PHOTOSENSITIVE AZ 5214E RESIST USED FOR E-BEAM LITHOGRAPHY APPLICATIONS

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1. Introduction

In this article we describe the electron-beam direct-write (EBDW) lithography [1] process for the AZ 5214E photoresist (Clariant Corporation, Switzerland) [2] which is, besides its sensitivity to UV radiation, to some extent sensitive also to electrons. This special photoresist is normally intended for lift-off-techniques which call for a negative wall profile. Although it is positive photoresists comprised of a novolak resin and naphthoquinone diazide as photoactive compound (PAC), it is also capable of usage as an image reversal (IR) and it is mostly used in this mode also for its excellent dry etch resistance and thermal stability. Its IR capability is obtained by a special crosslinking agent which becomes active at temperatures above 110°C and only in exposed areas of the resist. The crosslinking agent together with exposed PAC leads to an almost insoluble (in developer) and no longer light sensitive substance, while the unexposed areas still behave like a normal unexposed positive photoresist. After a maskless flood exposure, the overall result is a negative image of the mask pattern with a negative wall profile ideally suited for lift-off [3].

2. Experimental

The EBDW lithography experiments have been carried out on ZBA 23 (40kV modes, LaB_6 cathode) variable shaped e-beam pattern generator [4]. We have used the so called Exposure Wedge (EW) test that serves for the construction of the sensitivity (characteristic) curve and for extracting the contrast γ value of the resist for optimized resist pre- and post- exposure process parameters. We obtained the dependency of the remaining resist thickness to the applied exposition dose within large-area exposures (see Figure 1) [5]. We have exposed series of EW test samples (deposited on Si as well as on GaAs substrates) with exposure doses ranging from 10 to 640$\mu C/cm^2$. Our experiments showed that the AZ 5214E resist is electron sensitive and we show its technological process flow that suited our technological needs. As mentioned, AZ 5214E can be used either in positive or negative (IR) mode and for our purposes it appeared to be interesting also for its resistance towards etching in $SiCl_4$, CCl_4 and SF_6 plasmas.

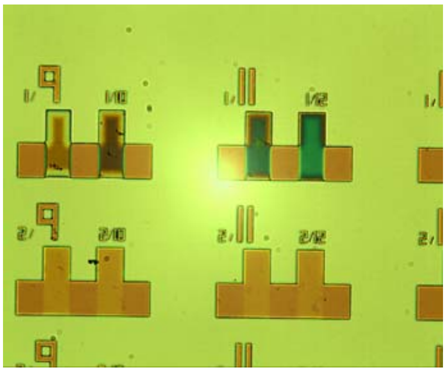

Fig. 1: *Example of an EW test with under-, over- and normally-exposed areas.*

In order to obtain ca 400 nm film thickness at 5500 rpm spin-speed, we used diluted solution of AZ 5214E (1:1, by the AZ EBR Solvent). We used the following resist process flow for the AZ 5214E in IR mode useful for the EBDW patterning: resist spin-coating; prebake at 120°C / 120s on hotplate (HP); EBDW lithography (ZBA23 at 40kV, 50nm mode); post-bake at 115-130°C / 2min with a step of 5°C (for technology fine-tuning); UV maskless exposure (Karl Süss) for 15s (this step turns the resist to IR); resist development in AZ400K + H_2O (1:5) for 1min; final rinse in H_2O for 10s.

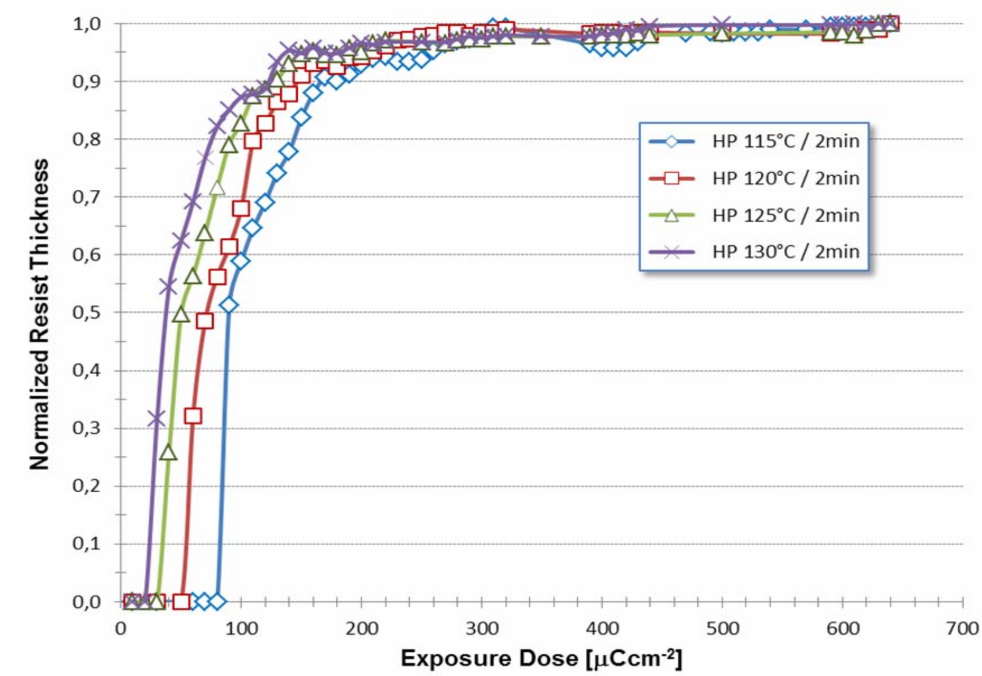

Fig 2. *Characteristic curves for the AZ 5214E resist on Si at 40kV accel. voltage.*

Figure 2 shows normalized resist thickness dependence as a function of exposure dose for four different post-bake temperatures ranging from 115-130°C, step 5°C (for 2min at HP). Silicon wafer was used here as substrate. As the most critical parameter of the IR-process is the reversal-bake temperature, it was kept constant within ± 1°C to maintain a consistent process [2]. This temperature was optimised individually (115°C was considered to be the value) and for all further samples we used this optimised process flow. The measurements in EW tests were carried out using the standard profilometry technique (Talystep, Alphastep).

3. Results and Discussion

Figure 3 shows patterns made by EBDW in the AZ 5214E resist. These results were obtained on GaAs wafers. To prevent charging of the resist during the e-beam exposure, the samples were metallized by a thin layer of chromium (12nm), which was afterwards etched away by

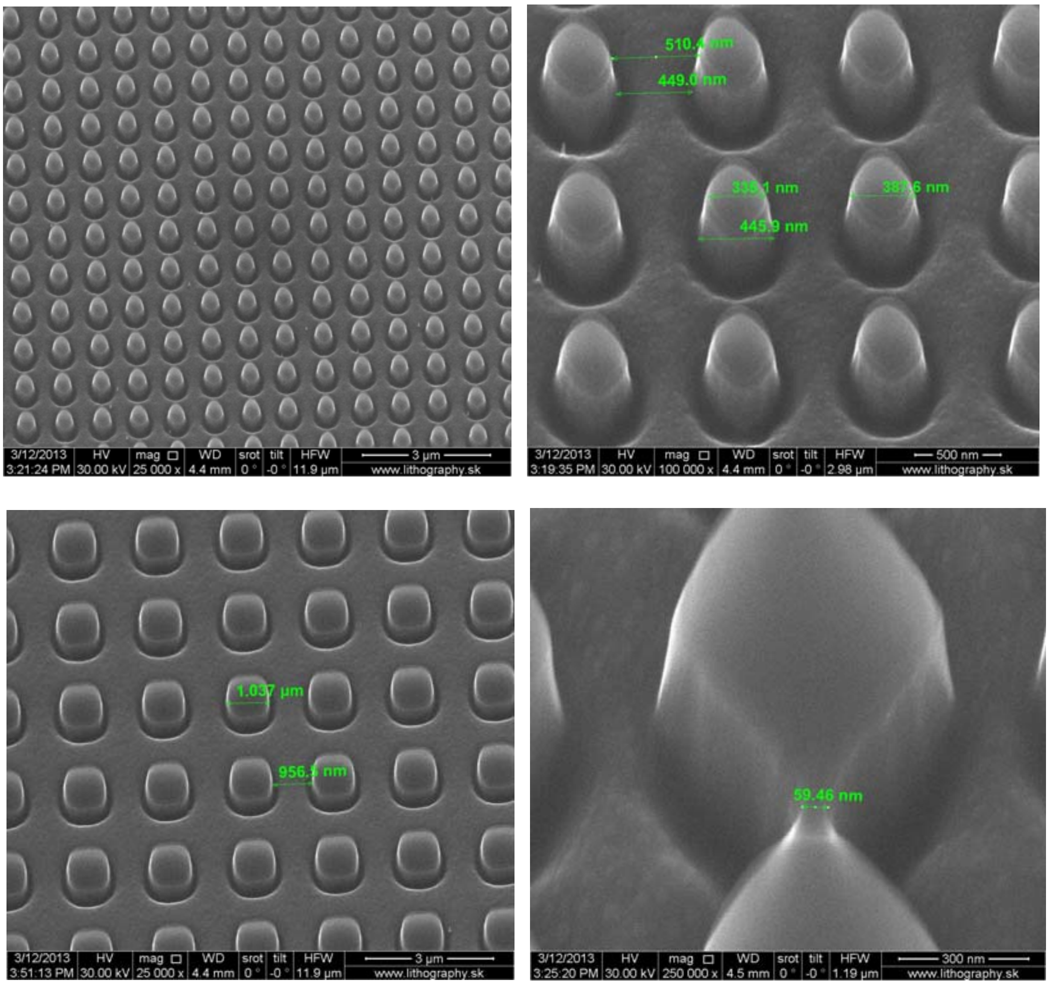

Fig. 3: *SEM pictures of patterns with AZ 5214E used as an etch mask in $SiCl_4$ plasma. Above: an array of dots (0,45/0,45µm); below: an array of dots (1,0/1,0µm); bottom-right: detail of a nanobridge.*

wet chemical etching. An array of 0,45/0,45µm dots is shown (Fig. 3). To achieve this profile three different exposure doses were used, after the exposure of the patterns the samples were descummed in O_2 plasma (150W, 1Pa, 30s) and subsequently RIE etched in $SiCl_4$ plasma (40W, 2Pa, 3min). We achieved a rather good homogeneity of the dots across the wafer, however an effect of trenching can be seen in the neighbourhood of the etched patterns. Due to a good resistance of the AZ 5214E resist to $SiCl_4$ etching, we exposed the samples to another etching in oxygen plasma in order to decreasing the resist thickness and its opening.

4. Conclusion

We have described an EBDW lithography process for the AZ 5214E photoresist which was used in image-reversal mode for its good properties for lift-off. Besides its rather good e-beam patternig use, this resist has shown to be interesting also for its resistance towards etching in $SiCl_4$, CCl_4 and SF_6 plasmas and that is why we used it as a mask for the RIE etching. An array of 0,45/0,45μm dots of a good homogeneity across the wafer, was achieved by a technique proposed in the article.

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