AR NEWS

24nd issue, April 2012

Allresist GmbH

Content:

Welcome to the 24rd issue of the AR NEWS, in immediate preparation for our 20th company anniversary. We would like to inform you again about the further development of the company and its current research projects:

1. Allresist is now employee champion and applies for the Ludwig Erhard price

On our way to Business Excellence, we faced in 2011 the challenge to participate in the competition "German employee champion". In this competition, all staff members of a company are requested to assess their company in detail in a questionnaire. After evaluation of the results by the German "Forum! Marktforschung" in cooperation with the DGQ, statements concerning employee motivation and binding of our staff members are obtained, which are then converted into points.

On May 8, 2012, Allresist not only gained the coveted seal, but also received an award and was thus one of the four finalists. The highest score of the prize winner amounted to 883 points, while we gained 840 points from the jury and therefore achieved a very good result in this German-wide competition.

This success also serves as benchmark for our application for the Ludwig Erhard price 2012. In our continuous effort to improve even further, also to the benefit of our customers, we will this year again meet the challenge to be evaluated by a team of assessors. We hope to get good results again and will inform you about further achievements at the latest in our next AR NEWS issue.

Abb. 1: Allresist receives the seal as employee champions

2. Results of the new e-beam resist AR-N 7520

A process-stable, sufficiently sensitive e-beam resist with a resolution of approximately 30 nm is urgently needed for further advances in e-beam lithography. The chemically enhanced e-beam resists meet the demands for a high sensitivity, but so far only resolutions of > 100 nm could be achieved with these resists. PMMA resists and non-chemically enhanced e-beam resists (e.g. AR-N 7500 or AR-N 7520) possess a high potential for resolutions < 30 nm, but these resists are not sensitive enough and thus require uneconomically long writing times. The long-termed research concept of the Allresist is among others aimed at the development of economically efficient high-resolution e-beam resist.

On the MNE 2010 in Genoa, resist SX AR-N 7520/4 was presented which, compared to the standard resist AR-N 7520, provides a sevenfold higher sensitivity (see also 21.st AR NEWS). Continuing this development since 2011, new cross-linking agents were tested which increased the sensitivity again slightly. For single measurements, a line width of less than 30 nm could be confirmed (see Fig. 2). A further advantage is the improved solubility in the resist solvent, which allows a higher solid matter content of resists and thus the generation of thicker films. Special applications for e-beam lithography up to film thickness values of 5 µm can therefore now be realized.

The improvement of the new e-beam resists is demonstrated in Fig. 3 shown below. Indicated is also the dose-dependency of the structure width. It is generally known that smaller structures require higher doses, which was also confirmed in our investigations. For a structure width of 5 µm, a dose of approximately 15 µC/cm² (30 kV) is sufficient. For 100 nm lines, the required dose ranges from 30 – 50 µC/cm² for the three patterns shown here (see Fig. 3).

Application features of the new samples are significantly improved as compared to the parameters of our standard resist AR-N 7520. We thus intend to replace the current e-beam resists by our new products. All customers are invited to use the new resists already this year. By the beginning of 2013, these improved resists will become our standard resists.

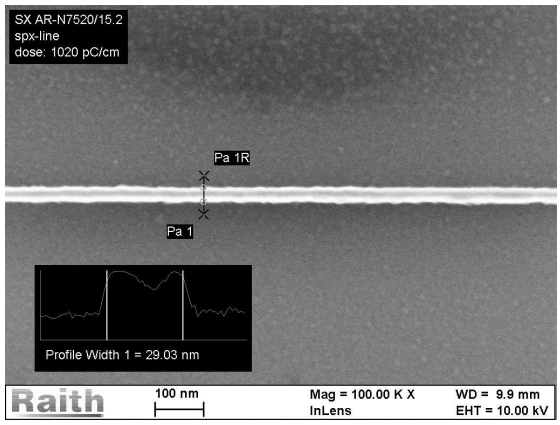

Fig. 2: 29 nm lines obtained with sample SX AR-N 7520/15.2

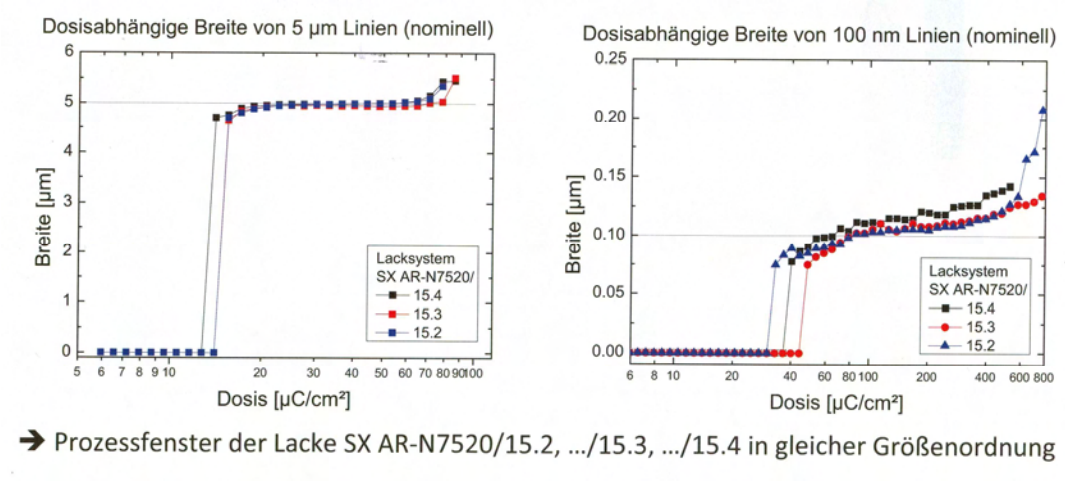

Abb. 3: Dose-dependent width of lines

3. NIR-coatings in development – fist successes

With the development of photoresists suitable for laser exposure in the wavelength range from 500 to 1100 nm, Allresist created a world novelty. Lithography with an exposure wave length of > 480 nm has so far been impossible using standard photoresists.

We now succeeded in developing a resist series (alternatively applicable for yellow or white light, see below) with sufficiently high sensitivity for laser exposure in this spectral range. The operation principle of these resists is also based on chemical enhancement. The sensitivity for the respective laser wavelengths is enhanced by dyes which absorb in the same spectral range.

We could demonstrate that it is generally possible to induce a cross-linking at exposure wavelengths of 532 nm and 1064 nm which results in a complete build-up of layer structures. The initial film thickness of 6 µm was fully achieved by writing points in a certain energy interval. Below this interval, no structures remained, while the resist film was destroyed and removed above this interval, due to the too high energy input of the laser beam. The development step was carried out in conventionally used aqueous-alkaline developers.

The second test series was aimed at the writing of lines. In this case, the writing speed of the laser beam gains even more importance. The higher the writing speed, the lower is the local energy input. Despite the high complexity of these investigations and the large number of influential factor, exact lines could be generated in these experiments after only few attempts.

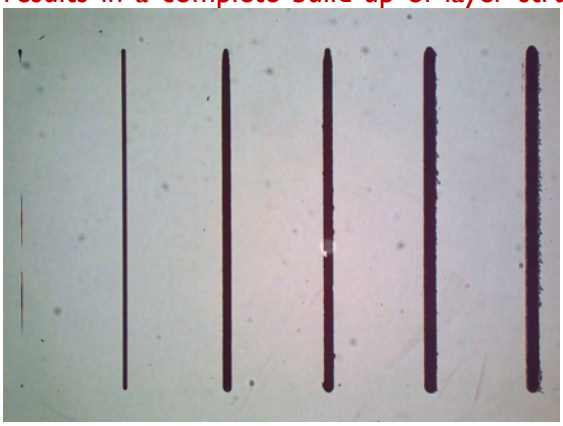

Fig. 4: Different line widths

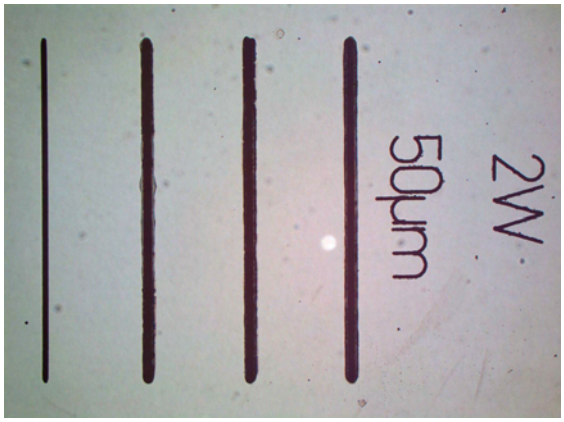

Fig. 5: 70 µm line (left) at 50 µm beam width due to different writing speeds

Experimental conditions: performed at the Günter-Köhler-Institut für Fügetechnik und Werkstoffprüfung GmbH

Beam source: ultra-short pulse laser Lumera Hyper Rapid, PW=9ps, F=1 000k Hz, Gauß

Line width: 20, 50 and 100 µm

Writing speed: 1 – 1 000 mm/s

Power: 200 – 2 000 mW

Clean lines were obtained which are, according to our current results, slightly larger than the beam diameter (see Fig. 5). An optimization of laser output power, writing speed and development regimen will clearly allow the production of dimensionally accurate structural patterns in the future.

These new negative resists also highly sensitive for all lasers in the range between 200 and 500 nm and can thus be employed for such applications, furthermore for applications in microelectronics and also for e.g. engraving rollers for the production of textiles and carpets or for CNC encoder disks. For these purposes, generally no yellow light is utilized; we therefore designed a NIR-resist for white light applications which can be processed without yellow light.

We will continue in our effort to expand and to consolidate these results and will inform you in the next AR NEWS about our further findings. Already now, we look forward to your suggestions, demands, or your expression of interest concerning our developments.

4. Our new developments – first results

4.1. Temperature-stable negative resist SX AR-N 4700/1

New aqueous alkaline soluble polymers may even outperform novolacs with respect to certain features. Standard novolac resins generally melt in a temperature range between 120 – 140 °C. The higher the film thickness, the greater is the effect of this behaviour on resist structures. Bridges with a height of 10 µm may simply melt away at 130 °C. A high thermal stability could prevent this effect, particularly during ion or plasma etchings.
A copolymer composed of PMMA and polystyrene is characterized by a high thermal resistance. By addition of acid generators and amine cross-linking agents, this polymer resulted in a chemically enhanced negative resist. First investigations with respect to thermal stability showed no rounding of edges up to 220 °C for films of 4 µm thickness. As expected for a chemically enhanced resist, resist films are highly sensitive. In addition to a use as one-layer resist, also applications for two-layer systems are intended (see item 4.4.)

4.2. Alkaline and solvent-stable negative resist SX AR-N 4340/7

Most novolac-based photoresists are characterized by a very good etch stability in the presence of acids (except for highly concentrated oxidizing acids or concentrated hydrofluoric acid). These resists are however relatively sensitive to alkaline conditions. Developers of these resists are consequently composed of aqueous alkaline mixtures with pH-values of 12 - 13.

We were now able to design a negative resist whose structures withstand an exposure to 1 n NaOH for 4 hours without measurable removal after an additional bake step. As developer serves here a 2:1 dilution of TMAH-remover AR 300-73. Despite the drastic development regimen, the resist is surprisingly highly sensitive.

This negative resist SX AR-N 4340/7 is thus perfectly suited for an application in strongly alkaline galvanic baths or the etching of aluminium films with strong TMAH-developers. Cross-linked resist films are furthermore surprisingly solvent-resistant. A baking of structures at 120 °C is already sufficient to prevent dissolution in acetone, IPA, PMA and NEP over several hours. Even higher bake temperatures stabilized the resist films to such an extent that all generally used removers remain ineffective. Removal of the resist can thus only be achieved by plasma etching or the use of Piranha solutions.

By a careful selection and combination of raw materials, the solvent stability can be adjusted accordingly. Upon request, we will find the best solutions for the demands of our particular processes.

4.3. Sensitive, etch-stable negative e-beam resist for applications without yellow light

The beginning of electron beam lithography dates back to the 1980th with the development of PMMA resists. These resists are completely light-insensitive in the UV-wavelength range above 300 nm. Clean rooms in which electron beam lithography is performed with PMMA resists therefore require no yellow light.
We have often been asked by users of our e-beam resists if we also offer negative resists that can be processed under white light conditions.
The negative e-beam resists of our 7500 – 7700 series are all sensitive also in the broad UV range (300 – 405 nm) and consequently well suited for mix & match technologies (e-beam and UV lithography combined in one process), but they definitely require yellow safe light.
Employing new acid generators which are characterized by an UV absorption < 280 nm, we developed the chemically enhanced e-beam resist SX AR-N 7700/46 which can also be processed under daylight conditions. Coated wafers were exposed openly for several hours in a white light room and subsequently exposed and developed together with wafers lacking this “additional“ exposure. Sensitivity and gradation of both test series was identical.
Samples are available for interested users.

4.4. Negative two-layer lift-off system

Our positive two-layer lift-off system AR-P 5400-3510 has already been used successfully for several years. The desired undercut can be adjusted according to the customer’s require-

ment by changing the duration of the development step.

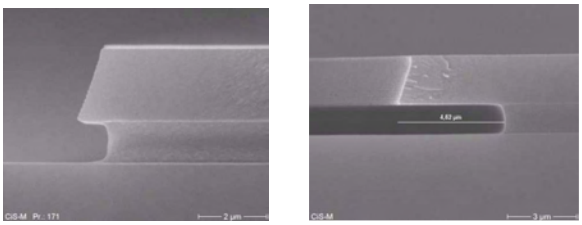

Fig. 6 + 7: Positive two-layer system

Since undercut structures like this are almost exclusively used for lift-off processes in which high temperatures (up to 200 °C) may occur during evaporation and in particular during sputtering, a high thermal stability of the upper layer is urgently needed. In undercuts as large as the undercut shown in the right picture, the upper layer melts and flows downwards, thus making the lift-off process impossible. Our attempts to develop a stable positive resist so far led to no considerable improvement.
Experiments with negative resists as upper layer in contrast gave promising results. We were relatively quickly able to optimize this two-layer development and to produce the desired undercut. In addition to the varied negative resists of the AR-N 4300 series, the new negative resist SX AR-N 4700/1 was employed. As single layer, this resist possesses a high thermal stability (see item 4.1.), but also our 4300-resists proved to be significantly more thermally stable than positive resists.
Currently, experiments are in preparation designed to evaluate the limits of stability for two-layer structures. We offer the possibility to all readers of the AR NEWS to participate in this development and to take an interest in the results.

We hope to have offered a few interesting ideas also for you and strongly encouraged our interested customers to communicate all your desires, requests and comments already at an early stage.

Our next issue of the AR NEWS will again be presented in October 2012.

Successful times until then!

Strausberg, May 14, 2012
Matthias & Brigitte Schirmer
And the Team of Allresist