AR NEWS

17th Issue

Allresist GmbH

Content:

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1. 2008 – a successful year for Allresist

Valued reader of the AR NEWS, we would like to inform you again about the future trends of the Allresist and our products, as well as our progress on the way to a Business of Excellence. For 2008 – meanwhile the 16th year after our company was founded - we already today look back on a very successful year again. Our sales expectancies were exceeded by far, and a new INNO-WATT project was initiated (☞ Item 4).

We are especially proud of the fact that both our scientific accomplishments were recognized with the Technology Transfer Award Berlin/Brandenburg, but also the high quality level of Allresist on our way to develop into a Business of Excellence, since we in addition received the Quality Awarded Berlin/Brandenburg this year.

In the following articles, we will also present the latest news from our research department. We wish and hope that these new developments will spark your interest and may even encourage a stimulating cooperation in the future.

1.1 Technology Transfer Award Berlin/Brandenburg 2008

The prize winners of the Technology Transfer Award were honoured at the CCI in Potsdam this year. Allresist received this award together with the Institute for Thin Film and Microsensoric Technology e.V. and the CIMAT, University of Potsdam, for the development of a new protective coating. **The procedure used so far** involves a deposition of structures on the wafer front surface by photo lithography in a first step, followed by etching of the wafer backside with strong alkaline solutions in a second step. During this procedure, sensitive structures however have to be protected. So far, this was a very time-consuming process since silica wafers have to be inserted separately into cassettes which only leave the backside to be etched accessible. **Our task was thus to develop a new methodology for a simple protection of circuits during etch processes.**

This task was accomplished within the scope of a research project "Development of a simplified procedure for the patterning of silica with wet-chemical methods", PRO INNO II of the Federal Ministry of Econimics and Technology (BMWi). The new procedure is based on the development and production of a novel polymer by the IDM e.V.. With this polymer, Allresist was now able to develop the protective coating X AR-PC 5000/30 which reliably covers structures during etching in caustic potash solutions, thus providing a sufficiently high protection in addition to a very easy handling (technical details ☞ www.allresist.de).

Employing process steps as commonly used in photoresist technology, even an automated serial production is possible with this resist. Our customers are thus able to reduce both work schedule and yield loss (due to wafer fractures). This resist is meanwhile used by customers worldwide for specific applications and technologies.

Picture 1 Ulrich Junghanns, Minister of Trade and Commerce, and Dr. Etta Schiller with award winners of Allresist and IDM e.V. in June 2008

Picture by: Dr. W. Lamm, IDM e.V., Teltow

1.2 Quality Award Berlin/Brandenburg presented by Minister Junghanns

Brandenburg's Minister of Trade and Commerce, Ulrich Junghanns, presented the Quality Award 2008 to members of the Allresist management board. In his honorific speech the Minister of Trade and Commerce particularly addressed the high quality level of our research results, and also acknowledged that we had made an important step forward on our way to become a Business of Excellence. During the past two years since our first application for the Quality Award, substantial progress was made in all business areas. This was also confirmed by the assessors who had visited the Allresist in advance. With their suggestions and newly gained experiences we now hope to improve our company, particularly for the benefit of our customers and partners.

Picture by: Eberhard J. Schorr, Photosign, Berlin

Picture 2 Honorific speech of Ulrich Junghanns, Minister of Trade and Commerce, for the Allresist in September 2008

2. Two component system for glass etching

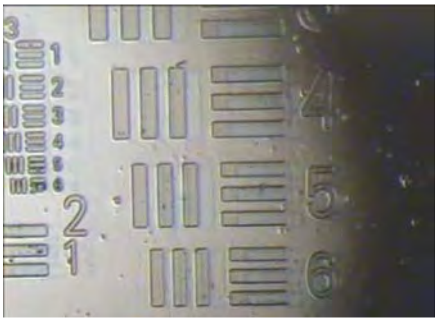
Within the frame of the project "Development of a simplified procedure for the patterning of silica with wet-chemical methods" resist systems were developed which not only meet the high demands of hydrofluoric acid etching, but are also suitable for etching in caustic potash solutions. Particularly remarkable are the results obtained for glass etchings with HF.

At low hydrofluoric acid concentrations (max. 5 %), commonly used photoresists may provide a short-term protection (☞ FAQ 19 at www.allresist.de). For deeper etchings however, these resists are not appropriate. With X AR-P 3100/10 which is optimised for HF etchings it is possible to extend the protective effects significantly, but in concentrated HF solutions even this resist is powerless.

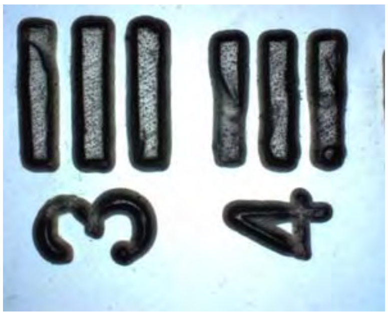
We therefore developed SX AR-PC 5000/40 specifically for this technology within the frame of our project. The first important application, the function as protective coating, is excellently fulfilled by the new resists. Even in 50 % HF solutions, films are stable for an hour. For standard applications in concentrated hydrofluoric acid solutions, etch times of 5 - 15 min are commonly used. Under these conditions, an etch depth of 200 - 400 µm can be achieved on the front side (depending on the kind of glass used).

For the second application, the patterning of glass surfaces, polymer layers can be patterned with a photoresist in such a way that structures of up to 500 µm can be etched into glass substrates (silicon dioxide). During isotropic etchings however, a substantial widening of the structure is likely to occur, and at best a wall slope angle of 45° can be obtained. In picture 3, an etch-protective mask after development with solvents is shown, and picture 4 shows the structures which were etched into glass.

Picture 3



Picture 4



Picture 5

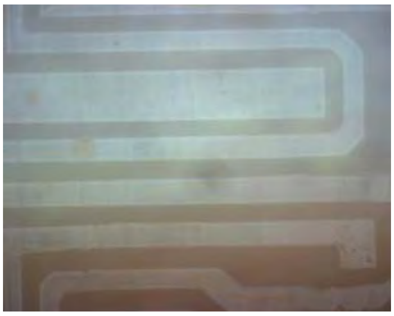
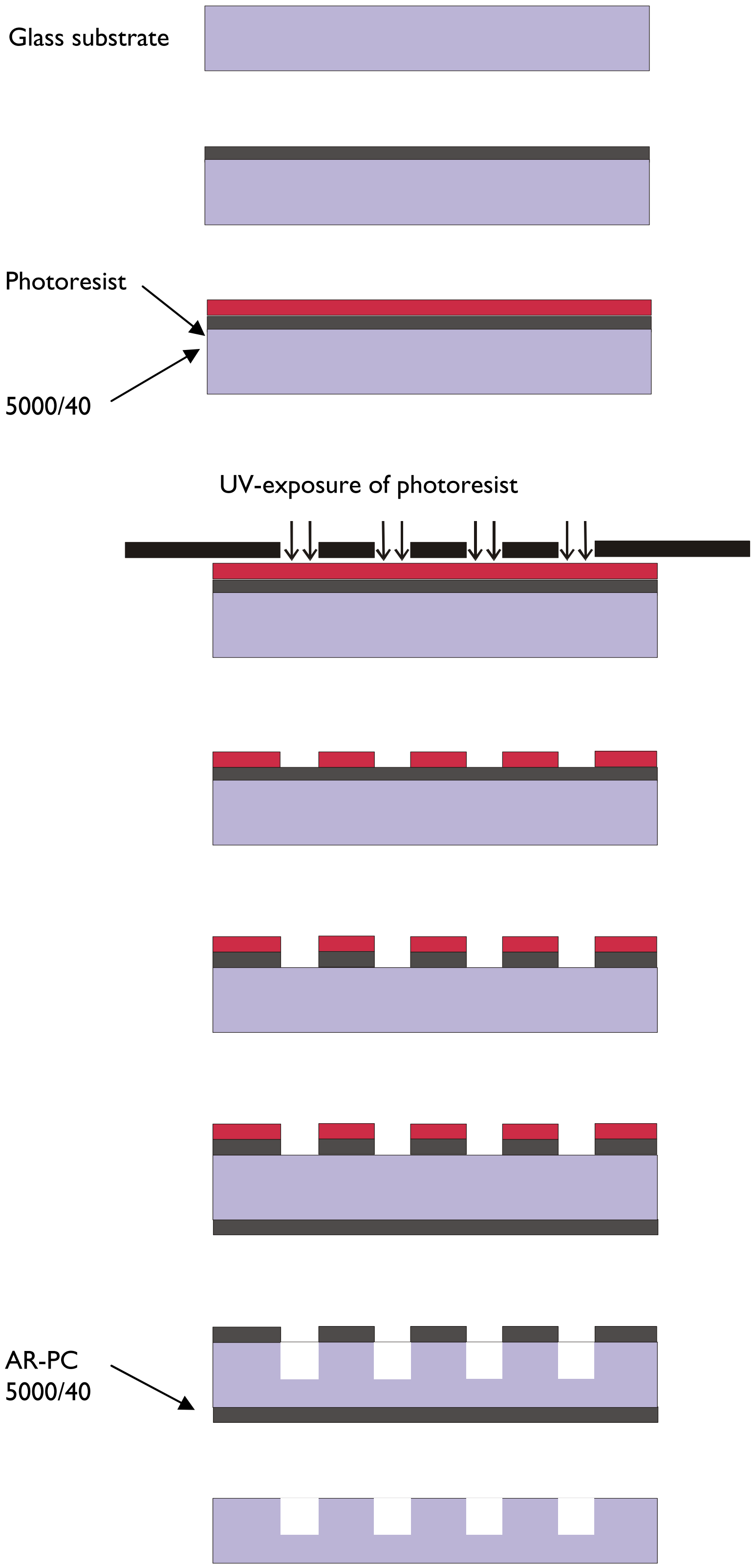


Table 1 schematically illustrates the process steps of glass etching procedures. The protective film can be patterned in two ways. After patterning of the photoresist, the SX AR-PC 5000/40 protective film can either be patterned itself using a solvent-based developer. (☞ Picture 3). In this case however, structural widening occurs due to the isotropic procedure, which has to be taken into account in order to obtain the desired structure size. On the other hand, patterning of the protective film can be performed with oxygen plasma. Photoresist and 5000/40 have similar etching rates. If both films are of approximately the same thickness, the photoresist is also removed during the plasma etch step. This procedure allows a dimensionally accurate transfer of structures, and no adjustments are required (☞Picture 5).

Table 1: Procedure for the structuring of SiO_2 or glass



Spin coating with SX AR-PC 5000/40
(10 to 12 µm film thickness)

Spin coating with photoresist

Photo mask

Contact exposure of the two layer system

Aqueous-alkaline development of the photoresist

Development of the protective layer under the photoresist mask

Backside protection – Spin coating with SX AR-PC 5000/40

Hydrofluoric acid etching of the glass substrate

Removal of protective films

Technical parameters for AR-PC 5000/40 are described in detail in the 15th issue of the AR NEWS (www.allresist.de, News-section), or contact our website for further product information. At present, several users already carry out product launch tests, we would thus highly appreciate your interest as well.

3. Results of nanometer-scale lift-off project

This project was successfully finished as scheduled. We here present some of the results which we obtained with PMMA resists.

3.1. PMMA two component system

For lift-off processes of high resolution structures with two component systems, PMMA resists (90K and 200K) were adjusted to give a film thickness of 30 nm to 80 nm. This resist system is suitable for the fabrication of sub-10 nm structures and for structures spaced at very small intervals with e-beam lithography. For this purpose, structures were produced as described in the following publication: “Fabrication of sub-10-nm Au–Pd structures using 30 keV electron beam lithography and lift-off“ by F. Lehmann, G. Richter, T. Borzenko, V. Hock, G. Schmidt and L. W. Molenkamp in **Microelectronic Engineering**; Volume 65, Issue 3, March 2003, Pages 327-333“. However, if this two component resist system is used for so-called finger structures (structures used for organic field-effect transistors) (Picture 2.1.5), lines are formed at the edges which cause short-circuits between adjacent finger structures.

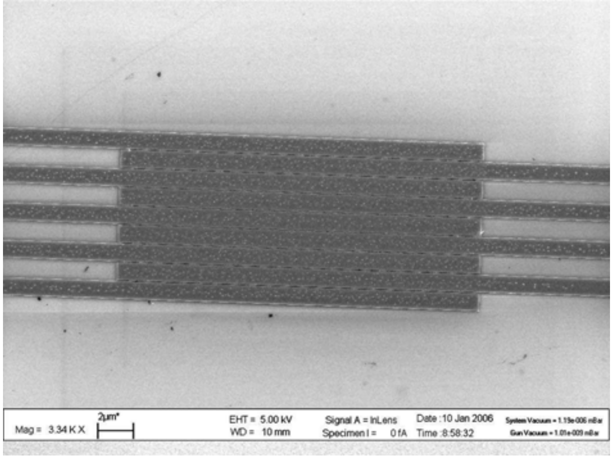
3.1.1 Process Parameters

In a first step, resist PMMA 90K is applied by spin coating, which results in a film thickness of approx. 60 - 70 nm under these process parameters. The following bake step is performed on a hot plate for 60 min @ 200°C. Subsequently resist PMMA 200K is spin coated to give a film thickness of 30 nm. The total film thickness thus amounts to approx. 90 -100 nm.

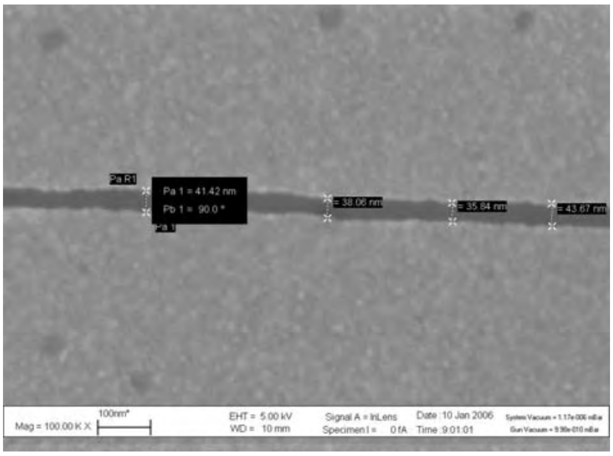
Exposure was performed using electron beam lithography at an acceleration voltage of 30 kV. Development was carried out in isopropanol for 40 s. As adhesive film, 1 nm titanium and 6 nm gold were deposited by evaporation, and the lift-off process was performed in acetone.

3.1.2 Results

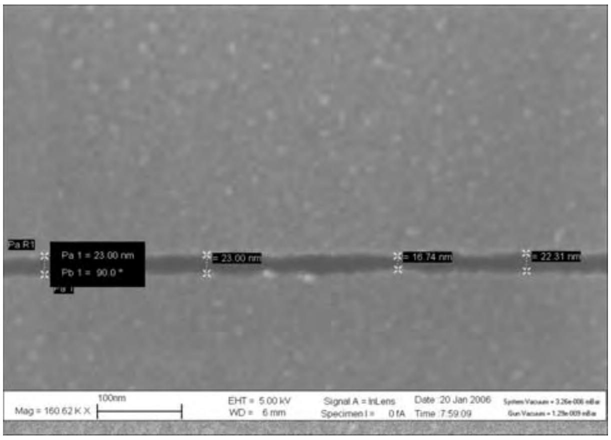
Finger structures with a channel width (distance between fingers of 1 µm size) of less than 50 nm width could be generated reproducibly and reliably, and no problems occurred during the lift-off. For the finger structures, the exposure dose was in a range between 250 and 300 µC/cm² at an acceleration voltage of 30 kV. The smallest channel width we achieved was determined to be 23 nm. Even for these structures, a reliable lift-off process was guaranteed.



Picture 6 Finger structures on silicon oxide wafers with a finger size of 1 µm and a channel width (spacing) of less than 50 nm. This structure was generated by lift-off (1 nm titanium, 10 nm gold). The exposure dose at 30 kV was chosen to be 280 µC/cm² in this experiment.



Picture 7 Picture of a channel of the structure as shown above with a width of less than 40 nm on average.



Picture 8 Smallest channel width obtained: 23 nm. Exposure dose for this structure was 260 µC/cm² at an acceleration voltage of 30 kV.

3.2. High resolution PMMA one component resist

If resist PMMA 90K is used as one component system, a variation of certain process parameters, particularly the dosage, may result in an even better resolution. Values indicating the sensitivity of e-beam resists are generally extremely dependent on the size of the structures which are desired. In order to obtain maximum resolution, a dosage may be required which is approximately 10 times higher than the dosage commonly used for e.g. squares of 1 µm size.

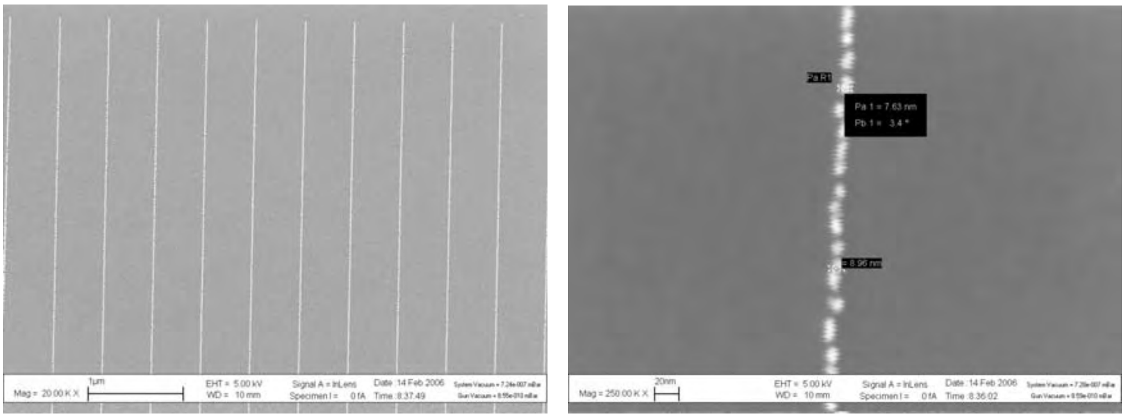
3.2.1 Process Parameters

Resist PMMA 90K was applied to give a film of 60 nm thickness. The subsequent bake was performed for 60 min @ 200°C on a hot plate, and exposure was carried out by electron beam lithography at an acceleration voltage of 30 kV. In this experiment, so-called single pixel-lines were exposed, i.e. lines with minimum width.

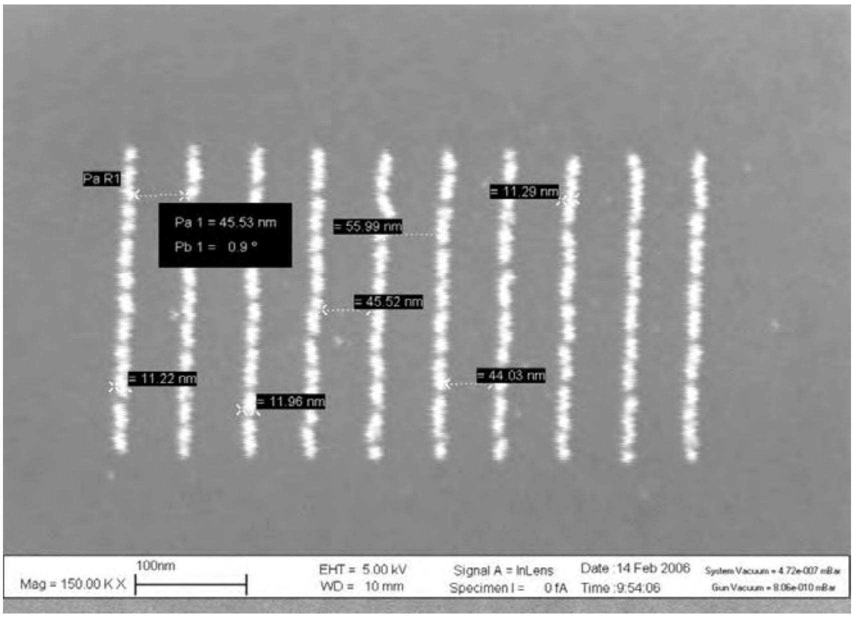
The development step was carried out for 1 min in undiluted isopropanol. Then, 6 nm gold were evaporated onto the surface prior to the lift-off in acetone.

3.2.2 Results

We were able to produce very thin lines with small periodicities under these conditions. This resist is perfectly suited for high resolution electron lithography. All results of the publication mentioned above with this resist could be confirmed. An exposure dose of more than 6000 µC/cm² is recommended at an acceleration rate of 30 kV. Under these conditions, lines as small as 8 nm are possible. Similarly, gold lines with very small spacing can be produced. The smallest periodicity achieved in this experiment was determined to 45 nm.



Picture 9 and 10 Line with 8 nm width after lift-off. The gold film which was evaporated has a thickness of 6 nm. Due to the naturally granular features of gold, the structure consists of a series of individual dots after the lift-off.



Picture 11 300 nm long and 11 nm wide gold line. The periodicity of structures was determined to be 45 nm.

Further results of this project will be presented in our next issue of the AR NEWS.

4. New project – e-beam resist for mask production

This project was aimed at the development of a new e-beam resist which is suitable for the production of mask blanks in an application range of sub-50 nm structures. These mask blanks are used for the fabrication of photo masks for the production of highest integrated circuits. Extremely high demands are made with respect to the quality of these blanks. So far however no resist is available which meets all demands of a cost-efficient production of sub-50 nm structures (i.e. structures of less than 50 nm).

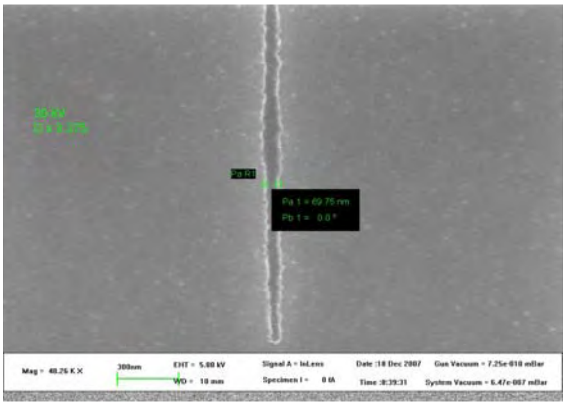
The new resist has to meet the following requirements:

- High sensitivity on mask blanks of 2 – 10 µC/cm² (20 kV)
- Structural resolution of at least 50 nm, desirable are 30 nm
- High Process stability
- Good plasma etch resistance
- Very smooth surface structures after development
- Conductivity of > 10 S/m

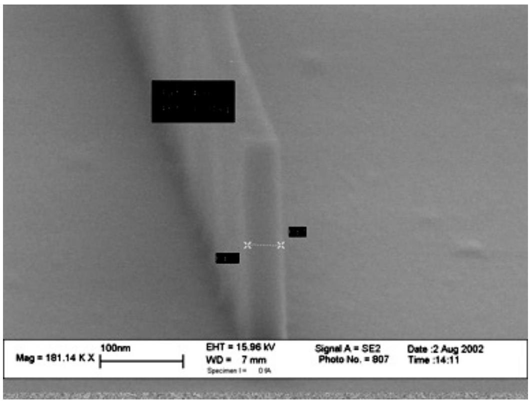
Even though single parameters are met by commercially available e-beam resists, an economically advantageous (short writing times due to high sensitivity) and at the same time stable (process susceptibility of chemically enhanced resists) production of 50 nm-structures cannot be realised with these resists so far.

Allresist offers a variety of e-beam resists which each meet one of the demands as listed above. For example, at a resolution of 50 nm resist SX AR-N 7700/37 (however with still insufficient structural quality) displays a sensitivity of approx. 3 µC/cm² (☞ Picture 12). Resist AR-N 7520 (☞ Picture 13) shows a very good resolution with high structural quality (☞ Publication [1]). Here, a 20 nm line at a film thickness of 80 nm is described. Our project is thus aimed at the development of a hybrid resist which combines the positive features of the respective resists now in one product.

Picture 12 50 nm-structure with AR-N 7700/37



Picture 13 40 nm-structure with AR-N 7520



These new e-beam resists will in future not only be applied in mask technologies. In this regard, we look forward to meet interested customers who would like to be informed about the progress of this project. Please do not hesitate to contact us with any own suggestions or for desired features of these new resists.

[1] "**Structures using a negative tone Novolak based e-beam resist**"

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With this presentation of our recent results, we hope to have encouraged you to address new applications with our photoresists.

The next issue of the AR NEWS will again be presented in April 2009.

Successful times until then!

Strausberg, 10.10.2008

Matthias & Brigitte Schirmer

Allresist team