AR NEWS

36th Issue, October 2017, Allresist GmbH

Content:

Welcome to the 36th issue of the AR NEWS. Once again, we would like to inform you about the further development of our company and its research projects.

1. 25 years of Allresist –a success story also of resist development

Almost 25 years ago, we noted in our first customer letter on the occasion of the founding of the Allresist GmbH: "A journey of 1 000 km always begins with the first step" (Chinese wisdom). Meanwhile, we left the cumbersome ups and downs of the first years and many "troubles of the plains" behind us. In the past 10 years, we became ever more successful. On the occasion of our anniversary, we look back and review the last 25 years.

Starting in 1992 with just a handful of former colleagues from the Fotochemische Werke (ORWO) and only eight products, we rented at first a small facility in Berlin.

Fig. 1 Allresist Team 1993

Today, we are producing more than 200 products in Strausberg with 12 employees in our own modern company building.

Fig. 2 Company building Allresist GmbH

Fig. 3 Detail of our production

During the 25 years of our existence, we produced and sold 30 tonnes of resists and 250 tonnes of process chemicals. This resulted in a total sales volume of € 17.5 million. We in addition successfully completed 32 research projects with project volumes of € 6.5 million and a total funding of € 2.9 million.

Meanwhile, we established a successor team consisting of three young PhD chemists and our daughter as Master of Business Administration.

This team supports us two managing directors and is gaining more and more responsibilities.

Not at least due to the very good work of our successor team, we developed new, innovative high-tech products like CSAR 62 and Electra 92 and established these products on the world market.

Many prizes and awards testify to the recognition of the convincing company philosophy which is based on the excellence concept of the EFQM model and aims at a win-win situation for all partners.

But of course all this successes would not have been possible without you, our customers. Today we would like to thank you for your loyalty. We cultivate long-term and valuable relationships to you as well as to many other partners, which sometimes even developed into very cordial friendships.

The economic development of Allresist, being based on new innovative products and the acquisition of additional, also large customers worldwide, now requires a further expansion of our company building by approx. 500 m² in 2018. The planning process has already started and is rapidly gathering speed – as is so often the case with our projects. The construction measures will be finished by mid-2018. And we can ensure, due to the thorough and complex planning of the construction activities, that the production and delivery is guaranteed without problems also during the building phase.

2. Allresist on the MNE Conference 2017 with Atlas 46

Fig. 4 Allresist booth at the MNE 2017 in Braga (Portugal)

Allresist participated as "silver sponsor" at the conference in Braga with an own large stand and presented many remarkable news. A special highlight was the scientific poster on our new development Atlas 46 and the lecture given by Dr. Glad about this interesting negative photoresist. Three variants of this resist are already now available:

- 46 S: equivalent to SU-8
- 46 R: easily removable
- 4600-10: sensitive at g-line

Fig. 5 Allresist lecture by Dr. Gerngroß on Atlas 46

If these different resist variants are combined, three-dimensional structures can be generated in the following process: Initially, Atlas 46S is exposed ($\lambda_1 \leq 365$ nm) and crosslinked by tempering. In a second step, SX AR-N 4600-10/10 is coated onto the first resist and exposed ($\lambda_2 \geq 380$ nm), followed by tempering of the bilayer. During the subsequent development step, the non-exposed areas of the top layer are removed. Likewise, the non-exposed areas of the bottom layer under the second resist are washed out since the second exposure wavelength is not able to expose the lower resist.

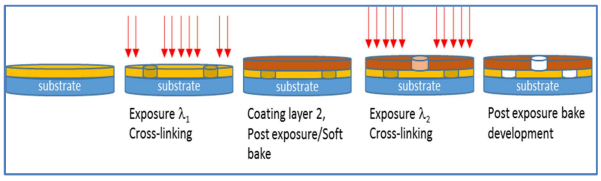

Fig 6 Process picture of 3D multilayer system Atlas 46

The new development Atlas 46 was already successfully applied in nanimprinting (University of Wuppertal, AG Professor Scheer). In a first step, the negative-working resist Atlas 46S was used to produce nanostructures which were subsequently cured with UV light at a wavelength of 172 nm. The next imprinting step then yielded the desired hierarchical and complex architecture.

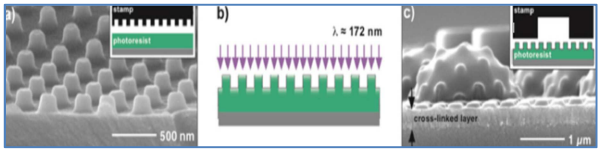

Fig. 7 Steps of the imprint process

a) Generation of defined nanostructures by thermal imprinting

b) Stabilisation of the pre-patterned surface by deep-UV exposure

c) Second imprinting step to create the hierarchical architecture

SU 8 and Atlas 46 yielded similarly good results; defined and very even structures could be produced. The particular advantage of Atlas 46R is its easy removability.

(Link to our posters at the MNE 2017)

3. Further new innovative product developments

3.1. Fluorescent and coloured resists for optics and sensors

A particular eye-catcher at the MNE 2017 were the **fluorescent structures of our new high-resolution coloured resists**.

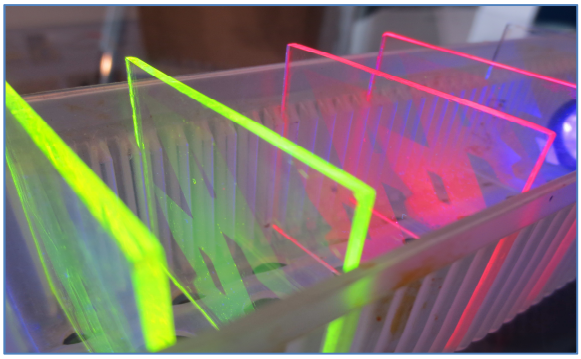

Fig. 8 Fluorescent samples presented at the exhibition stand

High-resolution PMMA and CSAR 62 e-beam resists were mixed with fluorescent components which brightly fluoresce upon exposure to UV light. In this case, the correct concentration of the dyes is extremely important; too little is just as bad as too much (quenching!). A striking application example is the finely divided scaling in night vision devices.

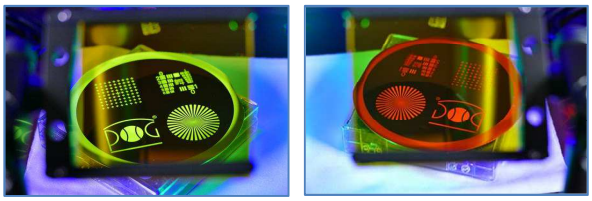

Fig. 9 Fluorescent e-beam structures with SX AR-P 672.08 (POG Gera). Left: yellow-green; right: red fluorescence

In a subsequent project, we coloured **negative photoresists with different dyes**.

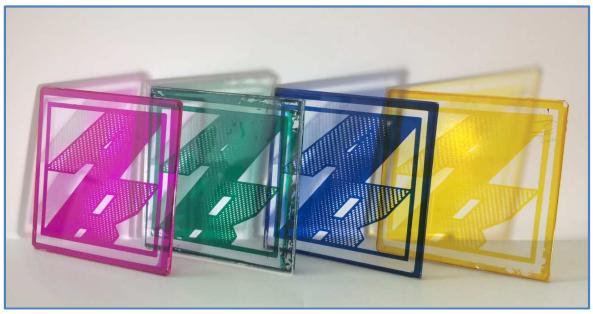

Fig. 10 AR logos in different colours (Allresist)

A typical application example for coloured resists is the FUJIFILM colour filter array which can be used to assess the colour fastness:

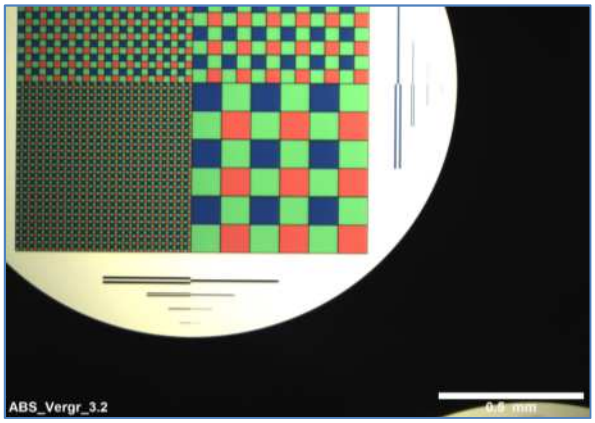

Fig. 11 Colour filter array with coloured negative resists (FUJIFILM)

FUJIFILM offers coloured red, blue, and green acrylate-based negative resists. These resists however contain colour pigments with a size of a few hundred nm, which considerably limits resolution and edge sharpness. In addition, organic solvents are required as developers which may be potentially hazardous to health.

Allresist now offers coloured negative resists under the designation SX AR-N 8500 which provide, in contrast to FUJIFILM products, high resolution and high edge sharpness. Since the new coloured resists are based on a slightly modified negative resist generally applied in "normal" photolithography, the development can be performed with conventionally used aqueous-alkaline developers.

Another special feature is our black resist. Depending on the respective layer thickness, this resist is characterised by complete absorption in the spectral range from 300 to 750 nm and can nevertheless be easily structured.

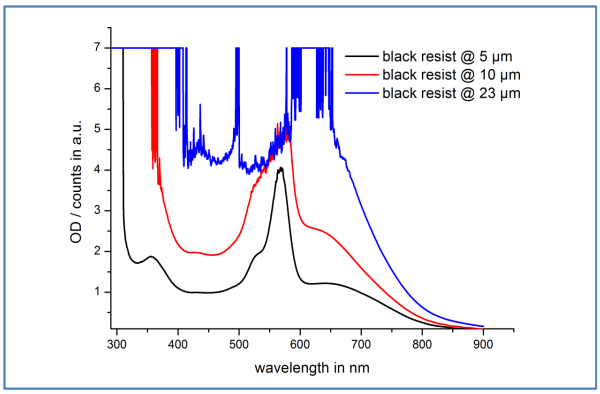

Fig. 12 Absorption spectrum of the black resist

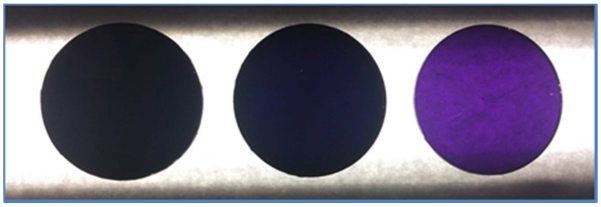

Fig. 13 Visual impression of optical density.
From left to right: 23 µm, 10 µm, 5 µm

Even at high layer thickness values of 23 µm, a structuring with conventional methods of photolithography is possible. This resist however requires a strong aqueous alkaline developer (AR 300-26 or AR 300-73 diluted 1:1).

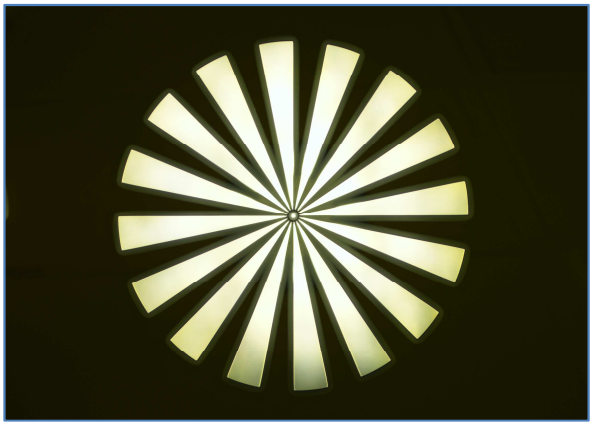

Fig. 14 Siemens star in 23 µm-thick black resist layer (Source: EV Group E. Thallner GmbH)

All resists described here are already available as experimental samples for own tests. We are looking forward to your feedback and ideas for new application possibilities!

3.2. Thick(er) CSAR 62 for the production of deep etch pits

Intense plasma etching applications for the manufacture of deep etching structures with high aspect ratio require etch-stable resists and higher layer thicknesses, which however pose special demands with respect to resolution and contrast.

With CSAR **AR-P 6200.18**, 1.5 µm thick layers were produced at the KIT (IMT, Dr. Lothar Hahn). Investigations confirm that highly regular trenches with a width of 300 nm and a period of 300 nm can be realised with this layer thickness (see Fig. 15).

The high contrast of 5 is made possible by the use of our developer **AR 600-546**, and a short rinsing with MIBK which results in a residue-free development.

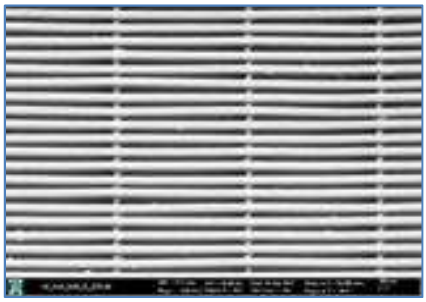

Fig. 15 Dose 180 µC/cm² at 100 kV; AR 600-546: 20 min, MIBK: 1 min; stable, highly regular line structure

If significantly longer development times of > 30 min are needed for a specific production process, the standard developer AR 600-456 is too strong and stress cracks may occur in thick layers (Fig. 16).

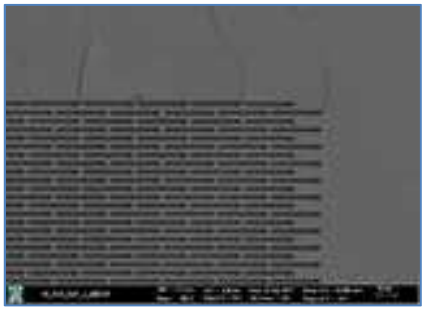

Fig. 16 Dos 180 µC/cm² at 100 kV; AR 600-546: 35 min, MIBK: 1 min; formation of stress cracks

Within the scope of our ongoing new developments, we tested a specifically modified developer for thick CSAR layers. The new X AR 600-546/2 develops also with very high contrast, but no disturbing stress cracks could be observed in CSAR 62 layers.

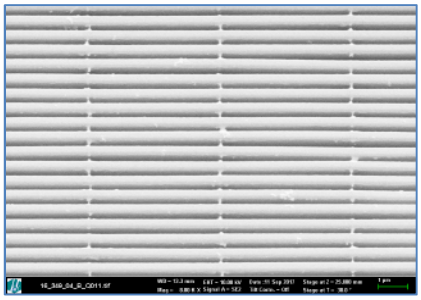

Fig. 17 Dose 180 µC/cm² at 100 kV; X AR 600-546/2: 4 h, MIBK: 1 min; stable, highly regular and residue-free developed line structure without cracks

This developer is however less sensitive than the standard developer AR 600-546. In order to solve this problem, tests to increase the sensitivity were performed: Increasing the developer temperature to 30 °C led to a considerably enhanced sensitivity, while the high contrast is still maintained.

In addition, also prolonging the development time increases the sensitivity.

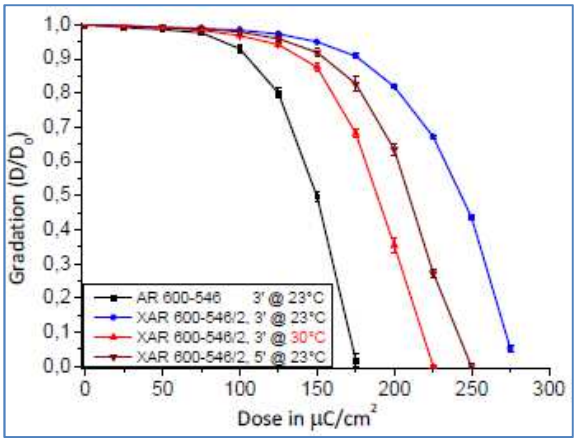

Fig. 18 Gradation of AR-P 6200.18 in AR 600-546 and new developer X AR 600-546/2 in comparison

We will now determine in further test the maximum thickness at which CSAR 62 films are still developable.

3.3. CSAR 62 in three-layer systems for the generation of T-gates

T-gate structures are mostly required for the manufacture of electronic components (MEMS, HEMTs). Corresponding nanostructures are generated in multilayer processes by e-beam lithography.

Generally, resist layers with different sensitivities (e.g. PMMAs of different molecular weight) are coated on top of each other, irradiated with electron beams and subsequently developed in one step. For the fabrication of more defined architectures it is however advantageous to combine different types of resists. Firstly, the mixing of the different layers can be avoided during the coating process, and secondly, the use of selective developers is possible. As a result, high contrasts and precise undercuts can be generated.

At the Martin Luther University in Halle (Prof. G. Schmidt), the following resist combination was successfully evaluated:

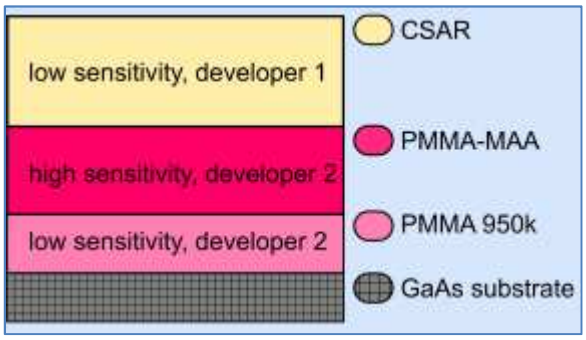

Fig. 19 Resist architecture for the manufacture of T-gates

CSAR 62 was used as the upper layer and the development was carried out with AR 600-546. In this contrast-rich developer, both CSAR 62 and the lower PMMA layer of 950k (AR-P 679.03) have a relatively low sensitivity. In the intensively exposed central area however, a complete development of all layers occurs. The second development step with X AR 600-50/2 then generates the undercut in the middle layer (PMMAcoMA 33, AR-P 617).

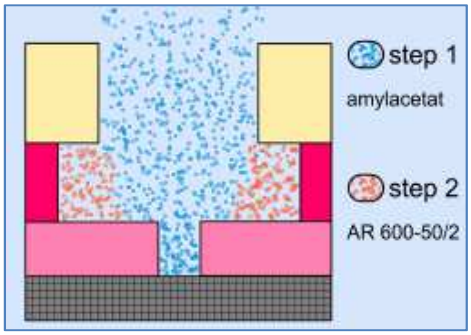

Fig. 20 Principle sketch of the development steps 1 and 2.

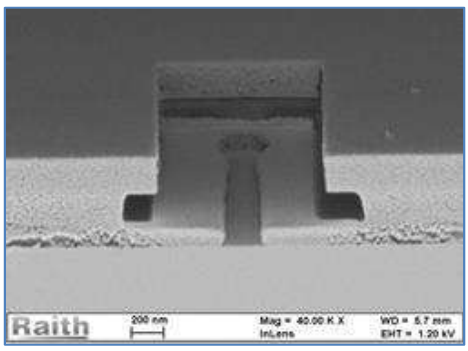

Fig. 21 3D resist profile after development and before the metallisation step

The special developer X AR 600-50/2 selectively develops the middle layer. The three-layer process as described here allows to generate high contrast three-dimensional nanostructures with only one electron beam exposure. The process window is wide, and both the amount of the undercut and the geometry of the lower PMMA layer can be easily modified.

After metallisation and removal of the resist structure by lift-off, both T-gate architectures and nanoscale metal bridges were successfully produced.

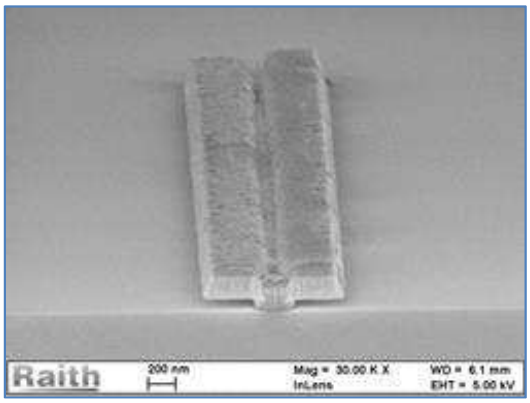

Fig. 22 T-Gate after lift-off

One interesting information is still left for all those of our readers who use **Cytop** as a dielectric or for organic semiconductors: We now offer a new product: SX AR-PC 5060. If you are interested in this product, please call us ☺.

We hope that you found some interesting new information or suggestions and welcome all opinions and comments. You are cordially invited to visit our booth at the **Semicon Europe 2017 in Munich (14. – 17. November 2017)**.

The next regular issue of the AR NEWS will be presented again in April 2018.

Until then we wish you and us every success!

Strausberg, 16.10.2017

Matthias & Brigitte Schirmer & the Team of Allresist