Karlsruhe Institute of Technology

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AR-P 6200 for EBL Applications up to 1.5 µm

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Introduction

- Range of application for E-Beam resists is up to 1.5 µm and higher. Application for high resists are phase gratings and etch masks for high aspect ratio applications
- Typical positive resists for these applications are ZEP520A, a resist for thinner film thickness values, with good etch resistance but costly and PMMA, a low cost resist but with poorly etch resistance
- Positive resist AR-P 6200 (CSAR 62) has also been qualified up to 1.5µm. The advantages of AR-P 6200 are: good etch resistance, high sensitivity, reasonably priced and ready availability

Aim of the Investigation

- Stability of structures in the sub-µm range with high aspect ratio: a grating with 300nm lines and 300nm spaces with a high aspect ratio of 5 was chosen
- Development parameters leading to steep sidewalls, no residual resist and no crack formation: A bridge grating with 2.4µm lines and 2.4µm spaces was chosen

Experimental

- Resist technique: adhesion promotor AR 300-80; resist AR-P 6200.18; soft bake 150°C; measured resist thickness 1.52 µm
- Layouts: sub-µm grating and bridge grating; field size 1cm²
- Exposure at 100kV with EBPG5200Z, dose 25 - 300 µC/cm²
- Development at room temperature in beaker; agents: AR 600-546 (amyl acetate), X AR 600-546/2 (methyl pivalate) and MIBK (Table 1), rinse in isopropanol
- SEM investigation

Results

- Stability of sub-µm gratings:
  Small process window (Figure 1 and 2)
- Development Parameters:
  AR 600-546: Optimum developing time 20-30 min (Figure 3)
  Developing time >30 min leads to cracks (Figure 4)
- X AR 600-546/2: Optimum developing time 4h; stable lines (Figure 5) and no cracks (Figure 6)
- MIBK: 2nd development step 1 min is optimum; allows the complete removing of remaining resist traces

Table 1: Process parameters and results (+: no or few residual resist, predominantly stable lines, no cracks)

Layout	Dose (µC/cm²)	AR 600-546 (min)	XAR 600-546/2 (min)	MIBK (min)	Res. resist	Lines stable	Cracks
Grating Line/space 300/300nm	180	5		5	+	-	+
	180	10		1	-	+	+
	190	10		1	-	-	+
	180	20		1	+	+	+
	180	25		1	+	+	+
	180	60		1	+	-	+
	180		240	0	-	+	+
	180		240	1	+	+	+
Bridge design Line/space 2.8/2.8µm	180	10		1	-	+	+
	180	25		1	+	+	+
	180	35		1	+	+	-
	180		240	0	-	+	+
	180		240	1	+	+	+

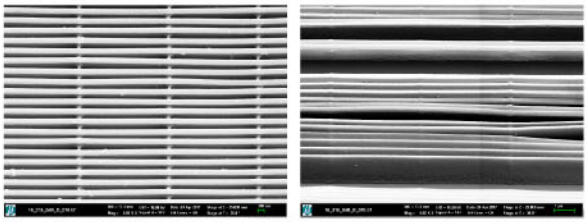


Figure 1: Dose 180 µC/cm²; AR 600-546: 20min; MIBK: 1min; lines are stable, nearly no residuals
Figure 2: Dose 180 µC/cm²; AR 600-546: 5min; MIBK: 5min; lines are unstable, side walls affected

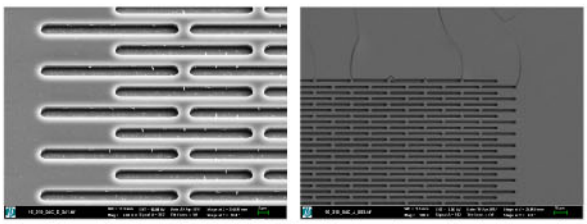


Figure 3: Dose 180 µC/cm²; AR 600-546: 25min; MIBK: 1min; nearly no residual resist, no cracks
Figure 4: Dose 180 µC/cm²; AR 600-546: 35min; MIBK: 1min; crack formation

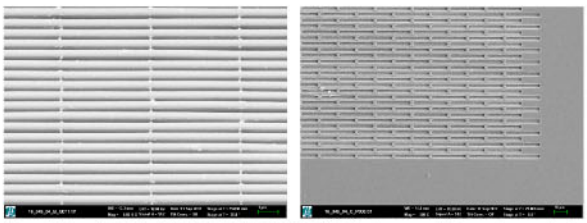
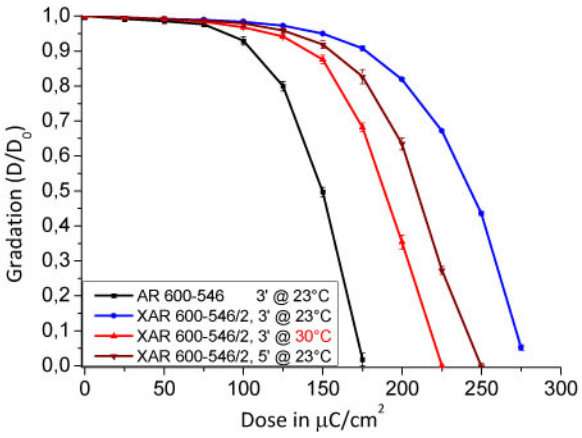


Figure 5: Dose 180 µC/cm²; X AR 600-546/2: 4h; MIBK: 1min; lines are stable, nearly no residuals
Figure 6: Dose 180 µC/cm²; X AR 600-546/2: 4h; MIBK: 1min; few residual resist, no cracks



Comparison of the sensitivity of resist AR-P 6200.18 (CSAR 62) in standard developer AR 600-546 and new high contrast developer X AR 600-546/2: variation of developing duration and the temperature

Conclusion

We identified a process window to structure 1.5µm thick positive tone resist AR-P 6200.18 with high aspect ratio up to 5. Developer AR 600-546 is more sensitive than the X AR 600-546/2. But the new developer also leads to very smooth side walls and stable lines up to aspect ratio of 5. Neither an extended developing time up to several hours nor a development at elevated temperatures leads to a formation of undesirable cracks.

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