AR NEWS

33rd issue, October 2016, Allresist GmbH

Content:

Welcome to the 33rd issue of the AR NEWS. We would like to inform you again about the further development of the company and its research projects.

1. 24th anniversary Allresist

Already some time ago, we coined the slogan "100 years of Allresist". Today, as back then, this slogan stands for sustainability, reliability, success, optimism and zest for life. At the end of next year, it will now get an additional meaning. The four, still active founding members Mrs Rehfeldt, Mrs Feldt, Mrs Schirmer, and Mr Schirmer will then together be part the company for a total of 100 years (4 x 25). Particularly in the last six years, the economic success – supported by the concept of Business Excellence – was constantly documented by double-digit sales increases. Innovative product developments, successful scientific projects, and major investments characterise the path of Allresist. A trustworthy, valued relationship with our customers is part of our company philosophy. We will acknowledge all these aspects once more on 16 October 2016 at our anniversary celebration and already look ahead to our 25th foundation day. We want to celebrate the quarter of a century with customers and partners in a larger setting. In addition to laudations and a glance back at our history, also short scientific contributions are planned. Let's look forward to this event together!

2. Allresist as silver sponsor at MNE 2016 in Vienna

Allresist this time appeared as silver sponsor at the MNE (Micro and Nano Engineering) 2016 in Vienna. The large variety of lectures and posters gave us new input and ideas for further developments. Many of the visitors at the booth of Allresist were "old acquaintances" who often brought along results from the applications of our resists; many other interested congress visitors wanted to inform themselves about the new products. In the focus of interest were resists CSAR 62, Electra 92 and our work on the manufacture of T-gates (see next section).

Fig. 1 Allresist booth at MNE 2016 in Vienna with Matthias Schirmer, Dr. Maik Gerngroß, and Dr. Christian Kaiser (from left to right)

Joint posters presented the successful cooperations with the companies EVG, Raith, and SwissLitho who were also represented as exhibitors at the MNE.

The EV Group from Schärding assessed our ready-to-use spray resists AR-P 1220 and AR-N 2220 on their EVG® 150 Automated Resist Processing System (200 mm) with very good results this year. In addition to a very good covering of critical edges, the surface of AR-N 2220 remains nevertheless smooth and free of dried resist beads (Fig. 2). After exposure, crosslinking and development, the conductor paths precisely stretch across the 150 µm deep cavities (Fig. 3). In the case of negative resist AR-N 2220, it is even easily possible to adjust an undercut of structures as required for lift-off processes (Fig. 4).

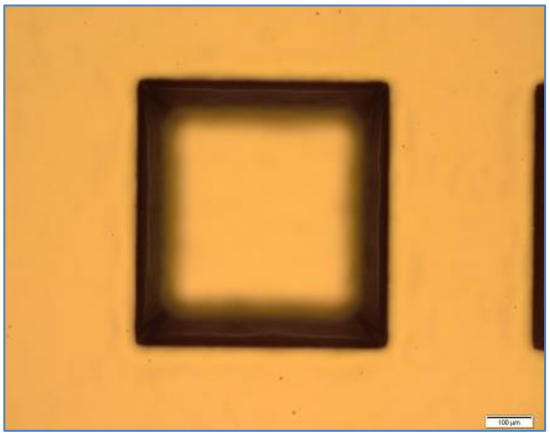

Fig. 2 Smooth surface after coating

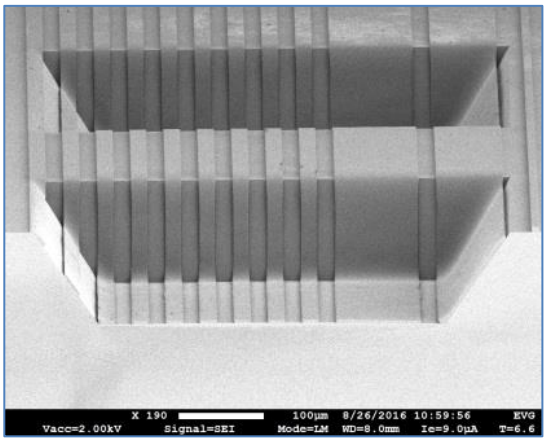

Fig. 3 Resist structures in 150 µm cavity

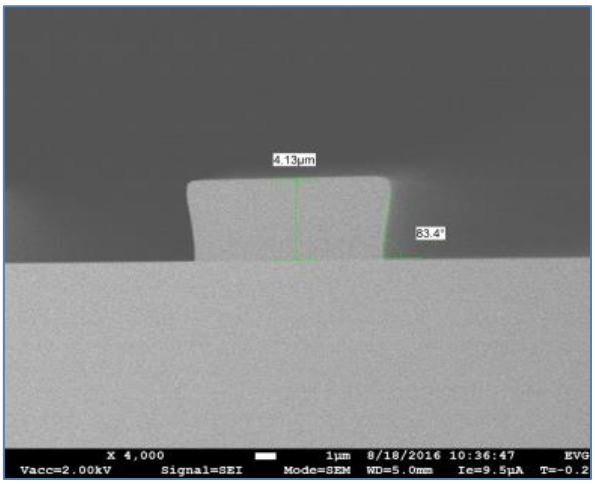

Fig. 4 Lift-off structure of AR-N 2220

The most recent results concerning poly (phthalaldehyde) resists (PPA) were presented together with SwissLitho AG and Raith Nanofabrication on a joint poster. The thermal structuring of PPA resists using a NanoFrazor remains the focus of the Eurostar project, but also more and more other possible applications than "only" a direct thermal structuring open up. In the 31st AR NEWS (October 2015), we presented already two lift-off methods with PPA-resist and PMMA or AR-BR 5400 (similar to PMGI).

Despite their thermal instability, PPA layers show surprisingly high plasma etch stability and can thus be used for even smallest etching patterns down to 10 nm. Further investigations with respect to a direct structuring by e-beam irradiation were carried out at the company Raith. An almost complete development at a dose of approx. 5 µC/cm2 (2 kV) is achieved with (not yet finally optimised) PPA polymers on a PMMA layer. At an acceleration voltage of 30 kV, the value is approx. 35 µC/cm². Substrates are already fully developed when they are removed from the e-beam device after exposure.

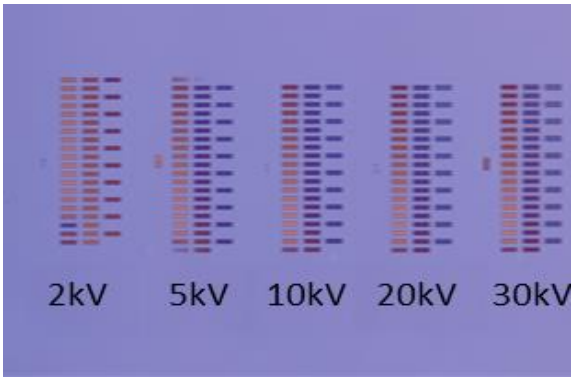

Fig. 5 Variation of acceleration voltage and exposure dose

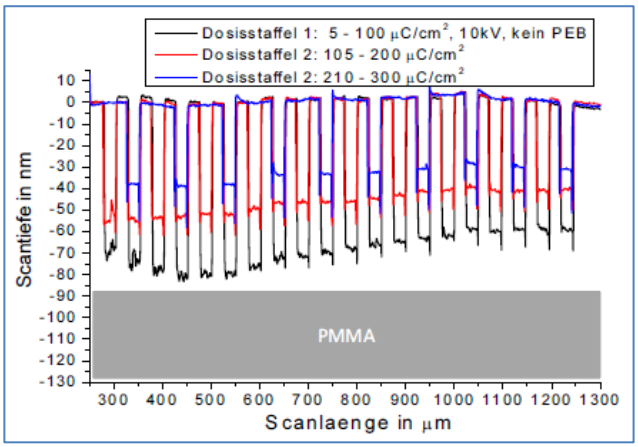

Fig. 6 Development depth depending on the exposure dose

Until the end of the project in April 2017, the PPA polymers will be optimised further. The first PPA resist samples will be available under the designation AR-P 8100 in the near future.

The MNE 2016 was a great success for Allresist. Many new business relationships were built, and we received a lot of valuable suggestions and ideas. Posters of the MNE can be viewed on our website.

3. News about CSAR 62 and Electra 92

Both products, having been developed over the last three years, established themselves on the market and now account for approximately 15 % of the total turnover of Allresist. Synthesis and production of Electra 92 was optimised this year, resulting in higher synthesis yields and a 10-fold increased conductivity. The most pleasing results however were the longer shelf life of the liquid resists as well as the stability of conductivity in layers. Meanwhile, the oldest liquid samples are more than two years old, and it has shown that the conductivity remained virtually unchanged over these two years. Also in Electra layers, the conductivity is maintained for weeks. Electra 92 differs considerably from similar competitors' products.

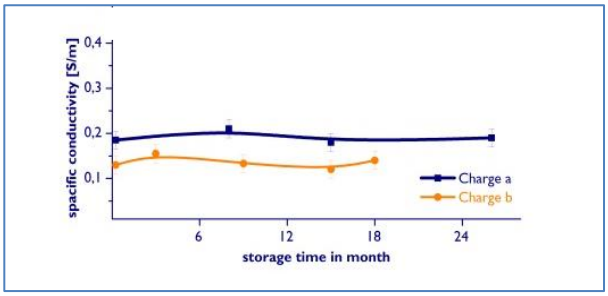

Fig. 7 Conductivity measurement of two Electra samples over month

CSAR 62 was furthermore assessed with regard to a use in extreme UV lithography (EUV) at a wavelength of 10.77 nm (S. Brose, RWTH Aachen). The sensitivity of a 42 nm thick layer was 50 mJ/cm² at a contrast of 1.84. These results provided evidence that CSAR 62 is also suitable for EUV lithography.

Several developers for CSAR 62 were tested in detail. It is thus now possible to conduct a structuring process according to your own specific requirements. At an acceleration voltage of 100 kV, the sensitivity can be adjusted with different developers in a range from 75 µC/cm² to more than 500 µC/cm² as required. If a certain amount of dark erosion (< 10 %) of unexposed layers is tolerated, even a dose of 50 µC/cm² can be achieved. The detailed results are available on our resist wiki:

Evaluation of various developers for e-beam exposed CSAR 62 layers (100 kV)

CSAR 62 nanostructures written at 100 kV

Use of CSAR 62 for the manufacture of nanostructures on GaAs

BOE etching of SiO_2 with CSAR 62 mask

HF etching of GaAs with CSAR 62 masks

Utilising Electra 92 for SEM applications

4. Optimised T-gate structures with three-layer system of PMMA, co-polymer 617, and CSAR 62

T-gates are required for the manufacture of high-quality transistors. Allresist optimised several three-layer systems for this particular application and designed both universal developers for a single development step as well as individual developers suitable to develop each one of the three layers specifically.

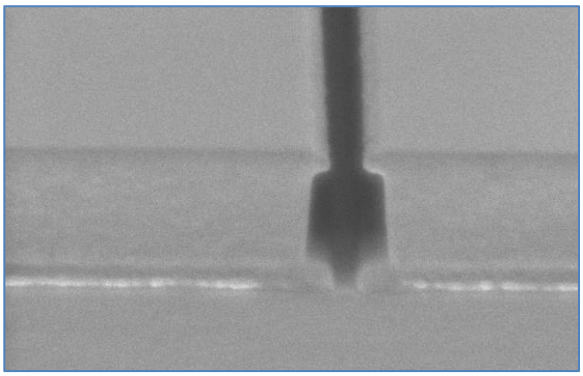

Fig. 8 T-gate resist structure (PMMA/PMMAcoMA/PMMA)

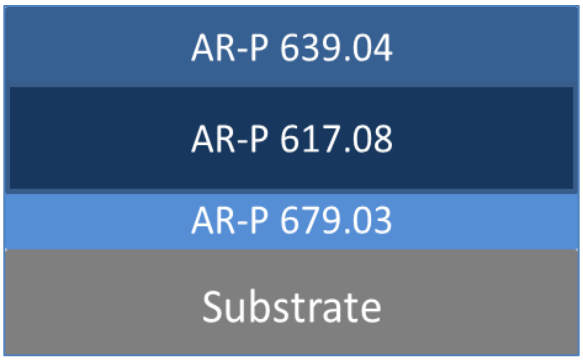

Fig. 9 Three-layer structure of PMMA and copolymer after development

The already well-established three-layer structure "PMMA 950k (AR-P 679.03) as bottom, copolymer (AR-P 617.08) as intermediate, and PMMA 50k (AR-P 639.04) as top layer" can be developed after irradiation with standard developers AR 600-55 and AR 600-50. Disadvantageous however is that the developer has to be changed during the development process. We thus aimed our research at the development of a mixture which should ideally be able to develop all layers in a defined manner, sufficiently high quality, and also with low dark erosion. Special developer X AR 600-55/1 is now optimised for this application. It is suitable for the development of AR-P 617 as well as for PMMA and can thus be used as universal developer for two- or three-layer processes. The degree of the undercut is easily controlled via the exposure dose.

Fig. 10 Three-layer structure of PMMA, PMMAcoMA and CSAR 62

In the second structural composition "PMMA 950k (AR-P 679.03) bottom, copolymer (AR-P 617.08) as intermediate, CSAR 62 (AR-P 6200.09) on top", each layer is developed individually with a specific developer. The additional effort of multiple development steps is outweighed by the advantages of an exact adjustment of the desired profiles and by a large process window of the single steps.

Each user now has to decide which development procedure provides the most advantages for his demands. Detailed results are published on the resist wiki. Should you be particularly interested in a certain product, we will be glad to provide all required information also in a personal conversation.

5. New developer for PMMAcoMA (AR-P 617, 50 kV)

X AR 600-50/2 is a new, very sensitive and highly selective developer for AR-P 617. The dark erosion is very low even at longer development times. Layers of PMMA or CSAR 62 are not attacked, which is especially important for multi-layer processes. The sensitivity can be well adjusted via the development time.

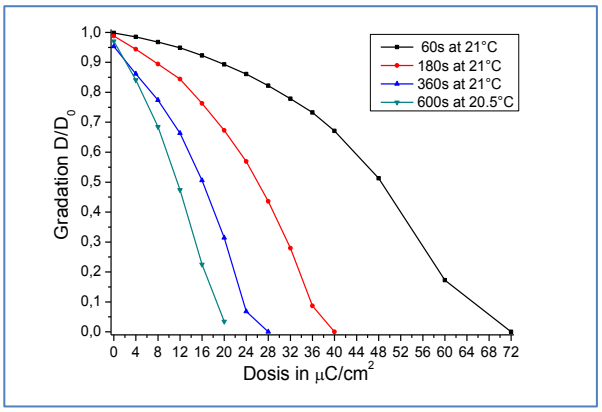

Fig. 11 Dose variations; dependence of the sensitivity on the development time with developer X AR 600-50/2 at room temperature, stopper: IPA. AR-P 617, film thickness: ~1 µm, SB 10 minutes at 200 °C, 50 kV

At a development time of 60 s, the dose to clear is approx. 70 µC/cm2, after development for 3 minutes about 40 µC/cm2, after 6 minutes still 25 µC/cm2, and after 10 minutes only about 20 µC/cm2! The dark erosion thus remains at moderate < 5 %. Developer X AR 600-50/2 shows pronounced temperature dependence.

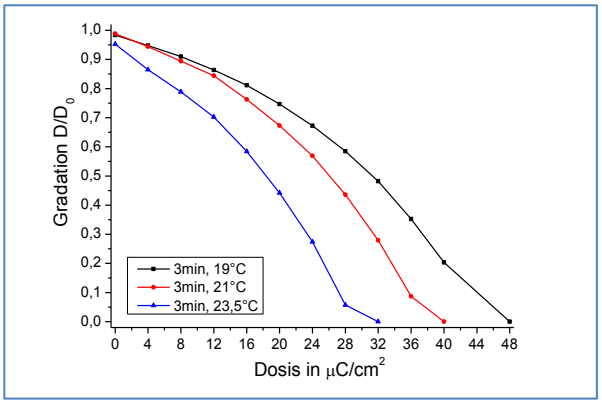

Fig. 12 Dose variations, dependence of the sensitivity on the development temperature, development time: 3 minutes, stopper: IPA. AR-P 617. Film thickness: ~1 µm, SB 10 minutes at 200 °C, 50 kV

The sensitivity considerably increases with raising temperatures. The dose to clear is approximately 48 µC/cm2 at 19 °C, but just about 30 µC/cm2 at 23.5 °C. If the development temperature is enhanced, lower dark erosion values of approximately 5 % result.

We highly appreciate any feedback from you. Please communicate your particular interests or at which point you intend to conduct own experiments.

Additional resist wiki articles:

New developers for AR-P 617

Additional new experimental developers for AR-P 617

6. New lab and new rotary evaporator for production

As already announced in the last AR news, we meanwhile modernised and completely re-equipped our laboratories. In addition to the feel-good factor for the employees, also technical and environmentally relevant aspects are now at the highest level. The newly designed media supply makes it possible to make better use of all analytical methods, and also the synthesis capacity is increased. This also benefits the production of CSAR 62 and Electra 92.

We provide a tailor-made resist for the complicated manufacturing process of a large, globally operating customer. One component of the resist is our copolymer PMMAcoMA. Since considerable amounts of this resist are required, the synthesis capacity of the production had to be increased. The bottleneck of our production is the step when the solvents have to be expelled from the reaction mixture, which is done with a rotary evaporator. The existing evaporator turned out to be too small; a 100-litre rotary evaporator was thus purchased and put into operation. A production of several hundred litres of resist per year can now easily be realised.

Fig. 13 New Allresist lab

Fig. 14 New rotary evaporator with 100 l-flasks

We hope that you found some interesting suggestions and encourage you to communicate your wishes. You are also invited to visit us at the **Semicon Europa 2016 in Grenoble (25 October - 27 October 2016)** at our exhibition stand.

We will present the next issues of AR NEWS again in April 2017.
Until then, we wish you and us every success!

Strausberg, 13.10.2016
Matthias & Brigitte Schirmer
In the team of Allresist