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A Water-Soluble Photolithography Process and the Application to OTFT Fabrication

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1. Introduction

Organic thin films are expected to be widely employed in the organic opto-electronic devices such as OLED, OTFT, and organic solar cell. This is attributed to synthesis of the molecules including the various functionality, and the easy process of deposition on the large area substrate. However, the organic thin film is vulnerable to the organic solvent and thus it is very difficult to pattern the organic thin film with the conventional photolithography process without damages on the film. Therefore, in the most cases the organic thin films are patterned by shadow mask [1-3]. But, the shadow mask patterning is not a good way for the large area application as well as the application requiring the high resolution patterns because the flexibility of large shadow mask may result in the unacceptable errors in patterns. Thus, for the large area application requiring the small line feature size on organic thin film it is necessary to develop a new lithography process.

In this paper we developed a new photolithography process which used a water-soluble photoresist instead of organic solvent soluble photoresist, and thus removed the damage of organic solvent on the organic thin film. And pentacene OTFTs were fabricated with the water-soluble photolithography process. The patterning of organic active thin film is very important for OTFTs because the patterned and thus confined thin film in the active area produced the small leakage current, resulting in the large on/off current ratio.

2. Water-soluble photolithography process

The proposed photolithography is identical to the conventional process except using a water-soluble photoresist instead of the organic solvent-soluble one. The water-soluble resist is based on polyaniline(PANI) which is a type of sulfonated polymer with hydrophilic SO_3H substitution in phenyl ring as shown in Fig.1. The resist consists of a fiber type polymer of PANI in solution mixed with UV photoinitator and monomer and oligomer. When the resist is exposed to UV, the UV initiator makes the monomers and oligomers initiate polymerization and connect PANI polymers each other, producing a very big polymer cluster. Therefore, the exposed area remains in the water developing process while the unexposed layer are washed away, resulting in a positive pattern.

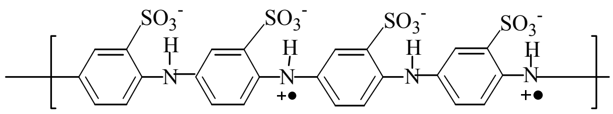


Fig. 1. A molecule of polyaniline

3. Results

The patterns resulted from the water-soluble photolithography is presented in Fig.2. The various patterns were generally well defined under optical microscope. However, in SEM picture of Fig.3 it was found that there was swelling in the edge of patterns. We need the optimization of process and it is under investigation.

The water-soluble photolithography process can be applied to OTFT fabrication. First, we deposited pentacene thin film on Si substrate. Subsequently, PANI resist was spin-coated and patterned by the photolithography process. The opened pentacene looked to be undamaged by the process under optical microscope. The variation of electrical characteristics of pentacene was not examined yet. Next, The patterned pentacene thin film was etched by O_2 plasma RIE process. In Fig.4 the etch rate of PANI and pentacene thin fim are plotted. Pentacene was etched in O_2 plasma faster than PANI film so that PANI film was able to take a role of mask for pentacene. A complete pentacene OTFTs are not fabricated yet at the present.

4. Conclusion

Generally, organic thin film can not be patterned by the conventional organic solvent based photolithography process because organic films are damaged by the organic solvent. We developed a new water-soluble photoresist and the photolithography process. It was found that the process did not give any damage on the pentacene thin film and the resist took a role of mask against O_2 plasma etching. Therefore, the water-soluble photolithography process can be applied to OTFT fabrication. The optimization of the process and the effect on electrical characteristics are under investigation.

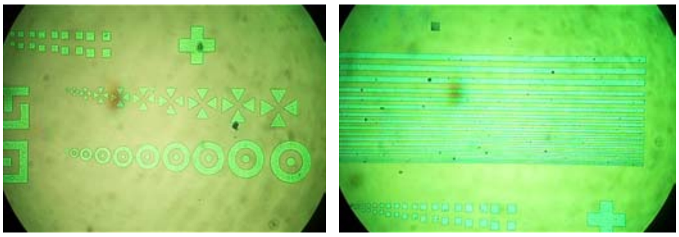


Fig. 2. The various patterns fabricated by the water-soluble PANI-based photolithography process.

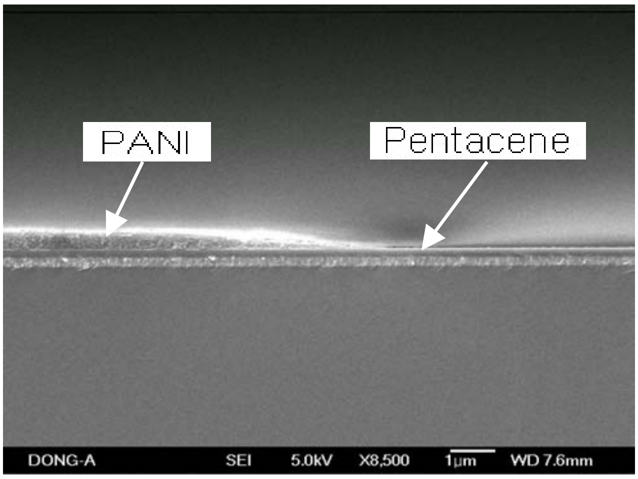
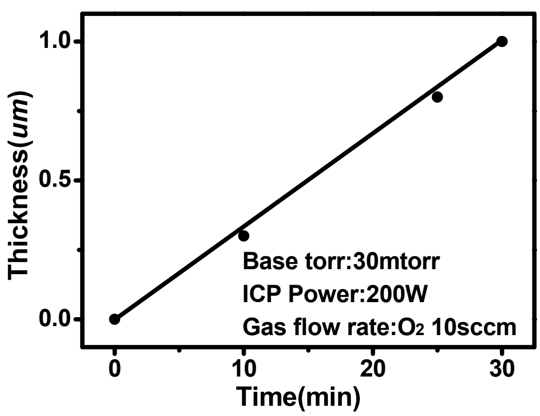
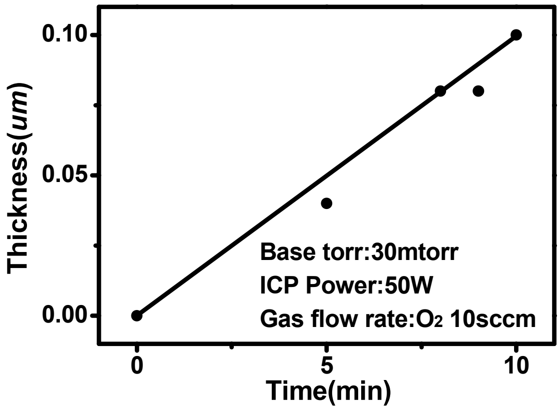


Fig. 3. SEM picture of the pattern edge.



(a)Etch rate:300Å/min



(b)Etch rate: 100Å/min

Fig. 4. The etch rate of a) PANI film at ICP power 200W and b) pentacene film at ICP power 50W in O_2 plasma.

Acknowledgments

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