PHOTOLITOGRAPHY ON FLEXIBLE SUBSTRATES

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Abstract

Nowadays preparation of structures on flexible substrates is highly demanded because of using this patterns in field of flexible electronics. This contribution deals with photolitographic procces for preparation of structures on flexible substrates. The method of photolitography enables to create designed patterns in various material (e.g. metals as conductive layers) on various substrates (silicon wafers, foils, etc.). First the designed pattern is exposed through the mask by UV light into polymer resist, then the pattern is transfered into metal layer by wet etching through the developed windows in resist. In this paper several patterns are prepared through the positive resist PMMA by photolitography into various metal layer (Cu, Al) on flexible substrates.

Keywords: Photolithography, flexible substrates, metal layer

INTRODUCTION

Nowadays, flexible electronics have received higher attention and the application of this electronics is rising in fields where classic electronics cannot be used and also instead of it. The flexible electronics is prepared on flexible foils as plastic or metal foils. These materials are flexible a can be easily rolled, wrapped or twisted without any affection of their functionality [1,2]. The advantages of these materials can be applied for production of electronic elements such as flexible displays, sensors, active antennas, etc. The essential step at electronic production is preparation of metallic electrodes. One possibility to create conductive layer is transfer of pattern through the mask prepared by photolithography [3]. In this paper we present the preparation of metallic patterns on flexible foils.

1. PHOTOLITHOGRAPHY

It is a method for patterning of sample, which is using light (especially UV light). The light is used for transfer of pattern into the sensitive layer deposited on substrate, as sensitive layer are often used polymer material sensitive to the light, mainly PMMA (poly methyl methacrylate) due to its low cost. The transferred pattern is chemically developed (wet way) after exposition. The principle of method is shown on **Figure 1**.

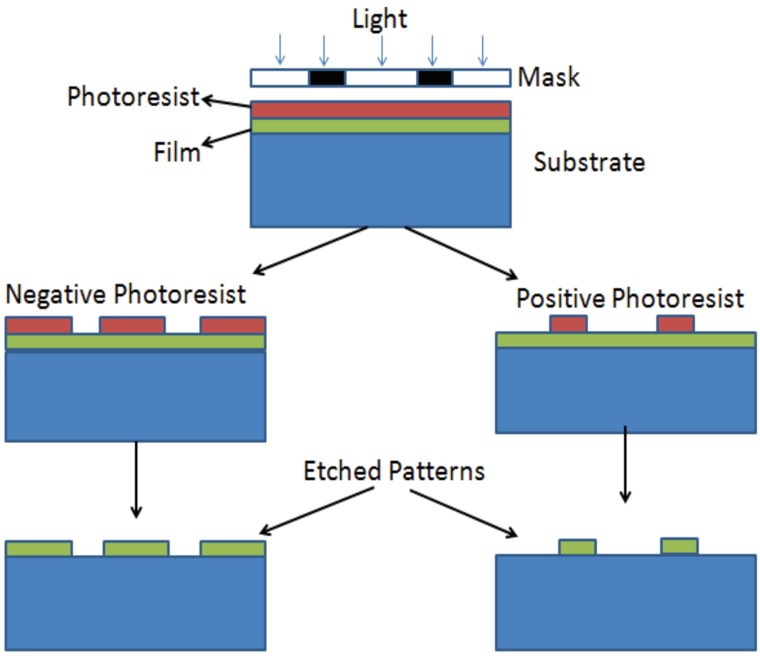

Figure 1 Principle of photolithography [4]

2. EXPERIMENTS

It was prepared aluminium mask as testing pattern for photolithography, the testing mask consisted of squared window 10 times 10 mm. The windows' distance was 10 mm.

2.1. Foil preparation

The following material was used as the flexible substrates: polyimide foil, DuPont TEIJIN FILMS Teonex® Q83 foil, Mylar® 125 DuPont TEIJIN FILMS foil. The foil was cleaned in isopropanol and then rinsed in deionized water.

2.2. Metal deposition

Magnetron sputtering of copper and aluminium was carried out prior the resist layer deposition. The sputtering time for both metals was 5 minutes. The magnetron sputtering was done after development process in case of lift off technique [5].

2.3. Resist layer deposition

PMMA resist was used for photolithography process on all types of flexible substrates. PMMA resist layer was prepared by spin coating from 6 wt. % solution PMMA in chlorobenzene at 2000 RPM and 3000 RPM and from 13 wt. % solution in anisole at 2000 RPM. The prepared resist layers were pre-baked for 30 minutes at 170°C.

2.4. Exposure and development process

The exposure was carried out by Phillips mercury UV lamp 400W for 10 minutes because of needs to achieve exposure dose over 500 mJ/cm^2 for PMMA resist [6].The development process was done by wet way in pentyl acetate for 30 seconds. The temperature of developer was at room temperature - 21.8°C. Then the samples were rinsed in isopropanol and deionized water.

2.5. Wet etching, lift off process, resist stripping

The samples prepared with metal layer prior to the PMMA deposition were developed and then to get designed pattern etched in solution in accordance to the sputtered metal: copper - Cu etchant (H_2O_2 + HCl), aluminium - Al etchant (water, acetic acid, phosphoric acid, nitric acid). The rest of resist layer was stripped in anisole solution.

The samples prepared by lift off technique were process sputtered by metal layer after development.Then the rest of resist layer and metal was removed in anisole solution inserted into ultrasonic bath.

2.6. Layer thickness characterization

The thicknesses of individual layers were measured by mechanical profilometer Brukker DektakXT.

3. RESULTS

First the samples prepared with metal layer prior to spin coating of PMMA were exposed (**Figure 2** and **Figure 3**). The aluminum layer sputtered before resist coating on polyimide foil was 32 nm thick. PMMA resist was developed in pentyl acetate after exposure. The thickness of resist was 336 nm before exposure. It is obvious that Al layer is compact and conductive (measured by multimeter) with some defects which can be solved by better sample cleaning procedure (**Figure 2**). Copper pattern on Mylar® foils was prepared through the resist with thickness of 8.59 μm which was spin coated from 13 wt. % PMMA solution in anisole, the resist layer was too thick for fabrication and during the mechanical resist stripping was also damaged thin Cu layer (16 nm - **Figure 3**).

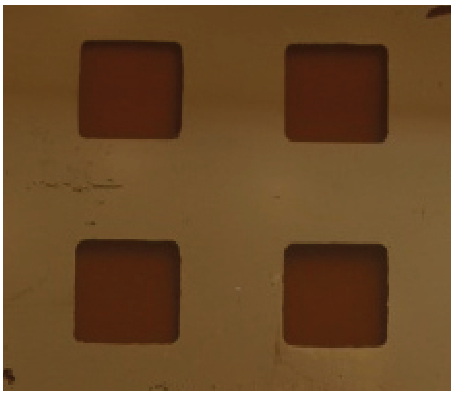

Figure 2 Aluminium pattern prepared on polyimide foil

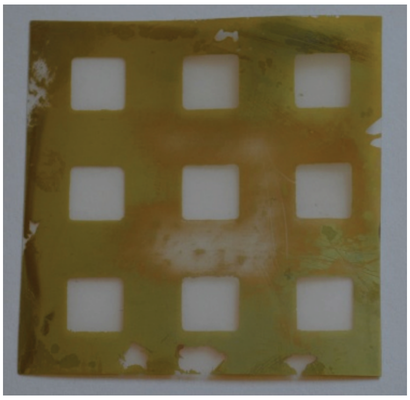

Figure 3 Copper pattern prepared on MYLAR® foil

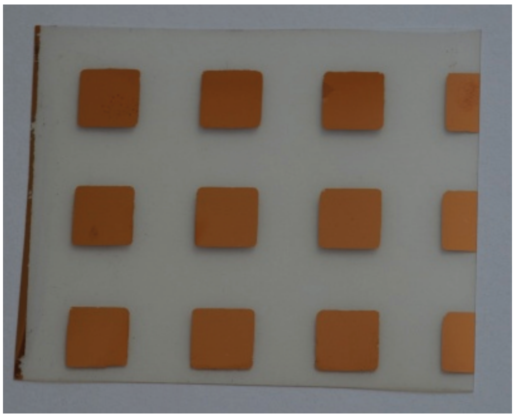

Figure 4 Copper pattern on TEONEX® foil prepared by lift off technique

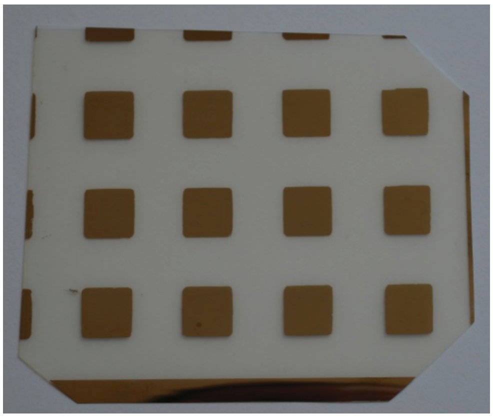

Figure 4 Aluminium pattern on TEONEX® foil prepared by lift off technique

Thereafter structures on TEONEX® Q83 foil were prepared by lift off technique (**Figure 4** and **Figure 5**). Thickness of copper layer is 45 nm and PMMA resist thickness for processing was 611 nm. The aluminium thickness is 28 nm and resist thickness used for lift off was 573 nm. The revolutions were set to 2000 RPM to obtain thicker resist layer for better fabrication. The metal patterns remained in exposed windows after stripping non-exposed resist in ultrasonic bath. It is visible that structures prepared by lift off technique have less defects.

4. CONCLUSION

We successfully prepared different copper and aluminium patterns for electrodes on various flexible materials which is necessary step in production of flexible electronic. This metallic structures were prepared by photolithography where we used two different approaches, first one was metallization before resist processing and second one was lift off technique.

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