micomixer in delivering more power to the load. A preliminary design is characterized by the on-wafer measurements, showing the isolation of 30 dB above, the return-loss of 25 dB, and the conversion gain of 4.8 dB in the 2.4 GHz ISM band. On the other hand, the comparisons between the preliminary design and enhanced designs show the following improvements. First, the gain of the cascode amplifier is increased 2.1 dB and the noise figure is maintained as almost the same value between 2.2 and 2.5 GHz. Second, the conversion gain of the P-type micromixer with a SSF is −1.0 dB and 9.5 dB higher than that of the P-type micromixer utilizing a common-drain (CD) stage, respectively.

ACKNOWLEDGMENT

This work was supported in part by the National Science Council of Republic of China under contract NSC 94–2752-E-009–001-PAE and contract number NSC 94–2219-E-009–014, in part by the Ministry of Economic Affairs under contract number 94-EC-17-A-05-S1–020, and by the National Chip Implementation Center (CIC).

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CHARACTERIZATION OF THIN-METAL ANODE BUFFERS IN ORGANIC DEVICES

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Received 12 March 2006

ABSTRACT: *The interposition of a thin-metal buffer between the anode and active layers of an organic light emitting diode (OLED) can significantly improve hole injection. Experimental results of devices using silver, gold, and gold-palladium layers are presented and correlated to their respective work functions. A significant reduction in resistivity was observed with a silver buffer layer in a bilayer OLED device.* © 2006 Wiley Periodicals, Inc. Microwave Opt Technol Lett 48: 2070–2072, 2006; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.21837

Key words: *OLED; anode buffer; PLED; MEH-PPV; CN-PPV*

1. INTRODUCTION

Research of organic light emitting diodes has been extensive during the past decade, as many company seek to develop flexible video displays with improved contrast, wide-viewing angles, and low power consumption [1]. Polymer light emitting diodes (PLEDs) were demonstrated by Burroughes et al. in 1990 [2] and offer significant cost-savings in production.

Indium tin oxide (ITO) is a popular choice for the anode material of PLEDs for its semitransparent properties [3]. ITO has a work function (φ_{ITO}) of 4.5 eV, ranging upwards to 5.1 eV depending on preparation and oxygen content. The highest occupied molecular orbital (HOMO) of the hole transport layer's (HTL) energy level ranges between 4.9 and 5.5 eV for typical PLED materials. Therefore, the ITO-HTL energy gap for hole injection ranges between 0 and 1.0 eV, reducing device efficiency.

Previous research has sought to mitigate these effects. Guan et al. replaced the ITO layer with high work function metals and achieved lowered resistance with comparable transmittance [4]. Shen et al. attained a significant improvement in hole injection after coating the ITO with a 5 Å layer of platinum (Pt) [5]. This effect was explained to be caused by an increased work function for the anode and possibly from a better mechanical contact that smoothed the metal side of the junction. In our research, we sought to expand upon this work by expanding the analysis to additional high work function metals. We selected silver (Ag), gold (Au), and gold-palladium (AuPd), which have work functions (φ) of 4.7, 5.3, and 5.5 eV, respectively [6]. Since φ_{ITO} typically varies between 4.5 and 5.1 eV, we expected at least one of these selected metals to potentially bridge the anode-HOMO energy gap, resulting in a hole injection enhancement. In this article, we present the experimental results of our research.

2. EXPERIMENTAL METHODS

Thin layers of Ag, Au, and AuPd were investigated as potential thin layer buffers to improve injection efficiency in PLEDs constructed with a poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene] (MEH-PPV) HTL and a poly[2-(6-cyano-6-methylheptyloxy)-1,4-phenylene] (CN-PPP) electron transport layer. The PLED molecular structures are shown in Figure 1. Solutions were prepared using 5 mg/ml MEH-PPV in xylene and 5 mg/ml CN-