Inkjet-Printed Silver CPW with Narrow Gap

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***Abstract*— Inkjet-printed silver coplanar waveguide on a glass substrate with narrow gap is firstly realized by using a selective surface treatment. The measured gap between signal and ground is 16.7 μm. Insertion loss is measured to be 2.04 dB/cm and 4.40 dB/cm at 10 GHz and 40 GHz, respectively.**

I. INTRODUCTION

Recently, there have been many researches to fabricated electrical devices by using inkjet printer. Fabrication cost can be dramatically reduced by inkjet printing technology, because the equipment is cheap and ink material is not wasted due to the direct-writing feature. Capability of large-area printing in a short time and ability to print on flexible substrates are other advantages of inkjet printing. For such a reason, many printing techniques to fabricate devices such as OTFT, solar cell, RF components, sensors by inkjet printing are reported [1].

Current state-of-the-art of inkjet printing technology, however, has some limitations in creating thick conducting structures with high resolution. The conducting structure is generally realized by using the mixture of metal nanoparticle and solvent as ink material. Dispersing of ink on the substrate occurs due to the surface tension of the solvent ink, hence it is hard to fabricate conducting structures with narrow and uniform gap [2].

In this paper, we printed a coplanar waveguide (CPW) with a narrow gap. The size of the CPW is also greatly reduced compared to previously reported inkjet-printed CPW, because the gap between signal and ground of the CPW is proportional to the width of the signal line.

II. EXPERIMENT

Silver nanoparticle colloid, which is a mixture of silver nanoparticle and TGME (Advanced NanoProducts Co., Korea), is used for the fabrication of the CPW. A piezoelectric print-head system with a 19 μm nozzle diameter (Fugifilm Dimatix INC., USA) is used for drop-on-demand printing. Fluorocarbon, which is a mixture of FluoradTM FC 722 and FC 40 (3M, Korea), is used to selectively modify the substrate surface energy.

The fabrication process is shown in Fig. 1. First, AZ4330 photoresist is patterned on a 500 μm-thick glass wafer. After fluorocarbon (FC) is spin coated for 60 seconds at 1500 rpm, the glass substrate is baked at 110°C for 10 minutes. Then FC patterning is completed by removing AZ4330 using acetone. FC surface has extremely hydrophobic characteristics, so dispersing of silver ink onto FC surface is effectively prohibited during the following ink-jetting process [3]. For such a reason, narrow and uniform gap between silver structures can be accomplished by ink-jetting of silver ink. Silver ink is sintered for 30 minutes at 220°C to remove the solvent after patterning, and the fabrication is finished by removing FC.

Fig. 2(a) shows the design parameters of CPW. Length and width of the signal are 5 mm and 100 μm, respectively, and the gap between signal and ground is 15 μm. The thickness of CPW is designed to be as thick as 3 μm to ensure a signal line thickness higher than the skin depth. As shown in fig. 2(b), inkjet-printed CPW is successfully fabricated.

III. RESULTS & DISCUSSION

Surface morphology and RF characteristics of the fabricated CPW are measured. As shown in the SEM images in fig. 3, the gap between signal and grounds is perfectly uniform, and the gap is measured to be 16.7 μm, which is slightly wider than the targeted gap of 15 μm. Some cracks and holes are observed on the surfaces of the CPW structure, as shown in fig. 4. It is expected that such defects are generated by the vaporization of TGME during the sintering process. Thickness profile of the fabricated CPW is measured using a 3D surface profilometer, which is shown in fig. 5. Although the thickness of the signal is 3.2 μm at the center, the edges of the signal are significantly thinner due to the surface tension of the silver ink.

RF characteristics were measured from 100 MHz to 40 GHz using a vector network analyzer after a SOLT calibration at room temperature. As depicted in fig. 6, the insertion loss is measured to be -1.02 dB and -2.20 dB at 10 GHz and 40 GHz, respectively, and the isolation is -16.27 dB and -16.68 dB at 10 GHz and 40 GHz, respectively. Loss can be reduced by improving structural characteristics and matching impedance, where slight mismatch was observed as shown in fig.7.

In conclusion, inkjet-printed silver nanoparticle CPW having a narrow gap is successfully realized by the aid of selective surface modification, and moderate RF characteristics were measured. By dramatically reducing the size of CPW, the suggested CPW can be used in applications requiring high degree of integration.

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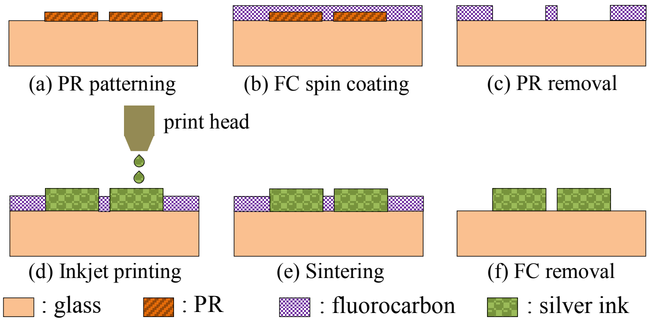

Fig. 1. Fabrication process

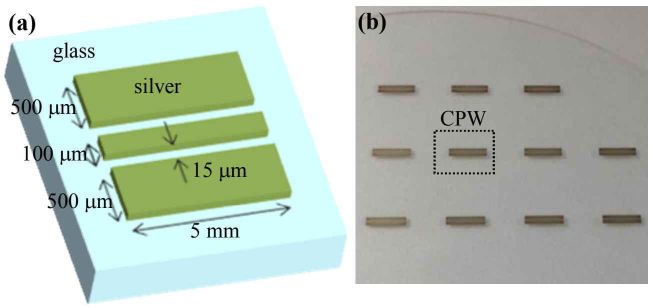

Fig. 2. (a) Design parameter of CPW, (b) optical photograph of fabricated CPW

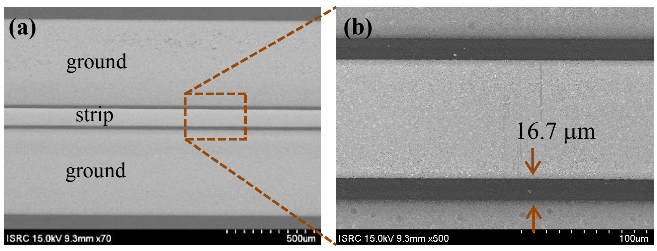

Fig. 3. SEM images of fabricated CPW

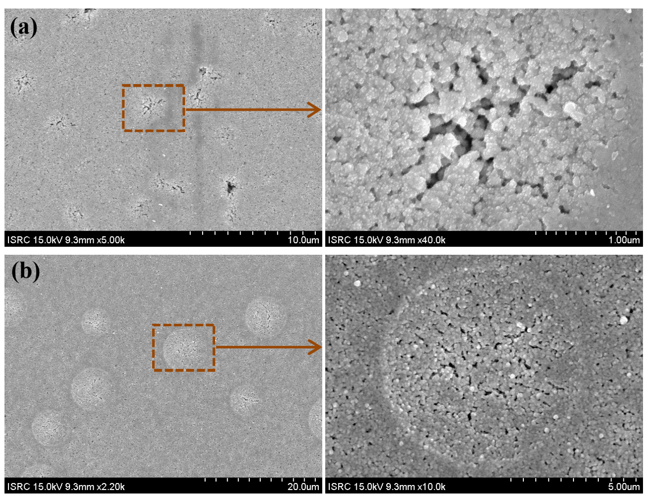

Fig. 4. (a) SEM images of strip and (b) ground

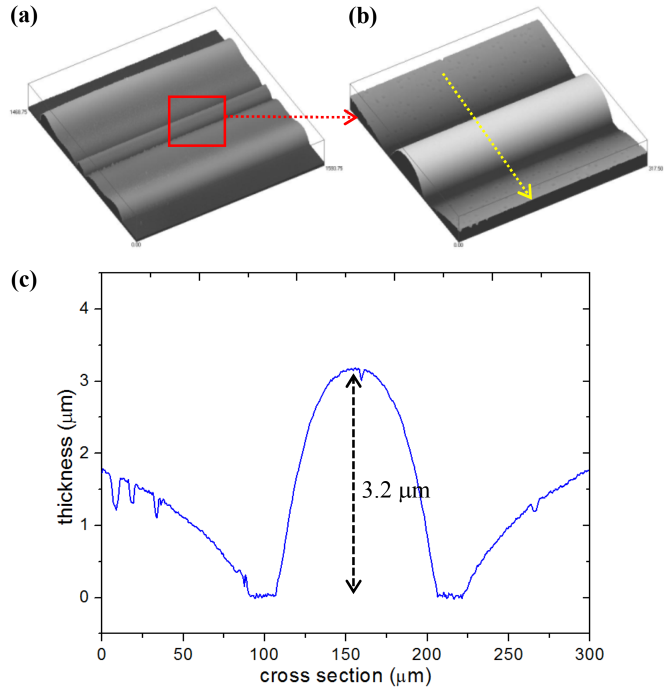

Fig. 5. (a) 3D image of CPW, (b) closed-up view, (c) thickness profile of CPW along the dashed line in Fig. 4(b)

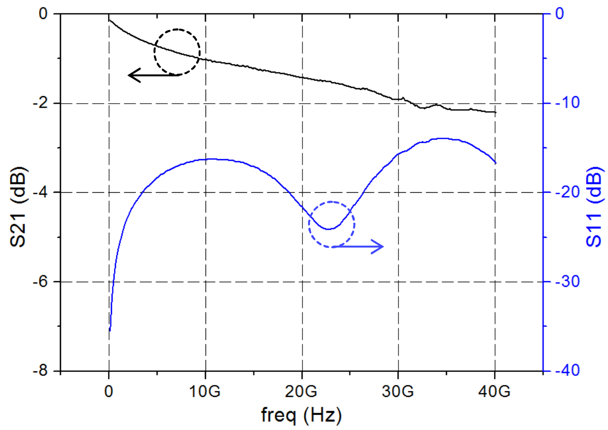

Fig. 6. Measured S-parameters of CPW

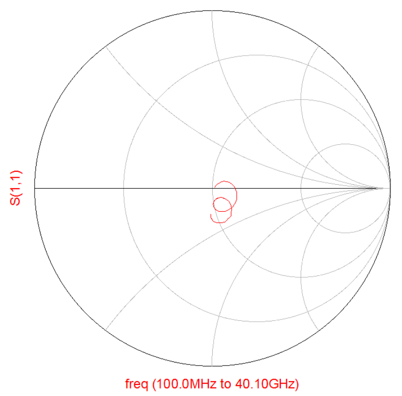

Fig. 7. Smith chart of S11