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| Objective |
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| This process flow describes how to fabricate a bilayer resist stack for lift-off of patterns defined by e-beam lithography and metallisation. The resist stack combines a lift-off resist LOR5A from Microchem (<http://microchem.com/pdf/PMGI-Resists-data-sheetV-rhcedit-102206.pdf>) and a standard e-beam resist CSAR from AllResist (<http://www.allresist.com/csar-62-ar-p-6200/>).  LOR 5A spin coats to a thickness of around 300 nm at 5000 rpm and is thus suitable for undercuts of around 300 nm. If a smaller pattern dimension or higher density of patterns is needed, a thinner LOR is required. For undercuts in range of 20 – 50 nm, SF3 or LOR 1A should be used. |

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| Step Heading | Equipment |  | Comments |
| 1. Pretreatment | | |  |
| * 1. Surface treatment | Hotplate | Dehydrate wafers 5 min @ 210 oC |  |
| 1. Spin coat of LOR and CSAR | | |  |
| * 1. Coat wafers | Spin Coater: Manual all resists (A-5) | **Resist:** LOR 5A  **Spin coating:**  5 sec @ 1000 rpm, acc 200 rpm/min/s  60 sec @ 5000 rpm (for appr. 300 nm)  **Softbake:** 10 min @ 210 oC (Hotplate set temperature: 230 oC)  **Resist:** CSAR:Anisole 1:1 (AR-P 6200, AllResist)  **Spin coating:** 60 sec @ 4000 rpm (for appr. 60 nm)  **Softbake:** 1 min @ 150 oC (Hotplate set temperature: 170 oC) | Use E-beam/Anisole process bowl in A-5. **It is not allowed to use ‘Spin Coater: Manual Standard Resists’ in E-5.**  Pre-spin of LOR5A is necessary to obtain uniform coating. Undercut etch rate depends strongly on softbake time and temperature.  Use E-beam/Anisole process bowl. Clean bowl and spin coater with 1165 Remover. |
| 1. E-beam exposure | | |  |
| * 1. E-beam exposure | E-beam writer | Dose: 200 - 350 µC/cm2; dose depends on resist thickness, pattern density, and developer. A dose-test is required. | Lines 200 – 500 nm |
| 1. Development & Rinse | | |  |
| * 1. Develop-ment | Developer (E-beam fumehood) | **CSAR:**  Develop with AR 600-546, 60 sec  Rinse in IPA, 60 sec, blow dry with N2  **LOR5A:**  Develop with AZ 726 MIF:H2O 2:1, 1-3 min.  Rinse in H2O, 60 sec, blow dry with N2 | Development of LOR5A can be followed by immersion in undiluted AZ 726 MIF appr. 10 s.  AZ 726 MIF is a TMAH based developer: wear 4H gloves and apron. Do not mix TMAH-based solutions with solvents: AZ 726 MIF is disposed of in TMAH waste bottle. |
| 1. SEM Inspection | | |  |
| * 1. Inspection | SEM Supra 2 | Inspection of resist profiles – see SEM pictures below.  WD ~ 4 mm  HV = 2 kV  InLens detector | Dice wafer into small samples. Clamp the samples as close to the SEM specimen holder as possible. |
| |  |  | | --- | --- | | **1 min development in AZ726MIF:H20, 2:1** | **2 min development in AZ726MIF:H20, 2:1** | | O:\CleanroomDrive\tigre\E-beam project\1815\60s AR600546 1min AZ726_H20 2_1\w1815_HD_03.tif ~128 nm line too narrow to create undercut in LOR5A | O:\CleanroomDrive\tigre\E-beam project\1815\60s AR600546 2min AZ726_H20 2_1\w1815_HD-6_02.tif ~360 nm line | | O:\CleanroomDrive\tigre\E-beam project\1815\60s AR600546 1min AZ726_H20 2_1\w1815_HD_10.tif ~198 nm line | O:\CleanroomDrive\tigre\E-beam project\1815\60s AR600546 2min AZ726_H20 2_1\w1815_unknowndose_16.tif ~200 and ~300 nm lines | | O:\CleanroomDrive\tigre\E-beam project\1815\60s AR600546 1min AZ726_H20 2_1\w1815_HD_01.tif ~230 nm line | O:\CleanroomDrive\tigre\E-beam project\1815\60s AR600546 2min AZ726_H20 2_1\w1815_unknowndose_10.tif ~540 nm line | | O:\CleanroomDrive\tigre\E-beam project\1815\60s AR600546 1min AZ726_H20 2_1\w1815_HD_12.tif ~440 nm line (almost too wide to create undercut) | O:\CleanroomDrive\tigre\E-beam project\1815\60s AR600546 2min AZ726_H20 2_1\w1815_HD-9_19.tif ~200 nm – 2000 nm lines |   When samples are developed 4 min in AZ726MIF:H2O 2:1, the undercut becomes so large the CSAR layer bends to the substrate. This could perhaps be avoided if the CSAR layer was thicker (i.e. use undiluted AR-P6200.09). | | | |
| 1. Metallization | | |  |
| * 1. Evaporation | Alcatel | E-beam evaporation of  5 nm Cr  50 nm Au  Rates ~ 10Å/s |  |
| 1. Lift-off | | |  |
| * 1. Lift-off | Fumehood, D-3 | **Lift-off:** Beaker with Remover 1165. If possible, face resist surface downwards to avoid re-deposition of metal onto substrate surface.  At 60 °C, the structures lift-off almost immediately, whereas regions without patterns took up to 30 minutes to lift.  **Rinse:** IPA  **General info on lift-off of LOR:**  LOR and acetone creates solids.  Liftoff and stripping of LOR must be done with NMP or DMSO based strippers only (<http://www.nnf.ncsu.edu/processes/lithographic/microchem-lift-resist-lor-process>).  At high soft bake temperatures, the removal rate of LOR 5A decreases, see [**http://microchem.com/pdf/PMGI-Resists-data-sheetV-rhcedit-102206.pdf**](http://microchem.com/pdf/PMGI-Resists-data-sheetV-rhcedit-102206.pdf) . | Wear 4H gloves and apron when handling Remover 1165.  Lift-off is enhanced by heating up Remover 1165: This may be done on a hotplate in a fumehood. The temperature of Remover 1165 **may not** exceed 65 °C. Use only hotplate with an external temperature sensor to heat Remover 1165, and never leave the setup.  Remover 1165 is disposed of in c-waste when cooled to room temperature. |
| 1. SEM Inspection | | |  |
| SEM Inspection | SEM Supra 2 | Inspection of metal lift off.  WD ~ 4 mm  HV = 10 kV  InLens detector | Due to undercut of resist, the line edge roughness of the deposited metal is among other things defined by deposition rate and substrate temperature during deposition. |