TWO-SIDE PATTERN GENERATION USING DIRECT LITHOGRAPHY SYSTEM*

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Abstract: *This paper presents a process technique developed for Thin Film Pattern generation using Photolithography & Wet Chemical Etching on two sides of substrate using Direct Lithography system for use in Thin Film Microwave Integrated Circuits (MICs). Pattern generation on two sides of the substrate is essential where the circuit involves Microstrip to Slotline transition and also where interconnections are required between two circuits positioned back-to-back in a trendy approach to achieve better performance and improved reliability. Direct Lithography is adopted for generation of critical Photo masks or Patterns directly on metallized substrates obviating the need of photo masks. Direct Patterning on substrates has the advantage of fine feature size and fast turn-around time. A method of pattern generation on two sides of the substrate is developed. Details on development of process technique are presented in the paper.*

Keywords: *Direct Lithography, Two Side Pattern Generation, Microstrip, Slot Line, Vias in Alumina*

1. INTRODUCTION

Thin film technology is best suited for realization of Microwave Integrated Circuits (MICs) wherein high purity Alumina substrates with different metallization schemes are used. Microstrip, Stripline, Coplanar Waveguide and Slotline are popular transmission lines used in MICs.

Microstrip transmission line (Fig. 1) has a thin conducting layer on one side of the dielectric, the other side of which is metallized completely. In microstrip based MICs, patterns on single side are preferred while the other side is used for electrical grounding. However, pattern generation on two sides of the substrate is essential where transitions between the microstrip and slotline are involved. It is also required between two circuits positioned back-to-back resulting in a compact structure to achieve better performance.

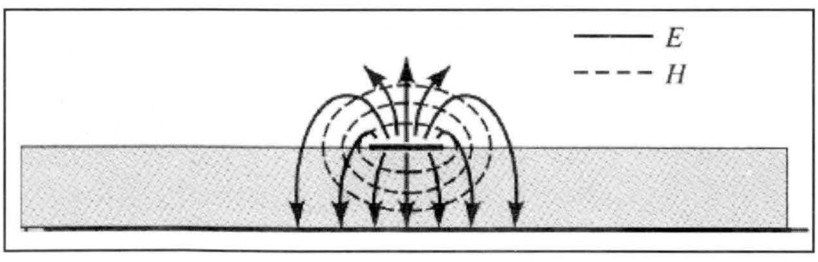

Fig 1. Microstrip Line

The basic slot line structure (Fig. 2) consists of a dielectric substrate with a narrow slot etched in the metallization on one side of the substrate. Slot line can be included in microstrip circuits by etching slot line in the ground plane of the substrate. This type of hybrid combination allows flexibility in the design of microwave circuits (for example series and parallel device mounting, wider range of line impedance, elimination of line crossings and substrate space saving) leading to better integration. Some circuit elements which cannot be easily realized in microstrip configuration can be realized in the slot line medium viz. short circuits, high impedance lines, series stubs and baluns.

Using different photolithography techniques (Fig. 3), desired patterns are transferred onto these metallized substrates [3]. Conventional photolithography with UV exposure requires mask of desired layout for exposing.

Dimensional variations in feature sizes in mask fabrication as well as the mask thickness contribute to the feature size variation in the final pattern. To overcome the variation and for achieving finer feature sizes, mask less lithography technique is preferred.

2. DIRECT LITHOGRAPHY

In Direct Lithography, the radiation is used to expose a photosensitive emulsion (or photoresist) without a photomask. The radiation is focused to a narrow beam (Fig. 4).

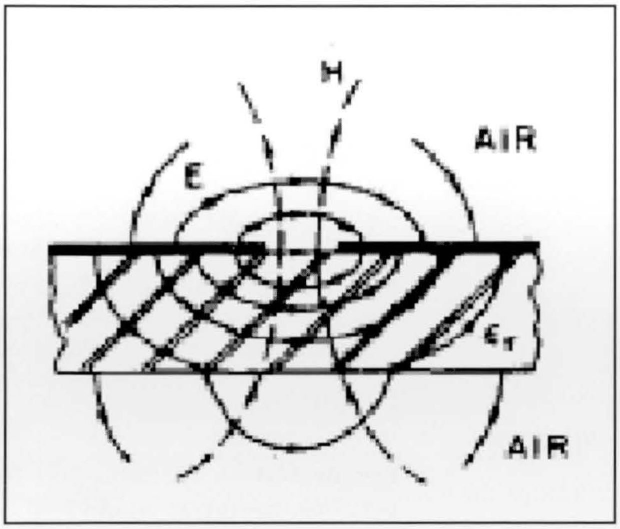

Fig 2. Slot Line

Direct Lithography is a very popular form of maskless lithography used for generating small features in a photosensitive material without the use of photomasks [2]. This method relies on a multi-photon absorption process in a material like a photoresist (PR) that is transparent at the wavelength of the LASER used for creating the pattern. By scanning and properly modulating the laser, a chemical change occurs at the focal spot of the laser. This technique is being used for rapid prototyping of structures with fine features. Highly directional LASER source of wavelength mostly falling within UV region is used.

In order to avoid cross-over interconnection in MICs, microstrip to slotline to microstrip transition schemes are adopted [1]. Such transition requires generation of pattern on both sides of the substrate as shown in Fig. 5. The positional accuracy plays an important role in the performance of these transitions.

Another commonly encountered application is in circuits where two Microstrip lines connected in back to back configuration (separated by metal plate) are to be interfaced through a semirigid cable (Fig. 6). In order to avoid short between semirigid cable and ground plane of substrate, it is essential to remove backside metallization around the via.

Conventional mask-aligning techniques are useful for generation of multilayer patterns and are

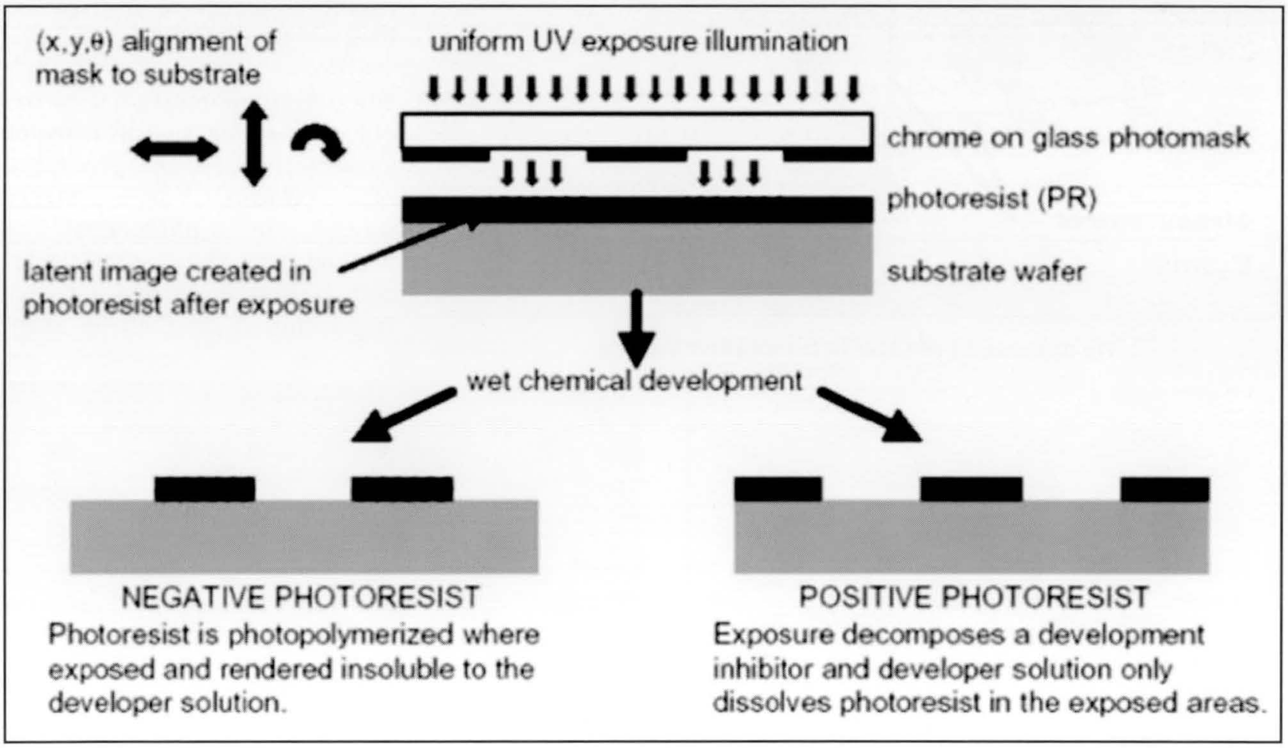

Fig 3. Photolithography Process

limited to one side of the substrate. Obtaining positional accuracy through alignment marks on two different masks is limited to capabilities of the photo-plotter and skill with which they are aligned manually. It is here that direct lithographic systems that offer extremely high positional accuracy are useful.

3. EXPERIMENTAL DETAILS

Heidelberg Laser Direct Writer DWL-66 equipment is used here for direct lithography [5]. It offers positional accuracy of 20 nm. The system has a He-Cd Laser source emitting light at 442nm (g-line) having 75 mW output power. Desired layout is loaded in the system with the given formats viz. CIF, DXF, GDSII, GERBER, HPGL and HIMT. The loaded file format is then converted to LIC format and transferred to DWL menu PC. The menu PC is directly connected to OS 9 of laser direct writer. Depending on the feature size requirement, write heads with different focal length can be adjusted. Different types of filters can be used on laser path for reducing the power output which is critical for fine feature size realization. 60% intensity filter to control the power of the laser spot is selected [4].

The photoresist coated substrate is placed on the stage and the stage initialization is carried out. Write head position is adjusted in vertical direction in such a way that photoresist coated substrate is at the focal point of Laser using pressure gauge system.

Photoresist Microposit S1818 is coated on metallized Alumina substrate and is soft baked at 90°C for 30 minutes. The soft baked substrate is placed on DWL stage which is then held by vacuum and plate centering is achieved. Required .LIC file is loaded and exposing is carried out. The exposing is accomplished by raster scanning of stripes in the layout.

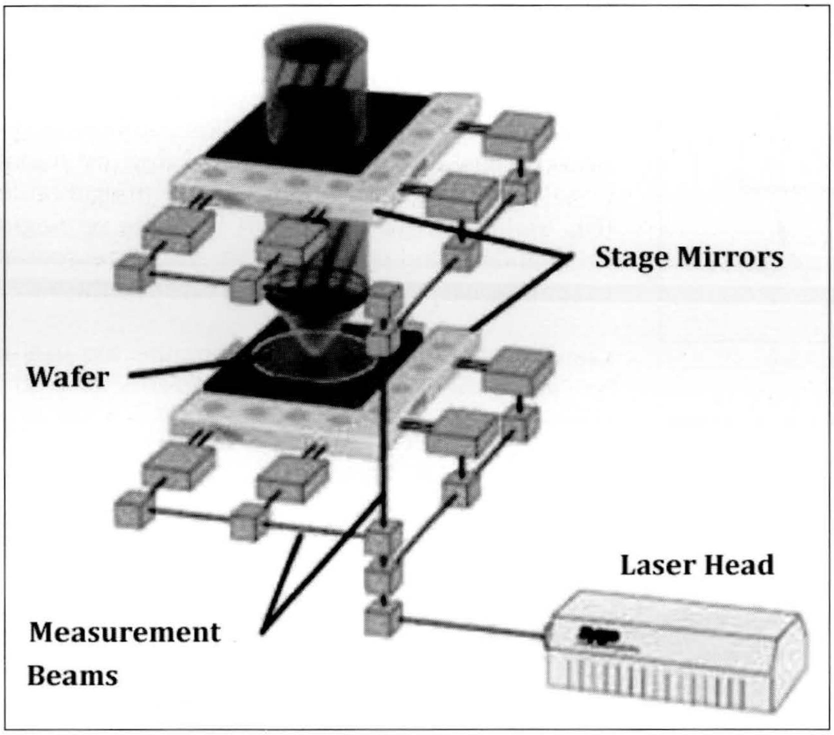

Fig 4: Focusing of Laser in Direct Laser Writing

Demonstration of microstrip to slot line transition at X-band is taken-up as part of an in-house developmental activity. Test circuit is designed and gerber files are generated.

The pattern generation is carried out on the first side in conventional method. For the generation of pattern on second side, the photoresist is applied (on the second side), soft baking is carried out and is positioned on DWL-66 stage.

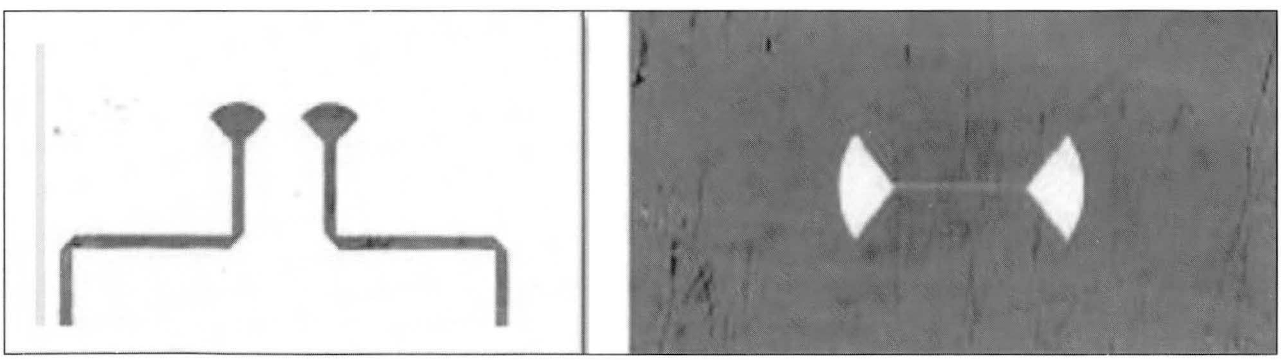

Fig 5. Two Side Pattern for Microstrip to Slot Line Transition

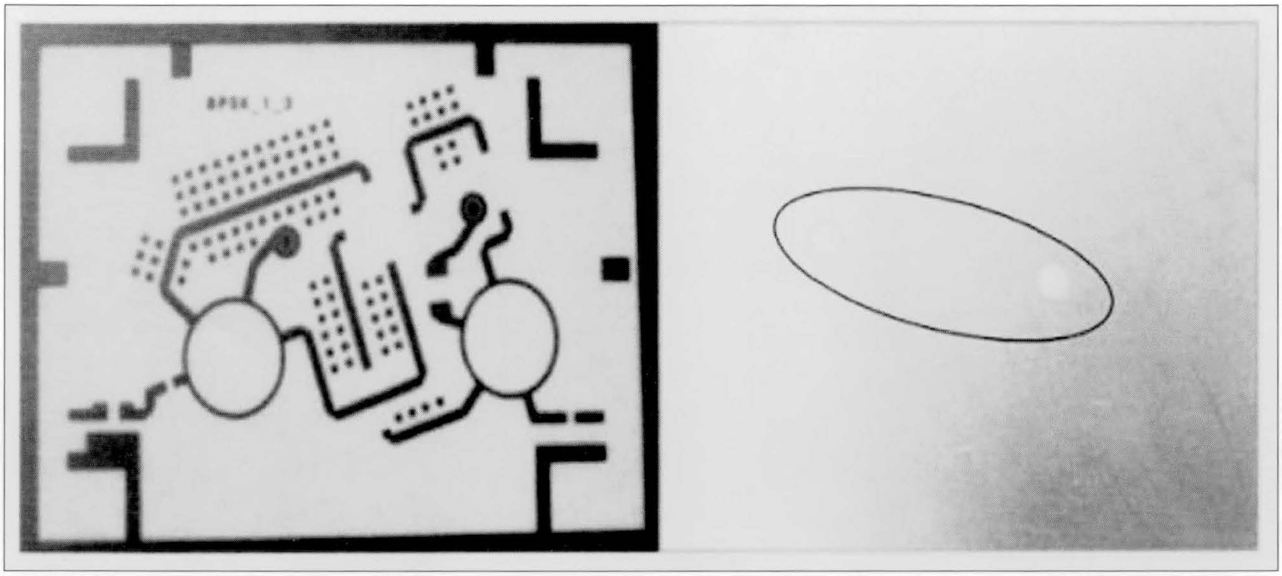

Fig 6. Two Side Pattern for a Microstrip Circuit

The substrate shape is identified, size is measured and center is located by the system. Under these conditions, the second side design is fed and photoresist is exposed. The pattern is developed and before hard-baking, the photoresist is applied on to first side. This time photoresist is applied manually instead of spinning. (If this process of manual application of photoresist is attempted before placing the substrate on DWL-66 for second side exposing, the small variations in thickness of photoresist would lead to variation in focal length lead to improper exposure). The substrate is now baked at an optimized temperature and time so that hard baking for the second side and soft baking for the first side are achieved simultaneously. Conventional wet etching is carried out to remove unwanted metal layers on second side and photoresist stripped.

4. RESULTS AND DISCUSSION

With the process steps detailed above, generation of pattern on two sides of the substrate is made possible. The images of patterns are shown in Fig. 5 and Fig. 6. It is important to identify the first and second sides of the substrate as there is slight chance of getting superficial scratches on the first side during the pattern generation on second side. It is observed that there is a 0.44mm spatial shift between front and back side via positions.

It is due to the inaccuracies in identifying the edge of the substrate where it is scribed. Alignment of vias is achieved by making a shift in the via position in the bottom side layout by same value in the opposite direction.

5. CONCLUSIONS

Pattern generation on two sides of the substrate is essential where transitions between the microstrip and slotline are involved. It is also required between two circuits positioned back-to-back resulting in a compact structure to achieve better performance. A method of pattern generation on two sides of the substrate is developed. Direct Lithography technique is used for obtaining high positional accuracy between front side and back side.

6. REFERENCES

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