AR NEWS

42. Issue, October 2020, Allresist GmbH

Content:

Welcome to the 42nd edition of our AR NEWS, which is still dominated by the ongoing Covid-19 pandemic. We would again like to keep you informed about the development of our company and the research projects.

1. Prime Minister Dietmar Woidke visits Allresist in times of Covid-19

On August 17th, Brandenburg's Prime Minister Dietmar Woidke visited Allresist GmbH on his information tour through Brandenburg. His main interest was focused on the question how Allresist copes with the current corona crisis. After a tour through our company and a detailed presentation of our work, Dietmar Woidke was especially enthusiastic because he was, as former graduate agricultural scientist, reminded of the scientific tasks in his previous job.

Fig. 1 Prime Minister Dietmar Woidke, in discussion with Brigitte and Matthias Schirmer, Foto J. Sell

Woidke especially appreciated our modern new building extension with photovoltaic system and ecological green roof as well as our product innovations presented on the world market by Allresist as "Made in Brandenburg". The Prime Minister promised to return again for our 30th company anniversary in 2022.

As in many companies, Allresist's sales volumes decreased in the last quarter, especially abroad. In order to compensate for sales losses and to support the region in the fight against Covid-19, Allresist currently produces disinfectants for medical practices, schools, government offices and customers according to the motto: "Necessity is the mother of invention & solidarity" in order to actively help break chains of infection. This support was very gratefully accepted by the region.

We also implemented numerous internal measures to protect our employees from infections. Minimum distances and a maximum number of people per room were specified, the disinfection of surfaces and latches was regulated, and ventilation and air ionization are strictly controlled. By these measures, we ensure that all customer requests can be met quickly and with the usual high quality, even during the difficult Covid-19 times.

Our product sales have now returned to their original level. Since Allresist has sufficient reserves from the last successful years, neither financial support nor short-time work was required. The salaries of the employees continue to run as usual, and in June, another employee was hired as planned.

2. Higher shelf live and more sensitive HSQ-alternative Medusa 82 for gray-scale lithography

(Abstract of our presentation at the EIPBN 2020)

Well known to all e-beam users are the good and reliable properties of HSQ resists. The major disadvantages when processing HSQ, however, are the relatively short shelf life and the small process window between coating and exposure.

We thus modified silsesquioxane (Fig. 2) in order to achieve a longer shelf life and a larger process window while maintaining the advantages such as the high silicon content for etch resistance and the excellent resolution.

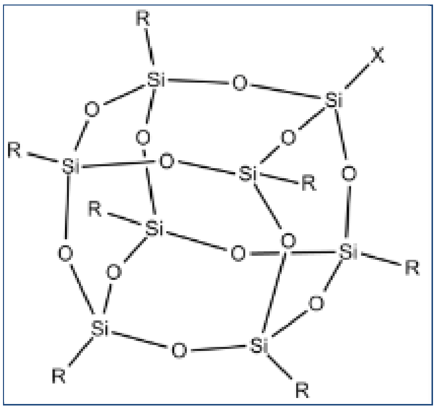

Fig. 2 Structure of silsesquioxane

From this modified silsesquioxane resulted our new electron beam resist Medusa 82. Even though not equal to HSQ, Medusa 82 can be developed with HSQ standard processes. In contrast to HSQ, however, Medusa 82 resists are characterized by a higher stability and tolerate a period of several weeks between coating and irradiation (Figs. 3 and 4).

The liquid resist also retains its properties unchanged over several weeks at room temperature.

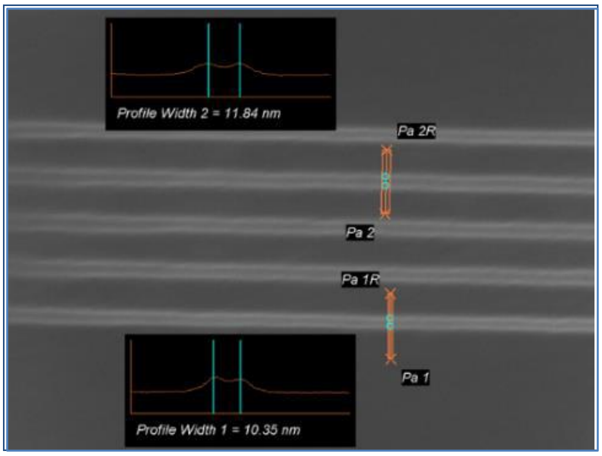

Fig. 3 SEM-image of 12 nm-lines with SX AR-N 8200.03, film thickness 50 nm, soft bake 10 min at 120 °C, exposure at 30 kV Raith Pioneer, development with AR 300-44 for 90 s at 23 °C

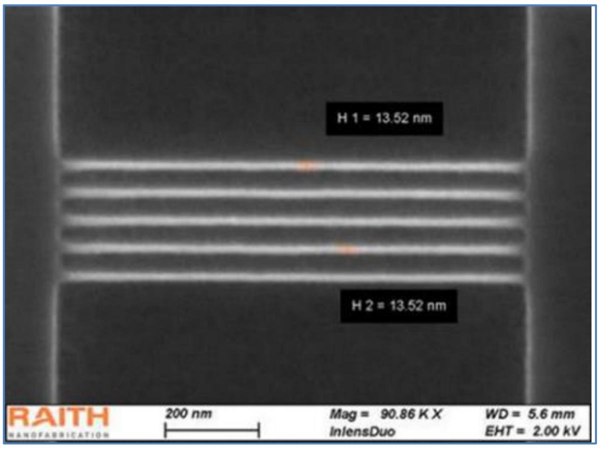

Fig. 4 13-nm lines of a coated substrate stored at room temperature for 22 days; process conditions as for HSQ

As became evident during our investigations, the sensitivity of Medusa 82 can be further enhanced: a post exposure bake (PEB) increases the sensitivity up to 20 times, and the addition of acid generators also causes a high increase in sensitivity. In addition, weaker alkaline developers can also be used.

The use of resists with glass (SiO_2)-like structures can considerably simplify the effort required for the complex manufacturing process of micro-optical components. This in particular applies to prototype developments and small batch productions of special customer gratings and diffractive optical elements (DOEs). Especially in the production of microlenses, microgrids and diffractive optical elements with multi-level or dashed line shapes in order to improve their diffraction efficiency, direct grayscale exposure in a vitreous resist material can replace the often very time-consuming, multi-stage lithographic processes.

The process to convert Medusa 82 into a vitreous material comprises an electron beam exposure, an annealing step, or a combination of both. In addition, the adjustable contrast and sensitivity enable grayscale lithography. Different irradiation doses induce a different degree of crosslinking within the layer, which then results in different layer thicknesses after development. The tempering after development causes further crosslinking and the complete conversion into SiO_x (Fig. 5).

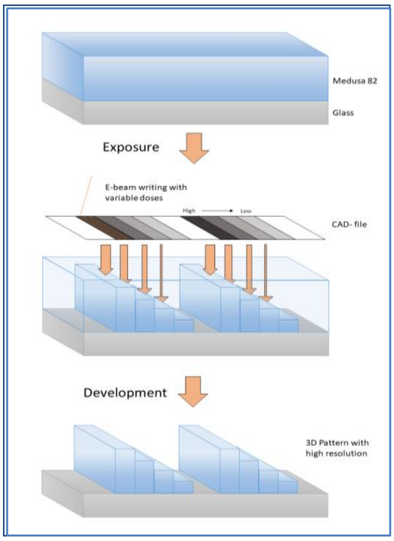

Fig. 5 Principle of grayscale lithography (Medusa)

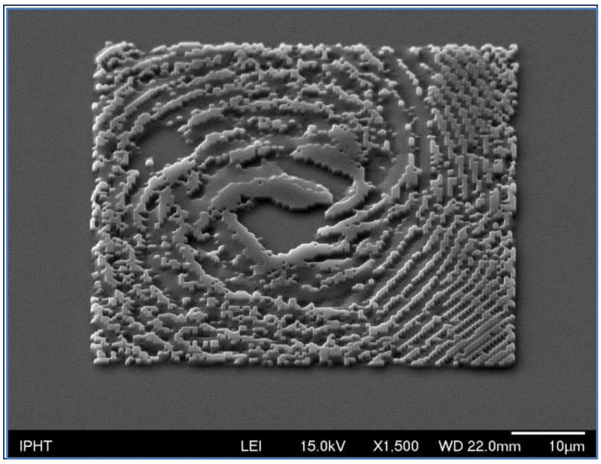

Fig. 6 DOE-Pixel (3-D) with Medusa 82

3. Medusa for UV-lithography

Medusa 82 was developed for e-beam lithography and is thus an improved alternative to HSQ. Particular advantages of Medusa are the (adjustable) higher sensitivity and longer durability of the resist. An overview of properties and applications of this resist can be downloaded here.

Upon irradiation of silsesquioxane, predominantly SiO_2-containing structures develop from which, under optimal condidtions, even hard masks for intensive KOH etching processes can be produced in one photolithographic step. The general structuring process of a hard mask is as follows: (1) the SiO_2 layer is deposited on the silicon wafer; (2) coating and patterning of the photoresist; (3) freely developed SiO_2 structures are etched away; (4) etching of the silicone with KOH.

The main problem with Medusa 82 has been so far that the resist cannot be structured photolithographically, but only by means of electron beam lithography. We now detected acid generators that crosslink silsesquioxanes in broadband UV, which means that normal i-line mask aligners or steppers can be used for the structuring.

Fig. 7 demonstrates the result of a Medusa-exposure series with a broadband UV filter.

Fig. 7 Gradation curve (photolithography) with Medusa

Corresponding experiments are currently still at early stages, and many process parameters have to be optimized, but we wanted to inform you already now about this interesting development for possible future applications.

4. Thermally structurable resists

A Eurostar EU project in 2015 was the beginning of a successful collaboration between the former SwissLitho AG (renamed Heidelberg Instruments Nano in 2018) and Allresist. Within the scope of the project, Allresist developed the thermally structurable resist Phoenix 81, which is now well established on the world market, for NanoFrazor applications.

Fig. 8 NanoFrazor, Heidelberg Instruments Nano

NanoFrazor systems are t-SPL (thermal scanning probe lithography) devices, allowing binary lithographies with a resolution of less than 10 nm and a 3D structuring with vertical resolutions in the sub-nanometer range. The heated tip sublimates the resist and conducts an *in-situ* imaging which is similar to AFM. NanoFrazor lithography is non-invasive, since no charged particles are involved in the process. The structuring does consequently not damage the samples and introduces no additional charges.

Furthermore, NanoFrazor lithography is compatible with other standard methods for pattern transfer like the lift-off of double layers, high-resolution etchings, or the transfer and enhancement of 3D patterns in various materials. NanoFrazor applications require neither a vacuum nor a clean room; the latter is however recommended for the coating of substrates with resist Phoenix 81.

Also other resists can be structured with NanoFrazor. For an overview of possible applications, we compiled a brochure which can be downloaded here. A few examples of our resists are briefly presented in the following.

Thermally structurable resist AR-P 8100/Phoenix 81 (PPA)

Phoenix 81 is a special resist for 2D and 3D structures with high resolution (7 nm) and clean sublimation for t-SPL. The resist can in addition be combined with a direct laser writer (exposure wavelength 405 nm).

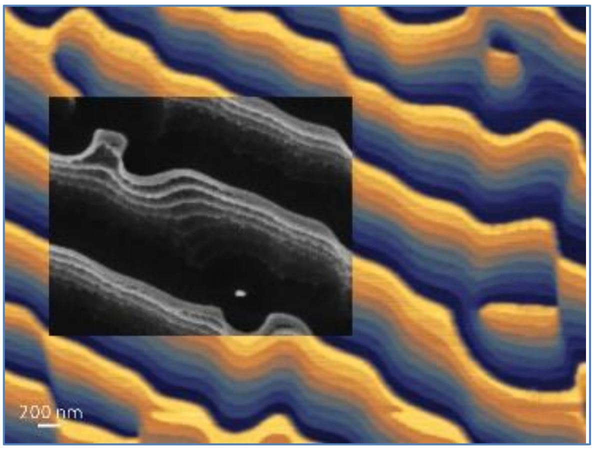

Fig. 9 A 3D hologram in Phoenix 81, silicon-etched

Thermally structurable resist AR-P 617 (PMMA-co-MA)

Also AR-P 617, a classical e-beam resist, can be patterned with NanoFrazor devices.

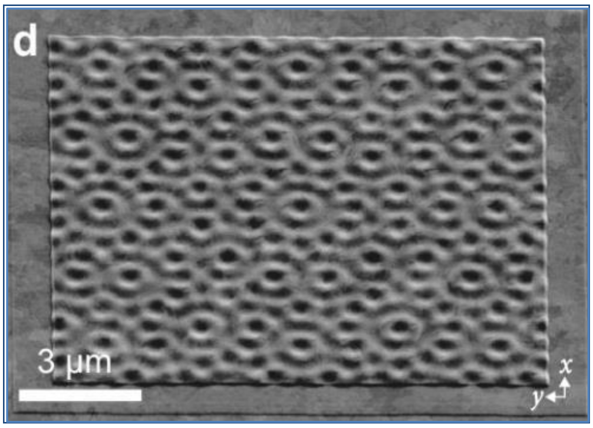

Fig. 10 Quasi-periodic optical Fourier surfaces, transferred to Ag

Thermally structurable resist of the AR-P 6200-series/CSAR 62

The high-resolution e-beam resist CSAR 62 (8 nm) can also be thermally structured. Small disadvantage with this procedure: the needle only has a limited shelf life.

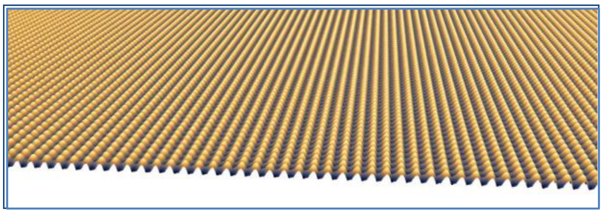

Fig.11 Array of 250-nm 3D-Strukturen, written directly in CSAR 62 with t-SPL

Mix&Match process with t-SPL and laser direct imaging

A very elegant procedure is the mix&match-process with t-SPL and laser direct imaging. Small structures (up to 10 nm) are written with the hot needle tip, while larger structures (µm-range) are generated directly using a laser with a wavelength of 405 nm. The laser likewise evaporates the resist, and no development step is consequently required.

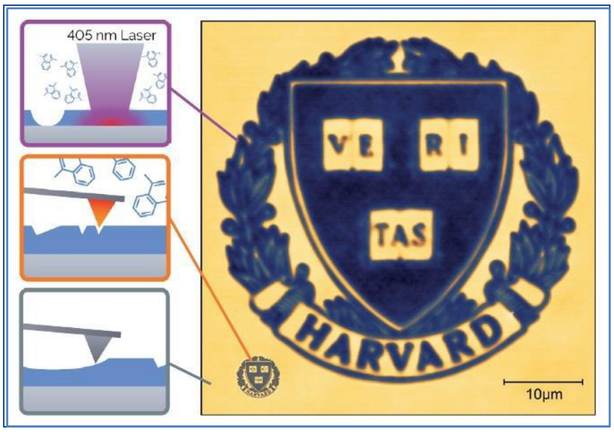

Fig. 12 NanoFrazor AFM-image of the Harvard logo, written with a 405-nm laser (large logo) and t-SPL (small logo) in Phoenix 81 with the same NanoFrazor system

We hope that you have found some interesting information and look forward to your suggestions concerning our further developments. The next AR NEWS issue will be presented in April 2021.

Until then, we wish you and ourselves every success. Stay healthy!! 😉

Strausberg, 14.10.2020
Matthias & Brigitte Schirmer in the Team of Allresist