Content

1. Fabrication System A: Electrode Patterning1

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Organization/Institution WORK IN PROGRESS

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**Fabrication System A**

**- Electrode Patterning -**

System A1: Lithography Au Electrodes 1/2

**A1**

This section describes all unit processes involved in the lithographic patterning of gold (Au) electrodes on a 1” x 1” glass substrate at the IAPP lab. Although gold as an electrode material comes with a higher cost, it is recommended for use in OECTs due to its electrochemical stability, resistance to oxidation, and good electrical conductivity. A pre-evaporated Au layer provides a highly planar surface with nanometer-scale layer thickness accuracy. Using lithography as an industry-standard patterning process, lateral resolutions of 1µm can be achieved. Therefore, this fabrication method is ideal for precise, small-scale structures, but comes with drawbacks like high energy and chemical consumption, resulting in a larger environmental impact and operational costs compared to printing techniques.

**Overview Unit Processes:**

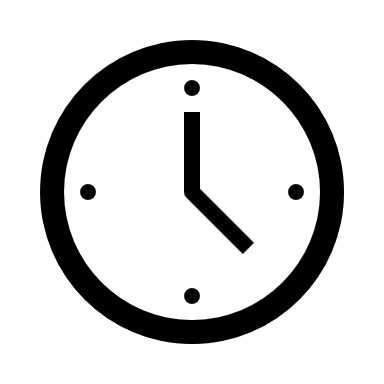
**Substrate:** 6“ x 6“ glass wafer (Schott Borofloat® 33, composition according to DIN ISO 3585 / EN 1748 T1, thickness of 1.1 ± 0.1mm)  
Info:Process done by IAPP Lesker-Team

**(1)** Wet cleaning process: 10min DI water + 10min ethanol ultrasonic bath (solvent reusable: ~200ml DI water, ~50ml ethanol per wafer)  
**(2)** Removal of residues (12min, 20L DI water) and drying (3min, 100L N2) in a spin-rinse-dryer  
**(3)** Surface activation by UV ozone-plasma for 10min **(4)** Vacuum evaporation of a 3nm Cr adhesion layer (60mg Cr, rate 0.1Å/s) followed by a 50nm Au layer (2.5g Au, rate 0.3Å/s)  
**(5)** Spin-coating (5s ramp-up, 60s 2000rpm, 5s ramp-down) of 18ml AZ 1518 photoresist to protect Au-layer  
**(6)** Cutting wafer into 1“ x 1“ substrates

**Info:**

**Info:**

**1h45min  
(1-4 Substrates)**



**Pre-processing**

**Cleaning**

**Resist   
Coating**

**UV Exposure**

**Development**

**Plasma   
Cleaning**

**Resist   
Stripping**

**Cr Etching**

**Au Etching**

**1 2 3 4 5 6 7 8**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Equipment** | **Chemicals** | **Process Description** | **Quality**  **Control** | **Remarks** |
| **1** | Ultrasonic cleaner,  100mL + 20mL Beaker | *30mL* Acetone,  *5mL* Isopropanol,  *10mL* DI water,  *2.5L* N2 | 1. Rinsing substrate with acetone  2. Ultrasonic bath for 15min (substrate in 25mL acetone in   small beaker, nested in 10mL water in large beaker)  3. Rinsing substrate with acetone followed by isopropanol  4. Blow away residual solvents with N2 | Clean and dustless substrate surface | Cleaning and removal of scratch-protective AZ 1518 layer |
| **2** | Spin-coater,  Pipette,  Hotplate,  Light-shielded box | *0.5mL* AZ 1518  (pos. photoresist)  *(stored in fridge at 5°C)* | 1. Spin-coating AZ 1518 Photoresist – use 1” x 1” holder  (5s ramp-up, 60s 3000rpm, 5s ramp-down)  2. Soft baking at 110°C for 60s (use precise hotplate)  3. Store substrate in a light-shielded box | ~2800nm thick  AZ 1518 layer, reddish, wavy surface, no bubbles | See appendix  Figure **1** for AZ thickness at various rpms |
| **3** | Mask aligner exposure unit,  Photomask |  | 1. Install electrode photomask + load substrate 2. Perform WEC (Wedge Error Compensation) + alignment   of substrate with photomask  3. UV exposure (I-line 365nm, intensity 5.2 mW/cm2) of  substrate for 13s |  | If the lamp is at the end of its lifecycle, increase exposure time to 14-17s |
| **4** | 2x40mL Beaker | *40mL* AZ 726 MIF  *(multiple reuse)*  *40mL* DI water,  *2.5L* N2 | 1. Submerge substrate in AZ 726 MIF developer and   slowly swing it back and forth for 60s   (do not block layout areas with tweezer)  2. Cleaning in DI water for 10s  3. Blow away residual water with N2 | Layout is slightly visible on substrate surface. | Removal of exposed photoresist |
| **5** | 2x40mL Beaker | *40mL* Au etchant  (1:10 DI water) *(multiple reuse)*  *40mL* DI water,  *2.5L* N2 | 1. Submerge substrate in gold etchant and slowly swing it   back and forth for at least 30s (stop once Au is   completely removed from the exposed areas, do not   block the Au electrode areas with the tweezer)  2. Cleaning in DI water for 10s  3. Blow away residual water with N2 | Clean Au electrode layout is visible without unwanted particles or Au dots.  Glass substrate is transparent but slightly greyish. | If the Au cannot be removed completely, the exposure time or the development time was too short. |
| **6** | 2x40mL Beaker | *40mL* Cr etchant  (1:10 DI water),  *40mL* DI water,  *2.5L* N2 | 1. Submerge substrate in chromium etchant and   slowly swing it back and forth for 20s  2. Cleaning in DI water for 10s  3. Blow away residual water with N2 | Glass substrate is fully transparent and non-conductive on its surface. (Multimeter check). | Disposal of Cr etchant in Cr waste bottle (acid shelf) |
| **7** | Ultrasonic cleaner,  100mL + 20mL Beaker | *25mL* Acetone,  *5mL* Isopropanol,  *10mL* DI water,  *2.5L* N2 | 1. Ultrasonic bath for 15min (substrate in 25mL acetone in   small beaker, nested in 10mL water in large beaker)  2. Rinsing substrate with acetone followed by isopropanol  3. Blow away residual solvents with N2 | Clean Au electrodes  (Au 50nm: 1.64Ω/□), step 8 if residual photoresist is visible | Cleaning and removal of unexposed photoresist |
| **8** | Plasma Cleaner  **OPTIONAL** | *250mL* O2  *50L* N2 (venting 2x) | Reactive O2 plasma cleaning of substrate surface for 5min (program ‚O2\_cleaning\_300s‘, RF Generator 50W and 250V, 30mln/min O2, start at 8.0e-05mbar) | No residual photoresist on substrate surface. | Further cleaning and removal of residual photoresist |

System A1: Lithography Au Electrodes 2/2

**A1**

**Additional Information**

**(A)** For structure sizes <10µm, exposure time and development time need to be tuned and precisely timed.  
**(B)** If the glass substrate is contaminated with particles after the final cleaning step, it is recommended to renew the developer   
 solution and/or the gold etchant solution.  
**(C)** Polyimid (PI) as flexible substrate is available. It has to be manually cut into the desired shape and attached to a corresponding   
 glass substrate using spray glue. Detaching is done using acetone in an ultrasonic cleaner.  
**(D)** As alternative to the SÜSS MicroTec mask aligner system, a Heidelberg Instruments µMLA maskless aligner (365nm, dose 400mJ/cm2,   
 defocus 8) for the AZ 1518 photoresist exposure (step 3) is available. The layout for the maskless tool needs to be in a .gds file format.  
**(E)** Other photoresist like AZ nLOF 2020 (neg. photoresist, soft baking 110°C for 60s, exposure time 15s, development 60s) and  
 AZ 5214-E (image reversal pos. photoresist, soft baking 110°C for 60s, exposure time 7s) are available in the IAP laboratory.  
 The Image reversal of AZ 5214-E is achieved by an additional reversal bake step at 120°C for 2min after the inital UV exposure (step 3),   
 followed by a flood exposure (no mask) for 25s. For lift-off processes, the AZ 5214-E thickness should be 1.2-1.5x of the deposited layer   
 and for a sufficient undercut, a 30% over-development is recommended.

A list of all required chemicals and tools, along with their respective maximum power consumption, is provided in the appendix.

**Info:**

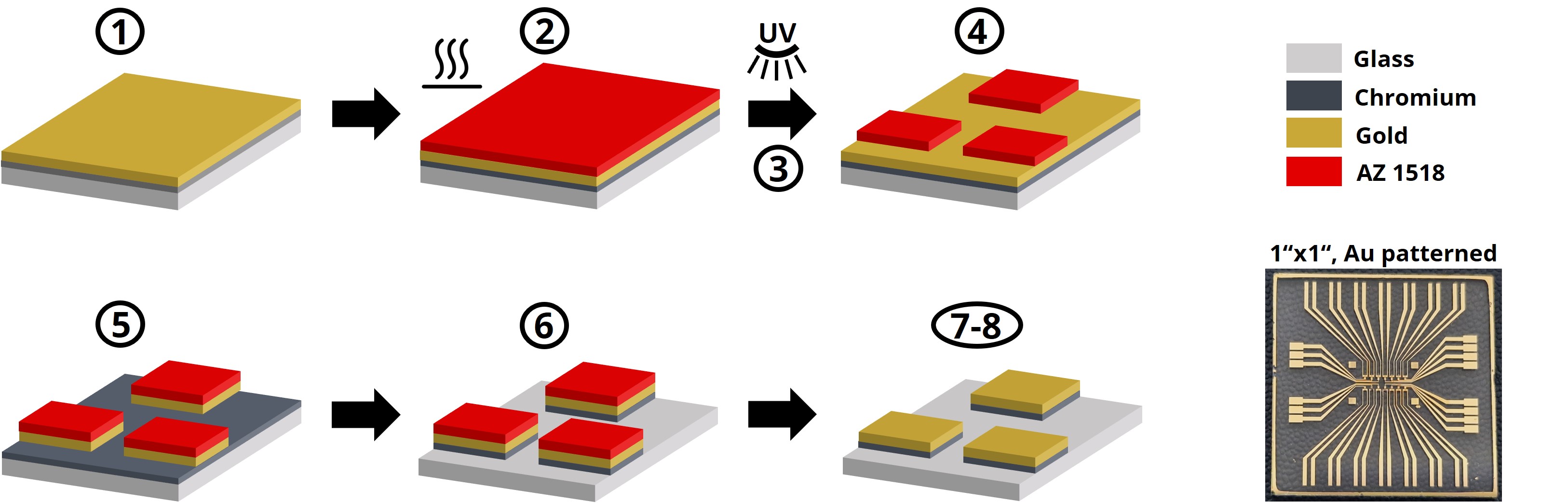
**Info:**

**Scaling:**

This section specifies the max. number of substrates that can be processed simultaneously with each equipment tool and the max. number of substrates for which a chemical can be reused before requiring replacement with a fresh solution. Additionally, it provides information on the disposal of chemicals after use. Tools and chemicals not listed are single-use per substrate or can only process one substrate at a time.

|  |  |  |
| --- | --- | --- |
|  | **PROCESSING CAPACITY & REUSE** | **Comments & Disposal Info** |
| **1** | Ultrasonic bath: 10x substrates at once (5x beaker setup) 25mL Acetone (ultrasonic) 5x (2 substrates at once) 10mL DI water (ultrasonic): 50x | To arrange 2 substrates in the 20mL beaker, place them back-to-back with the active sides facing outward for cleaning in acetone.  Acetone/isopropanol is disposed of in organic solvent waste. |
| **2** | Hotplate (soft baking): 25x substrates at once | Spin-coating is limited to one substrate at a time. |
| **3** | - | Only the maskless tool can process multiple substrates at a time. |
| **4** | 40mL AZ MIF 726: 25x 40mL DI water: 5x | The same DI water can be used for step 4-6.  The developer is disposed of after a maximum of 25 substrates. |
| **5** | 40mL Au etchant: 25x 40mL DI water: 5x | The same DI water can be used for step 4-6.  The Au etchant is disposed of in the Au waste bottle (acid shelf) after a maximum of 25 substrates. |
| **6** | 40mL Cr etchant: 25x 40mL DI water: 5x | Same DI water can be used for step 4-6.  Cr etchant must be used within a single day and is disposed of in the Cr waste bottle (acid shelf) afterward. |
| **7** | Ultrasonic bath: 10x substrates at once (5x beaker setup) 25mL Acetone (ultrasonic) 5x (2 substrates at once) 10mL DI water (ultrasonic): 50x | To arrange 2 substrates in the 20mL beaker, place them back-to-back with the active sides facing outward for cleaning in acetone.  Acetone/isopropanol is disposed of in organic solvent waste. |
| **8** | Plasma etcher: 25x substrates at once  (250mL O2 and 50L N2 fixed amounts per run) |  |

**Process Schematic:**



**Appendix**

I. Appendix: Supporting Information

**1)**

|  |  |
| --- | --- |
| **AZ 1518 spin-coating thickness:**  500rpm 60s: 7100nm (22s UV)  1k rpm 60s: 5000nm (18s UV)  2k rpm 60s: 3600nm (15s UV)  3k rpm 60s: 2800nm (12s UV)  2x3k rpm 60s: 5400nm (18s UV)  3x3k rpm 60s: 7600nm (22s UV) |  |

II. Appendix: Equipment List

This section lists all important tools needed for the different fabrication techniques, for performing measurements and other utensils and materials. It includes details on their respective commercial manufacturers, estimated power consumption during operation, and their location within the IAP laboratory is given. The laboratory itself is an ISO-7 classified cleanroom with a size of 250m2 and a regular power consumption of ~ Wh.

Fabrication tools:

|  |  |  |  |
| --- | --- | --- | --- |
| **Equipment Name** | **COmmercial Manufacturer** | **Power** | **Location** |
| SÜSS Microtech MJB4 mask aligner systems | SÜSS MicroTech AG, Germany | 1500W | -- |
| SAWATEC SM-180-BT spin-coater | SAWATECH AG, Switzerland | 2500W | -- |
| SAWATEC HP-150 hotplate | SAWATECH AG, Switzerland | 350W | -- |
| Photomasks (4inch, custom made, soda-lime glass with Cr) | Compugraphics Jena GmbH, Germany | - | -- |

Measurement tools:

|  |  |  |  |
| --- | --- | --- | --- |
| **Equipment Name** | **COmmercial Manufacturer** | **Power** | **Location** |
| **N2** MB 200B + MB 20G nitrogen-filled glovebox | M. Braun Inertgas-Systeme GmbH, Germany | 1800W | -- |
| **N2** Keithley 236 SMU | Keithley Instruments, USA | 100W | -- |

III. Appendix: Chemical List

This section lists all chemicals/materials needed for the different fabrication techniques with their corresponding commercial supplier and location in the IAP laboratory.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Product NAmE** | **Type** | **Density** | **Supplier** | **Location** |
| DI water | Solvent | 0.99823g/mL |  | v |
| Acetone | Solvent | 0.7900g/mL | TU Dresden Chemical Storage | -- |
| Isopropanol | Solvent | 0.7854g/mL | TU Dresden Chemical Storage | -- |
| Ethanol | Solvent | 0.7892g/mL | TU Dresden Chemical Storage | -- |
| Ethylene glycol (EG) ≥ 95% | Solvent | 1.113g/mL | Sigma Aldrich | -- |
| Dimethyl Sulphoxide (DMSO) | Solvent | 1.1004g/mL | VWR Chemicals | -- |
| AZ 1518 | Photoresist (positive) | 1g/mL | Merck Performance Materials GmbH | -- |