

Progress on an Intra-Level Mix-and-Match approach of the chemically amplified positive-tone photoresist AR-P 7200.1 series for EBL and i-line stepper lithography

M. Gottwald^a, S. Hartmann^b, C. Helke^{a,b}, M. Sendel^c, H. Biller^c, M. Schirmer^c
and D. Reuter^{a,b}

^a*Fraunhofer Institute for Electronic Nano Systems (ENAS), Chemnitz, Germany*

^b*Technische Universität Chemnitz, Center for Microtechnologies (ZfM),
Chemnitz, Germany*

^c*Allresist GmbH, Strausberg, Germany
markus.gottwald@enas.fraunhofer.de*

We present the first results of an ongoing analysis of a novel chemically amplified positive tone resist by Allresist, AR-P 7200.1/1.n, which is sensitive to both i-line UV light and electrons. It therefore is a candidate to perform an intra-level mix-and-match (ILM&M) approach¹, where two exposures of different kinds are combined in the same resist layer. With this, the advantages of i-line stepper and electron beam lithography (EBL) can be combined with overall fewer processing steps and less processing time. It is necessary to first independently characterize the behavior for the two exposure kinds to find an overlapping set of processing parameters. To accommodate this, a study of UV exposure dose and post-exposure bake (PEB) was conducted. Additionally, a spin curve as well as the dark erosion for a common development process were determined.

The resist yields a thickness of around 340 nm at 5000 rpm. After development in AR 300-44 the thickness of unexposed areas was reduced by around 25 nm. The exposure dose / PEB study revealed a linear relationship between dose and the examined gap width. Multiple parameter sets were found that give an adequate imaging of the exposed structures in the resist. For example, 1 μm features can be transferred into the resist with a dose of 280 mJ/cm^2 and a PEB of 10 min at 130 °C, as well as with a dose of 480 mJ/cm^2 and a PEB of 5 min at 120 °C. The latter also yielded good imaging of structures with dimensions of 500 nm. Furthermore, it was discovered that structures with a gap width below 500 nm could not be correctly imaged. While this is significantly higher than the critical dimension limit of the used i-line stepper NSR2205i11D from NIKON (at about 350 nm), it presents a clear border where EBL takes over in the aforementioned ILM&M approach.

As multiple parameter sets for i-line lithography have been found, it shows these are quite flexible to fit the needs of the EBL. Early examinations of EBL for the resist showed minor problems that are currently being further investigated in cooperation with Allresist. Nevertheless, it is feasible that ILM&M lithography can be realized with this resist.

¹ Hofmann, Martin, et al. "Mix-and-match lithography and cryogenic etching for NIL template fabrication." *Microelectronic Engineering* 224 (2020): 111234.

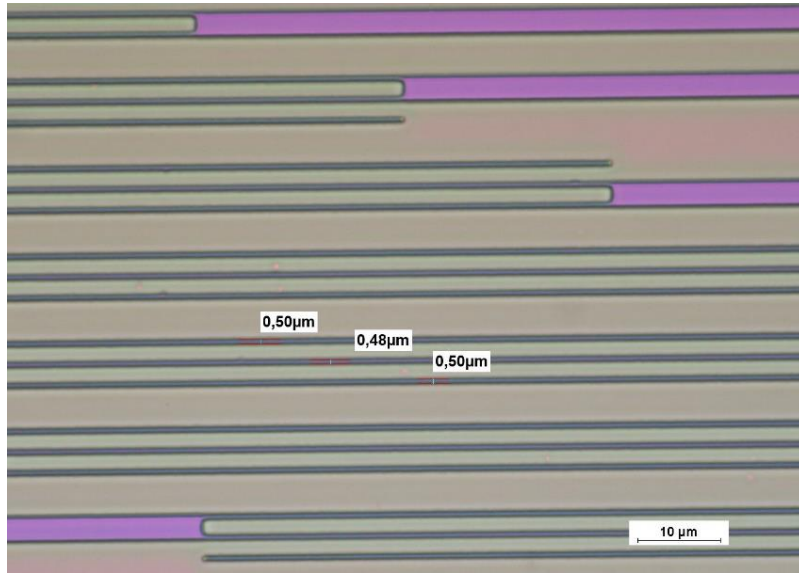


Figure 1: Microscope image of 500 nm wide structures in the test layout exposed by i-line with a dose of 480 mJ/cm² and processed with a PEB of 120 °C for 5 min.

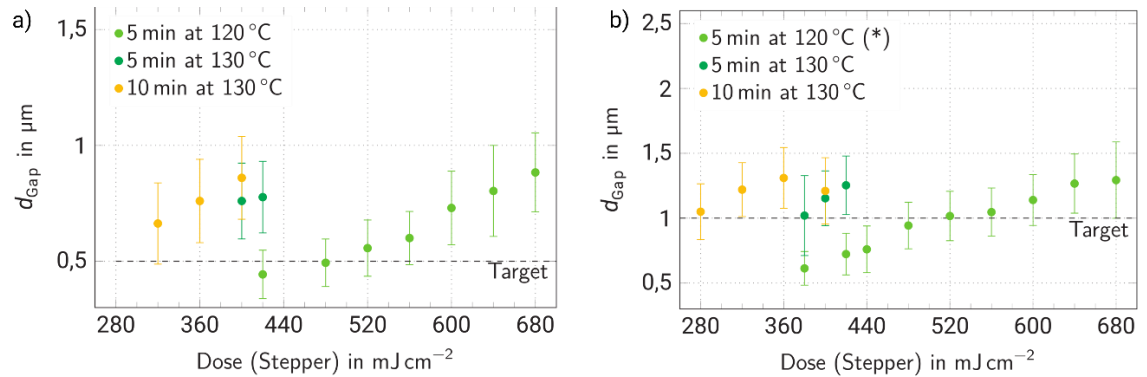


Figure 2: Exposure dose / PEB study results for feature sizes of 500 nm (a) and 1 μm (b). To demonstrate which parameter combinations hit the target width, this value is represented by a dashed line.