# AR NEWS

40th Issue, October 2019, Allresist GmbH

Content:



Welcome to our 40th anniversary issue of the AR NEWS. Once again, we would like to inform you about the further development of our company and the current research projects.

## 1. 27 years of Allresist – firmly established on the world market

When we founded Allresist 27 years ago on October 16, 1992 under the motto of the Chinese saying, "A journey of 1000 miles begins with the first step", we had no idea how strenuous, responsible and successful the path then still ahead of us would turn out to be. Allresist meanwhile supplies users all over the world with innovative resist developments. And we are proud to manufacture all products ourselves in the own company.

Our economic success in the past years is also reflected in the timely completion of our building extension last year which we already reported on in the last AR NEWS. With great energy and enthusiasm, triggered by the further modernisation of our company, we optimised the entire work processes. This will enable us to master even more rising sales volumes quickly and easily also in the future.

And two other projects are (almost) self-propelling – our green roof and the atrium have developed magnificently. The roof in fact required a bit of watering during the hot summer, but we all now enjoy a beautiful piece of nature.

Fig 1 Our atrium for breaks and the green roof

## 2. Allresist successful on the congresses Triple Beam (EIPBN 2019) and MNE 2019

This year's highlight of our new resist developments was certainly Medusa 82 which Allresist presented at the EIPBN 2019 in Minneapolis, USA, and at the MNE 2019 in Rhodes, Greece. Our presentations of the progress made with Medusa 82 aroused great interest at both congresses. Well received were also our latest improvements. Tests after six months of refrigerator storage at 10 °C resulted in a stable, unchanged resist. We are thus confident that the shelf life will in future amount to more than 12 months. This is a huge advantage compared with HSQ which has to be stored at very low temperatures.

It could also be shown that variations of the developer concentration (TMAH, 25 %; up to 0.2 n) and the time between irradiation and development (up to 22 days) had no negative effect on the results. Medusa 82 thus provides an even wider process window and more reproducible results for users.

Also our other resists like CSAR 62, Electra 92, Phoenix 81, and Atlas 46 were quite popular with the congress participants. Many users approached us with own results and experiences concerning these resists. This feedback is particularly important to us as it helps us to further improve our resists and to respond to specific user requests.

Together with our partners, we presented in addition to the lectures altogether six scientific contributions in the form of posters at the two congresses. The intensive cooperation with our partners thus produced very good results this year. We would like to thank Prof. Schmidt, MLU, Halle, Dr. Ing. Hübner, Leibnitz-IPHT, Jena, Dr. med. Brose, RWTH Aachen, Mr. Eibelhuber, EVG, St. Florian, Prof. Kumke, University Golm, Potsdam, Mr. Steglich, POG, Gera, and Dr. Papageorgiou, Institute of Nanoscience & Nanotechnology, Greece.


Fig 2 Dr. Gerngroß and Dr. Mai in discussion with users at the EIPBN 2019 in Minneapolis

Fig 3 Dr. Mai presents Medusa 82 in the USA

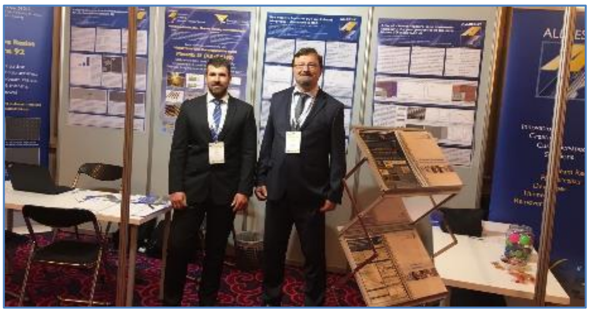

Fig 4 Our booth on the MNE 2019 in Rhodes

Fig 5 Nice setting for the beach party on the first evening in Rhodes!

### 3. Medusa 82 for e-beam grayscale lithography

On the occasion of a meeting with Dr. Hübner (Leibnitz-IPHT) at the end of 2018, we also discussed the specific properties of Medusa 82 for future applications. We noticed that the dose scales of Medusa showed very smooth surfaces even at low doses and correspondingly low layer thickness values. Since the refractive index of Medusa is 1.46 (which exactly corresponds to the refractive index of quartz), we decided trying e-beam lithography with Medusa to develop a grayscale lithography system for diffractive optical elements (DOEs).


Fig 6 Dose variations of Medusa 82 at 30 kV acelleration voltage, developer AR 300-44, 90 seconds

DOEs are often produced in quartz in a five-step process:

1. Fabrication of a hard mask layer in the quartz substrate
2. E-beam lithography
3. Structuring of the hard mask
4. ICP-etching of the quartz
5. Removal of the hard mask

For the process we had in mind, only step 2 (e-beam lithography) is required. After development, the desired structures are similar to pure quartz structures. We initially determined the gradation of our resulting product.

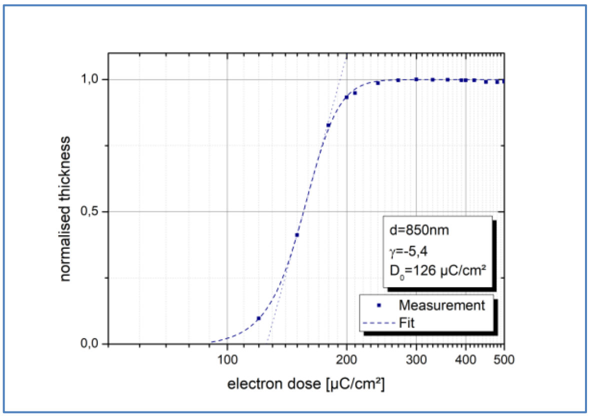


Fig 7 Gradation curve of Medusa 82 UV at 30 kV

A gradation value of -5.4 is suitable for graytone lithography. This became already apparent when we tried to write a blazed grating. Ten different UV doses were applied to a Medusa 82 layer and yielded the following grating after development (Fig. 8).
Using Medusa 82 UV (plus addition of a photoacid generator), the dose-scale range of 155-300 µC/cm² reaches a very sensitive level. HSQ requires approximately the 10-fold dose under comparable conditions.

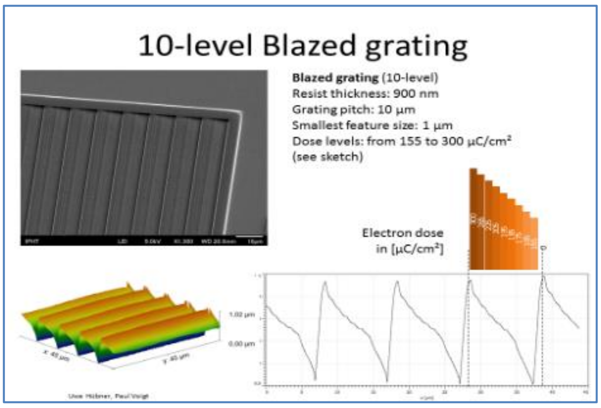


Fig 8 Blazed Grating of Medusa 82 UV, 900 nm

Next, a 3-level DOE pixel was written. Three doses of 0, 210, and 450 µC/cm² were applied. The desired DOE pixel could be produced in excellent quality.

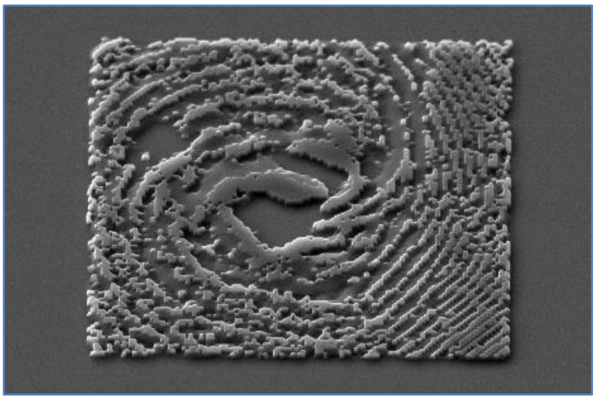

Fig 9 DOE pixel of Medusa 82 UV, 800 nm film thickness

This work was jointly presented by the Leibniz-IPHT and Allresist in a scientific poster at the MNE 2019 in Rhodes. More detailed information is provided on the poster and can be downloaded from the article on our website.

**4. Resist structures for the spin Hall effect**

Investigations with respect to the spin Hall effect were carried out under the direction of Prof. Georg Schmidt at the Martin-Luther-University Halle. For this purpose, precisely defined nanostructures down to the 10 nm range had to be produced. Two Allresist resists were used for the experiments, a two-layer PMMA system and Medusa 82.
The physical background: The generation of high-frequency signals without a microwave source was demonstrated utilising the spin Hall effect (SHE) in nano-oscillator

components. Generating high frequency signals without a microwave source has been demonstrated using the spin-Hall Effect (SHE) in nano-oscillator devices. The SHE can drive pure spin currents into a ferromagnetic material, exciting spin waves detected electrically with powers up to 10 pW. The efficiency of generating such signals however substantially depends on the geometry of the device. It is thus important to have excellent control of the nanoconstriction (NC) shape and dimensions.

Figure 10 shows an example of typical target structures.

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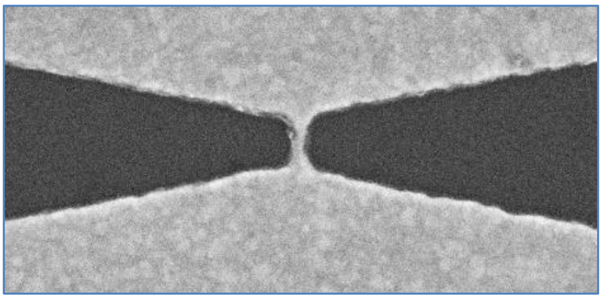

Fig 10 Structure for using the spin Hall effect

The positive-tone PMMA two-layer system for lift-off structures has long been known. Already in 1981, such structures were produced at the Academy of Sciences Berlin Adlershof with the participation of M. Schirmer (then Fotochemische Werke, Berlin). The slightly more sensitive low-molecular weight 50k PMMA is used as bottom resist, while the less sensitive higher-molecular weight 200k PMMA as top layer. After irradiation, the 50k PMMA is developed more strongly and an undercut is formed. Subsequently, a ferromagnetic material can be vapour-deposited on this structure. The resist is removed, yielding the final nanostructure (Fig. 11a).

In the case of the negative-tone Medusa resist, the resist is applied onto the ferromagnetic layer, irradiated and developed. The exposed metal layer is then removed by argon etching before the resist is removed in the final step (Fig. 11b).

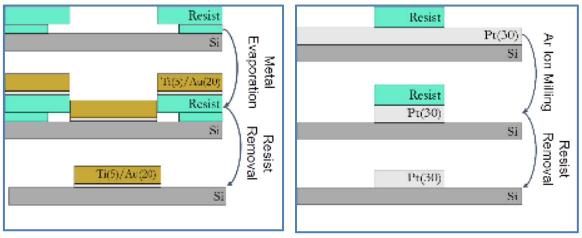


Fig 11a PMMA 2-layers 11b Process scheme Medusa 82

This work was also presented as scientific poster at the MNE 2019. Detailed results of our posters can be downloaded from the article on our website. Please contact the research group of Prof. G. Schmidt for more in-depth physical background information.

We hope that you could find a few interesting and helpful suggestions and would appreciate your feedback. We will be present at the EIPBN 2020 in May in New Orleans and at the MNE 2020 in September in Leuven. Please visit us at our booths, if possible.

The next regular issue of our AR NEWS will be presented in April 2020. Until then, we wish you and us every success.


Strausberg, 16.10.2019

Matthias & Brigitte Schirmer in the Team of Allresist