AR NEWS

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Welcome to the 49th issue of our AR NEWS!

For many of us it seems as though the world is on the brink of surrendering to the resolution of catastrophes (the war in Ukraine and Gaza Strip, and, not to forget, the undeniable climate changes). The powerlessness of humanity in the face of increasingly autocratic leaders in Europe and neighbouring states is simply frightening. However, it is even more important that each of us contributes to doing good in the places where we can make a difference. Everyone can do something for the environment, and everyone can donate to alleviate global suffering.

Allresist remains strongly committed to the pursuit of excellence, promoting climate protection, the prevention of environmental damage, and supporting not only our region financially but also contributing with global donations. In the spirit of excellence, we value respectful relationships with our partners and customers, who appreciate our products of the highest quality with prompt delivery times.

As in every April and October, we would like to keep you informed about the progress of our company and its research projects.

1. Allresist at the "8th Thermal Probe Workshop" of Heidelberg Instruments Nano AG

The fruitful collaboration between Heidelberg Instruments Nano AG (formerly SwissLitho AG) and Allresist began in 2014 with the EuroStar project "PPA-Litho" which was aimed at developing a reliable resist for the newly developed NanoFrazor (→ item 2). We completed the project in 2017 with great success.

The NanoFrazor has since become established worldwide, and also our Phoenix 81 (AR-P 8100, thermolabile resist) has proven to be reliable for corresponding applications. Every year, Heidelberg Instruments Nano AG hosts a workshop in Zurich to which all users and interested parties of the NanoFrazor are invited. Over two days in March, highly interesting presentations were given, focusing on the topic of tSPL (thermal Scanning Probe Lithography).

Also, our colleague Harry Biller gave a highly acclaimed lecture on the further development of the Phoenix 81, particularly highlighting its significantly improved stability.

Due to the limited shelf life of the thermolabile resist Phoenix 81, Allresist has previously sold the freezer-stored resist powder which users mixed with solvent to prepare the resist themselves.

Through optimising the synthesis of the polymer PPA (polyphthalaldehyde), the main component of Phoenix 81, the stability could be significantly improved (→ item 2). With these improvements, we are now able to offer the resist ready for use.

Fig. 1 Allresist at the Workshop: Maik Gerngroß, Matthias Schirmer, Emine Cagin (HI), and Harry Biller (from left to right)

Our hosts came up with a very special idea for the communal workshop dinner. We were invited to the restaurant "Stadtkäserei" where it was revealed to us that we would be preparing the dinner from the provided ingredients ourselves. Just as productive as the workshop earlier, the evening turned out to be very special and cheerful. Thank you 😉.

Fig. 2 Workshop participants preparing their dinner together

2. From PPA powder to liquid resist: Phoenix 81

The development of the NanoFrazor marks a significant technological achievement for Heidelberg Instruments Nano AG.

Fig. 3 NanoFrazor (HI Instruments)

NanoFrazor systems are t-SPL (thermal scanning probe lithography) devices that enable binary lithography with a resolution of less than 10 nm and 3D structuring with vertical resolution in the sub-nm range. The heated tip sublimates resist Phoenix 81 and also allows for in-situ imaging similar to AFM. Since no particles are involved in the process, NanoFrazor lithography is non-invasive, meaning the structuring neither damages the samples nor implants additional charges. NanoFrazor lithography is furthermore compatible with standard methods for pattern transfer: lift-off of the double layer, high-resolution etching, transferring and amplifying 3D patterns into various materials, etc.

The use of NanoFrazor does not require vacuum or cleanroom conditions. However, the resist coating with Phoenix 81 should be done under cleanroom conditions.

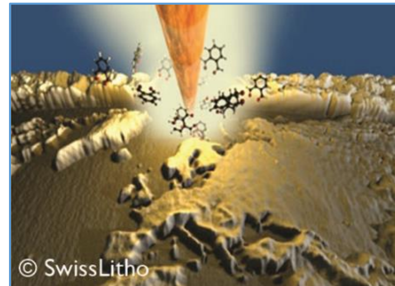


Fig. 4 Three-dimensional structuring with NanoFrazor

Beyond the thermal process, structuring can also be achieved through laser (photolithography) and e-beam techniques. This significantly expands the potential range of applications for our Phoenix 81. It was thus essential to increase the resist stability accordingly.

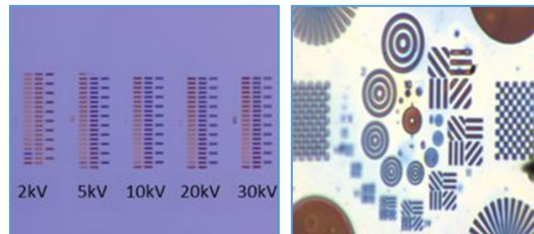


Fig.5 E-beam structures Laser structures Phoenix 81

Together with our long-standing partner IDM e.V. (Institute for Thin Film and Microsensor Technology e.V., Teltow), we revised the manufacturing concept and achieved a much higher purity of polyphthalaldehyde in the following. Allresist investigated these new Phoenix 81 resist samples with respect to their stability.

Parallel experiments at Heidelberg Instruments Nano AG demonstrated that the improved resist samples retained their excellent application properties even after three months of storage at room temperature.

Harry Biller presented the results of the advancements of Phoenix 81 in a lecture at the workshop.

Fig.6 Harry Biller during his lecture on Phoenix 81

For the experiments, resists with 6 % solids in the solvent anisole were prepared. The samples were stored in the freezer (-18 °C), refrigerator (10 °C), at room temperature, or in the oven at 40 °C. In monthly intervals, wafers were coated and the layer thickness and decomposition temperature were measured. For the measurement of the decomposition temperature, the wafer was placed on a hotplate at 100 °C and then heated further at a rate of 5 °C per minute. Complete evaporation was visually assessed.

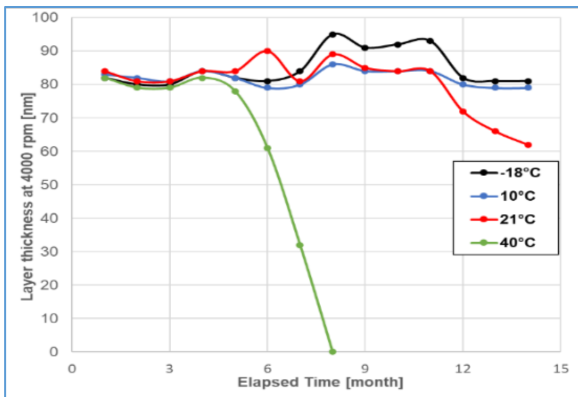


Fig.7 Film thicknesses after respective storage time

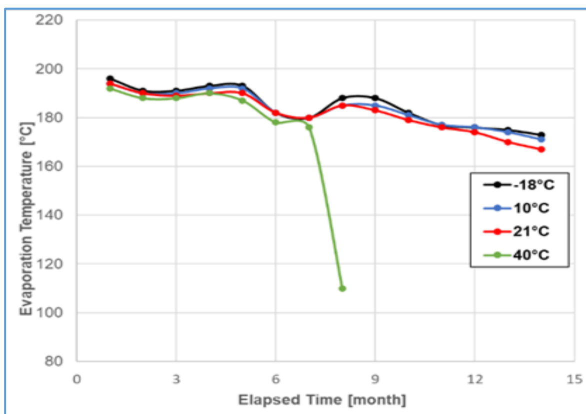


Fig.8 Relation between decomposition temperature and storage time

The investigations confirm that even after storage at room temperature, usability is maintained after 12 months. Even samples stored at 40°C can be used without any loss of quality after 6 months.

This fact is particularly important for air transport during the summer.

The second part of the presentation focused on our new project "TMS PPA for increased etch resistance," for which a special PPA with 14% Si was synthesized.

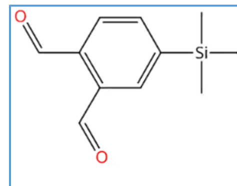
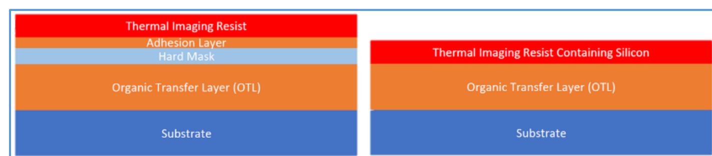


Fig.9 TMS polyphthalaldehyde with 14 % silicon

With this new polymer, a hard mask for the smallest structures can be produced directly and much faster.



PPA TMS PPA

Fig.10 Comparison of etching methods

In Figure 10, the conventional process is depicted on the left. A hard mask layer (SiO_2) is applied to the layer to be etched (OTL), then coated with adhesion promoter and finally with PPA. The PPA is patterned, the hard mask is etched, and then the layer to be processed is etched.

If, however, the silicon-containing TMS PPA is applied to the layer to be etched (Fig. 10, right) and structured, silicon oxide can be produced from the silicon of the polymer with a short oxygen plasma etching step (RIE). This creates an etching mask made of SiO_2. Due to the desired low layer thickness (in this case 17 nm), a resolution of up to 10 nm is achievable.

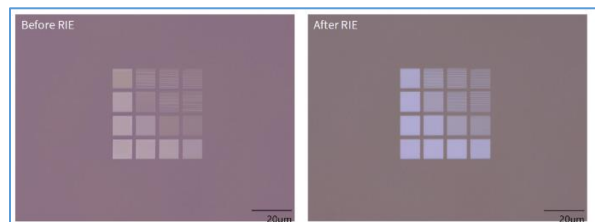


Fig.11 Etched structures of TMS PPA with 14 % Si

Tests at Heidelberg Instruments Nano AG confirmed that TMS PPA can be processed just as effectively as Phoenix 81, but with significantly higher etch stability.

This positive result prompted us to synthesize another TMS PPA with even higher silicon content.

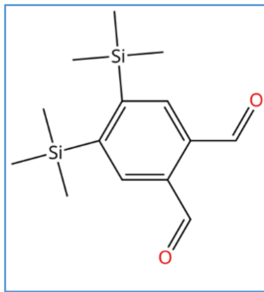


Fig.12 Double TMS PPA with a silicon content of 20 %

As soon as we have reliable results on these application properties, we will be happy to inform you.

3. Medusa 84 SiH – SX AR-N 8400: Market launch has begun

The resist HSQ is used worldwide in electron beam lithography. Despite its good properties, its durability is very limited. After many customers complained that the supply of HSQ was becoming increasingly difficult, we developed our own, basically identical resist. Similar to the HSQ, our new development called **Medusa 84 SiH (SX AR-N 8400)** consists of inorganic silanes (SiH). The resulting high level of transparency also predestines this resist for optical applications.

The polymer development was again carried out in collaboration with the Institute for Thin Film Technology and Microsensor Technology e.V. The synthesis process was improved to selectively synthesize and isolate a polymer fraction that is optimal for application properties. Additionally, we now use a special solvent to increase the shelf life. Even samples meanwhile stored for 10 months still retain their very good properties.

Meanwhile, also users have tested these samples. All of them praised the easy handling of the resist and also confirmed that its properties did not change during the testing period.

Dr. Heyroth conducted intensive experiments with Medusa 84 SiH at Martin Luther University under the direction of Dean Prof. Schmidt.

At the same time, the commercially available HSQ was tested under identical conditions. A comparison of the sensitivities reveals that Medusa 84 SiH is considerably more sensitive.

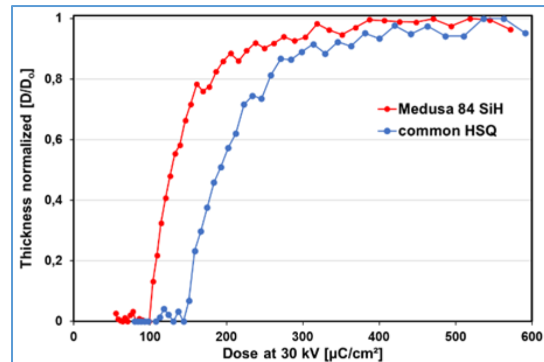


Fig.13 Comparison of sensitivities of Medusa 84 SiH and HSQ, developer AR 300-73

The layer thicknesses of both resists were adjusted to 70 nm. The acceleration voltage was 30 kV.

Medusa 84 SiH

Sensitivity: 159 µC/cm², AR 300-44

Sensitivity: 210 µC/cm², AR 300-73

HSQ - sensitivity: 252 µC/cm², AR 300-73

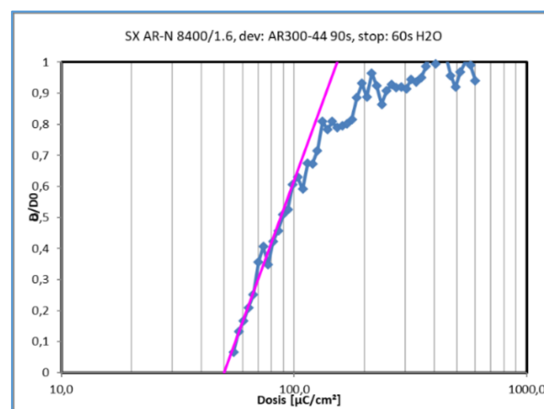


Fig. 14 Gradation curve of Medusa 84 SiH (then still test sample SX AR-N 8400/1.6), 159 µC/cm², 30 kV, developer AR 300-44

This makes Medusa 84 SiH remarkably sensitive. The maximum resolution achieved with a thickness of 70 nm was 15 nm.

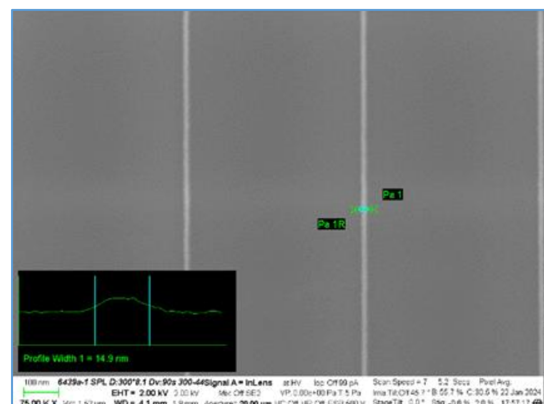


Fig. 15 Medusa 84 SiH bridges with a width of 15 nm

During parallel investigations by Raith, resolutions of 10 nm were measured.

Advantages of Medusa 84 SiH include:

1. Significantly higher stability with consistent quality over months
2. Higher sensitivity for shorter writing times
3. the silicon-containing Medusa variants show a significantly improved plasma etching behaviour.

With these positive properties, Medusa 84 SiH could be an interesting alternative to the long-utilised HSQ for many users.

4. Post Scriptum – another tree-planting event!

It has meanwhile become a beautiful tradition for our entire team to participate in our annual tree planting day in the forest near Gottesgabe in the Märkisch Oderland district. Since 2021, we have been supporting the local forester with generous donations, which he uses to purchase hundreds of seedlings that we then all plant together. If the term "team-building" ever needed to be applied, it would be here. We'll soon have an Allresist forest.

We hope that you will find some interesting news or suggestions and look forward to your opinion. The next issue of the AR NEWS will present in October 2024.

Until then, we wish you and ourselves much success ☺.

Strausberg, 04/29/2024
Matthias & Brigitte Schirmer in the Team of Allresist