Your product idea

It starts with your idea or your vision of a new product. You may be uncertain about feasibility, costs, potential risks or the technology which leads to the optimal product. As a research and development institute of the Fraunhofer-Gesellschaft, we offer you advice and support.

We accompany your project with concept and feasibility studies from the very start – from the specification and the design to the draft and the fabrication of prototypes through to the product qualification.

The pilot fabrication of your circuits and ICs is carried out by us as well. At our institute you receive microelectronics from a single source.

We provide our services and know-how across all industries. Our circuits and systems are used in particular when it comes to the creation of unique selling points and competitive advantages for our customers. Thus our customer is able to serve his target market in an optimal way.
Step by step to project success

The way to a successful project is work-intensive and requires a good planning. Step by step, the following project phases are passed through:

- Concept & feasibility studies
- Specification & design
- Demonstrator development
- Prototype development
- Qualification
- Pilot fabrication

Quality pays off

The Fraunhofer IMS is certified according to DIN EN ISO 9001 since 1995. The certificate is valid for all divisions of the institute: Research, development, production and distribution of microelectronic circuits, electronic systems, microsystems and sensors as well as consulting in these fields. The CMOS line is certified according to ISO/TS 16949.

The success of your project is our mission.

Infrastructure

<table>
<thead>
<tr>
<th>Microsystems Technology Lab &amp; Fab</th>
<th>CMOS factory</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wafer size</strong></td>
<td>200 mm (8 inches, 0.35 μm)</td>
</tr>
<tr>
<td><strong>Cleanroom area</strong></td>
<td>1,300 m²</td>
</tr>
<tr>
<td><strong>Cleanroom class</strong></td>
<td>10</td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
<td>&gt; 70,000 wafers/year</td>
</tr>
<tr>
<td></td>
<td>200 mm (0.35 μm)</td>
</tr>
<tr>
<td></td>
<td>600 m²</td>
</tr>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>5,000 wafers/year</td>
</tr>
</tbody>
</table>
## CAPABILITIES

### Substrates

<table>
<thead>
<tr>
<th>Size</th>
<th>200 mm / 8 inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Si, SOI, others on demand</td>
</tr>
</tbody>
</table>

### Intelligent Substrates (CMOS)

- Automotive-qualified high volume CMOS fab available for pre-processing
- 150 employees working in 4 shifts
- Capacity of 70,000 wafer per year
- Complete CMOS process line plus integrated sensors
- 0.35 µm CMOS process
- Customer supplied wafers on request

### Lithography

<table>
<thead>
<tr>
<th>Coating / Development</th>
<th>0.8 µm to 50 µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive resist</td>
<td>Red, green, blue (+ transparent), black</td>
</tr>
<tr>
<td>Color filters</td>
<td>Photo sensitive, ca. 10 µm</td>
</tr>
<tr>
<td>Polyimide</td>
<td>Microlenses</td>
</tr>
</tbody>
</table>

### Isotropic Etching

<table>
<thead>
<tr>
<th>Wet Processes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Metals</td>
<td>Al, TiW, Cu, other materials upon request</td>
</tr>
<tr>
<td>Resist stripping</td>
<td>Solvent + IPA, in-situ stripping in ICP @ 50°C</td>
</tr>
<tr>
<td>Wafer cleaning</td>
<td>EKC265, SC1, Piranha</td>
</tr>
</tbody>
</table>
### Gas Phase Etching / Release Etch

<table>
<thead>
<tr>
<th>Etch Type</th>
<th>Etchant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxide etch</td>
<td>HF gas</td>
</tr>
<tr>
<td>Silicon etch</td>
<td>XeF₂</td>
</tr>
</tbody>
</table>

### Dry Etching

<table>
<thead>
<tr>
<th>Etch Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIE</td>
<td>Oxide, nitride, silicon, Ti(N), Al, a-Si (ICP), AZO (ICP), and other materials upon request</td>
</tr>
<tr>
<td>DRIE</td>
<td>Silicon, oxide etch in situ, EPD, SOI, BOSCH-process, aspect ratio max: 1:20, sidewall angle: ± 0.5 °, ER up to 20 µm/min</td>
</tr>
<tr>
<td>Ion milling</td>
<td>Inert, chemically assisted</td>
</tr>
<tr>
<td>Resist etching</td>
<td>Ashing in O₂/CF₄</td>
</tr>
</tbody>
</table>

### Films

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Metals</td>
<td>p/n-aSi, a/µc-Ge, SiO, SiN</td>
</tr>
<tr>
<td></td>
<td>aSi, SiO (silane / TEOS), SiN, SiC, DLC</td>
</tr>
<tr>
<td></td>
<td>Wet/Dry oxidation, H₂ high temp anneal</td>
</tr>
<tr>
<td></td>
<td>Al₂O₃, Ta₂O₅, ZrO₂, TiO₂</td>
</tr>
<tr>
<td></td>
<td>Al doped ZnO</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>TCO</td>
<td>High-K layers for optical interference filters</td>
</tr>
<tr>
<td>Doping</td>
<td></td>
</tr>
<tr>
<td>Evaporation</td>
<td></td>
</tr>
</tbody>
</table>

### Metals

<table>
<thead>
<tr>
<th>Metal Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sputtering</td>
<td>Al, Ti(N), TiW, Cu, NiCr, other materials upon request</td>
</tr>
<tr>
<td>Evaporation</td>
<td>Cu, W, Ti and many other metals</td>
</tr>
<tr>
<td>Electroplating</td>
<td>Cu, Ni, Sn, Au</td>
</tr>
<tr>
<td>Atomic layer deposition</td>
<td>TiN, Ru</td>
</tr>
</tbody>
</table>

### Integration

<table>
<thead>
<tr>
<th>Integration Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flip chip: chip-to-chip and chip-to-wafer bonding</td>
<td>Manual and automatic</td>
</tr>
<tr>
<td>wafer-to-wafer bonding</td>
<td>Direct, SLID</td>
</tr>
</tbody>
</table>
**Metrology**

<table>
<thead>
<tr>
<th>Dimensional</th>
<th>SEM (inline + cross-sections), profilometer, AFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual</td>
<td>3D microscope, inspection microscopes, interferrometric microscopes</td>
</tr>
<tr>
<td>Characterization</td>
<td>Ellipsometer/reflectometer, defect measurement, CD/overlay, sheet resistance, wafer geometry (bow)</td>
</tr>
</tbody>
</table>

**Packaging**

<table>
<thead>
<tr>
<th>Dicing</th>
<th>Si, glass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thinning/polishing</td>
<td>Standard grinding, TAIKO process</td>
</tr>
<tr>
<td>Wire bonding</td>
<td>Al, Au, Pd</td>
</tr>
<tr>
<td>Standard ceramic packaging</td>
<td>CLCC, DIL, PGA</td>
</tr>
<tr>
<td>Chip-on-board</td>
<td>Die-attach, wire-bond, glob-top</td>
</tr>
<tr>
<td>Special packages</td>
<td>Available for optical devices, pressure sensors, medical applications, high temperatures (300 °C)</td>
</tr>
</tbody>
</table>

**Test**

<table>
<thead>
<tr>
<th>Manual parameter characterization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic parameter test</td>
</tr>
<tr>
<td>Fully automated device test (mixed signal)</td>
</tr>
<tr>
<td>Special test equipment</td>
</tr>
</tbody>
</table>

**Reliability**

<table>
<thead>
<tr>
<th>Pull tests</th>
<th>Wire strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature change chamber</td>
<td>Max: 150 °C in 15 min – -65 °C in 15 min</td>
</tr>
<tr>
<td>HAST chamber</td>
<td>Temperature + 105 °C – + 142 °C, humidity 75 – 100 %, Pressure 0.002 ... 0.196 MPa</td>
</tr>
<tr>
<td>Pressure chamber</td>
<td>35 mbar – 150 bar</td>
</tr>
<tr>
<td>Temperature storage</td>
<td>Max: 300 °C</td>
</tr>
<tr>
<td>Aging and life cycling</td>
<td>Temperature and bias, customer specified</td>
</tr>
</tbody>
</table>
The MST Lab&Fab takes up two floors of the Fraunhofer IMS in Duisburg, with a total area of approximately 600 m². The cleanroom has a bay/chase layout with the clean bay area and a chase area containing the equipment bodies, a maintenance area, storage rooms and media supplies. The equipment is installed «through the wall», minimizing the expensive bay area and still allowing access for maintenance.

**Cleanroom part 1 in the 1. floor**

Bay area: approx. 127 m² with 110 m² in laminar flow for a cleanroom class 3 (DIN EN ISO 14644); the rest of the area is class 5
Cleanroom part 2 in the 2. floor

Bay area: approx. 130 m² with 60 m² in laminar flow for a cleanroom class 3 (DIN EN ISO 14644); the rest of the area is class 5.
The equipment in MST Lab&Fab is automated, cassette-to-cassette and set up for 200 mm wafers. Thus we are compatible to our CMOS fab and other foundries and ready to offer high quality post-processing.

**Lithography**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mask Aligner MA200 Compact (Suess MicroTec)</td>
<td>Mask aligner broadband, g-line, i-line or gh-line exposure resolution: 1 μm in contact mode and 3 μm in proximity mode, topside (TSA) and bottomside alignment (BSA)</td>
</tr>
<tr>
<td>Spin Coater Developer Maximus 804 (ATMvision)</td>
<td>Resist coating and development for positive photoresists (0.7 – 25 μm)</td>
</tr>
<tr>
<td>Spin Coater Developer Cube Series (iOS Instruments)</td>
<td>Resist coating and development for coloured positive photoresists (RGBpatterns), thick positive photoresists (25 μm), positive polyimides (5 – 20 μm)</td>
</tr>
<tr>
<td>I-Line Stepper PAS5500/200B (ASML)</td>
<td>I-Line wafer-stepper with 365 nm 5 x reduction, field size 22,0 x 22,0 mm resolution: 0.35 μm, NA = 0.48 – 0.60 3D-align: front-to-backside (FTBA) and back-to-backside alignment (BTBA)</td>
</tr>
<tr>
<td>Single Wafer Spin Processor WS-400B (Laurell Technologies Corp.)</td>
<td>Resist coating with new materials</td>
</tr>
</tbody>
</table>

**Deposition and Etching**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P5000 MxP (Applied Materials)</td>
<td>Metal-etching, oxide-/ nitride-etching</td>
</tr>
<tr>
<td>P5000 (Applied Materials)</td>
<td>CVD (doped / undoped silicon oxides and amorphous silicon, silicon nitride)</td>
</tr>
<tr>
<td>SVR Multisystem with XeF₂ + HF-Modules (Memstar)</td>
<td>Isotropic silicon and silicon-oxide etching</td>
</tr>
</tbody>
</table>
Deep Plasma Etching System Tegal 200
(Tegal Corp.)

Ionsys 500
(Roth & Rau)

ALD reactor ALS system
(Picosun)

ICP Deposition System 100 Pro
(Oxford Instruments)

PVD CS850S
(Von Ardenne Anlagentechnik GmbH)

Integrity 26 Electron Beam Deposition System
(Denton Vacuum)

Apollo
(Trion)

**Wet Processing**

Spin Rinser Dryer 280S
(Semitool)

Spray Solvent Tool 742
(Semitool)

Spray Solvent Tool 421
(Semitool)

EPM 305F
(Rena Sondermaschinenbau GmbH)

EPM 305F
(Rena Sondermaschinenbau GmbH)

Suncup EPM
(NB Technologies)

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**Wet Processing**

Spin Rinser Dryer 280S
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Spray Solvent Tool 742
(Semitool)

Spray Solvent Tool 421
(Semitool)

EPM 305F
(Rena Sondermaschinenbau GmbH)

Suncup EPM
(NB Technologies)
Wet Spin Processor System OPTIwet ST 30
(ATMvision AG)  
Wet etching of Cu, TiW, Al; wafer cleaning
(Piranha, SC1, Megasonic, DI-Jet)

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**Thermal Processing**

ATV SRO-706-R
(ATV Technologie GmbH)  
Solder reflow oven

ATV PEO-603
(ATV Technologie GmbH)  
Multipurpose fast ramping process furnace
(N2-atmosphere, vacuum)

ATV PEO-604
(ATV Technologie GmbH)  
Multipurpose fast ramping process furnace
(N2 and H2-atmosphere, vacuum)

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**Bonding Processes**

Flipchip Bonder Fineplacer183
(Finetech GmbH)  
Flipchip bonding

High Accuracy Die-Bonder AFC
(AMICRA Microtechnologies GmbH)  
Flipchip bonding

Waferbonder AML-AWB08 Platform
(Applied Microengineering Ltd.)  
Wafer bonding

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**Inspection and Measurement**

Surface Profiler P-16+
(KLA Tencor)  
Step height measurement

Inline-SEM 1250
(Fei)  
Electron beam microscope, full wafer

CDE Resmap 168
(CDE)  
Sheet resistance measurement
UV-1280 Advanced Thin Film Measurement System
(KLA Tencor)

Dimension Icon-PT Scanning Probe Microscope
(Veeco)

Surfscan 6420 Wafer Surface Analysis System
(KLA Tencor)

Qualilab QL-5EX
(ECI Technology)

Muetec 3000
(MueTec GmbH)

Capacitive Wafer Geometry Measurement System MX 208
(Eichhorn & Hausmann)

SEMDEX 301
(ISIS Sentronics GmbH)

LH Microscope
(Nikon Metrology GmbH)

3D Konfokal Mikroskop
(Leica Microsystems)

1 Programming a recipe
2 Wafer cleaning
3 Electroplating
Available resources

The aforementioned equipment is ready to provide you with individual process steps. Your sensing and actuating devices may require more than that: Process modules, a consolidation of thoroughly grouped process steps, form the basis of our microsystem development. Several modules are described in the following; listing the technologies used naming some of the underlying principles, and their already existing or potential application. Further modules will be added, derived from current projects or adapted to your requirements.

Overview Process Modules (8 inch)

- Free standing structures
- Electrodes
- Packaging
- Optical components and devices
- Bio sensors
- Nanostructures
- Passive components
FREE STANDING STRUCTURES

Surface micromachining is used to generate freestanding structures. A sacrificial layer is deposited and structured, the functional layer on top will be freed by removing the sacrificial layer underneath.

Technologies

• (SOI-) Free standing structures
• Electrically connected free standing structures a-Si/SiGe/Ge
• Sealed structures
• Sacrificial techniques (oxide, a-Si)

Principles

• Thermal isolated structures
• Resonantly oscillating components, e. g. cantilevers, membranes

Applications

• Bolometric sensors
• Fluid flow sensors
• Mass sensor
• Optical devices
• Pressure sensors

1 Membrane on top of CMOS
ELECTRODES

Accessing sensitive layers, packaging of sensors, or supplying signals and power require reliable electrodes and contacts. Low resistance and inert metals are deposited and structured, their surfaces sometimes modified by additional thin film coatings.

Technologies

- Substrate planarized CMOS
- Thin film electrodes (sputtering, evaporation, atomic layer deposition)
- 3D-electrodes (electroplating)

Sensor Principles

- Resistive
- Capacitive sensing
- Electrochemical redox reaction

Applications

- Interdigital electrodes
- Electrochemical sensors
- Capacitive and resistive sensors
- Moisture sensor

2. Electroplated contacts
PACKAGING

Microsystems packaging is science and art. It combines offering access for the media to be measured with protecting the device for longtime reliable operation.

Technologies

- Wafer-to-wafer bonding (SLID, direct)
- Flip chip bonding
- Wafer thinning
- Electroplating

Applications

- Chip scale packaging
- Vacuum packaging
- High temperature packages
- Flip-chip-to-ceramic package
- Bumping (Au, Ni, Sn, Cu)
- Optically transparent lids
- Anti reflecting coating (from UV to IR)
- Getter

3 Cu-Sn-Cu SLID connection
Semiconductor layers are sensitive to light. If you put them on top of the CMOS wafer, novel imaging applications may be generated. Or you may just modify an existing optical device by adding filters, lenses or light shields. We have already dealt with optical wavelength from extreme UV (10 nm) to infrared (> 10 μm).

**Technologies**

- Anti reflecting coatings / structures evaporation
- Atomic layer deposition
- Micro lenses
- Color filters
- UV transparent passivation
- Hybrid imager integration by wafer to wafer bonding

**Principles**

- Optically active layers: Si, SiGe, Ge (amorphous, micro-crystalline)
- Evaporation, ALD
- Interference layers (vis, IR, UV)
- Backside illuminated imagers

**Applications**

- Photo diodes
- Photo cells
- Imagers (vis, IR, UV)
- Optical components (optical interference filter, Fabry-Perot filter)

4 Solar cells for on-chip energy scavenging
BIO SENSORS

Postprocessing on CMOS is an ideal means for intelligent bio sensors. If an adsorption reaction of a bio molecule has an electronic response, e.g. a charge change, you may read it out directly. If the adsorption creates a mere mass change, read it out with a resonantly vibrating microstructure. Resistance or capacitance changes, even the local detection of light are other useful sensing methods.

Technologies

- Surface machined membranes
- Surface functionalized electrodes
- 3D electroplated electrodes

Principles

- Resonant components: cantilevers, membranes
- Capacitive sensing
- Electrochemical reactions

Applications

- Glucose sensor
- Allergen sensor
- Nanopotentiostat

Resonant membrane bio sensor with readout circuit
NANOSTRUCTURES

Inert films, a few 10 nm thick, offer excellent device protection, when combined with suitable passivation layers. The exploitation of nanostructured electrodes, especially when combined with CMOS readout or stimulation, has just scratched the surface of potential applications.

Technologies

- Thin protection films by atomic layer deposition
- 2D and 3D nano structures

Principles

- Protection films
- 3D electrodes

Applications

- Nano needles
- Nanowires
- MOx gas sensors
- Bio-compatible protection layers
- Catalytic layers

Tips of submicron hollow metal needles
PASSIVE COMPONENTS

Microsystems integration not only requires active devices like sensing layers or circuits, but benefits from passive devices as well. Electronic passive devices (capacitors, resistors) may be integrated or used as standalone components. We may use the process steps available also to create passive mechanical structures, e.g. precision holes, or modified surfaces.

Technologies

- Bulk micromachining
- High aspect-ratio etching
- Atomic layer deposition

Applications

- (High temperature) trench capacitors
- Metal film resistors with near zero TCR
- Oxide isolated trenches in thickfilm SOI
- Sieves

7 Deep trenches in silicon
Fraunhofer Institute for Microelectronic
Circuits and Systems IMS

Finkenstraße 61, D-47057 Duisburg
Phone +49 203 37 83-0
www.ims.fraunhofer.de

Contact
Martin van Ackeren
Phone +49 203 37 83-130
martin.van.ackeren@ims.fraunhofer.de

Access by car
via motorway A40
• exit »Duisburg-Kaiserberg«
• direction »Innenstadt«, »Zoo« (Carl-Benz-Straße)
• after approx. 1 km (direction »Innenstadt«) turn right into Mülheimer Straße
• pass the Zoo
• after 300 m turn left at traffic light into the Loharthstraße
• at third street turn right into Finkenstraße
• institute is on the right side

via motorway A3
• exit »Duisburg-Wedau«
• direction »Innenstadt« (Koloniestraße)
• at third traffic light turn right into Mozartstraße, which turns into Loharthstraße in the following of the street
• after 800 m turn left into Finkenstraße
• institute is on the right side

Access by airplane
arrival at Airport Düsseldorf-International
a) Taxi (duration 20 min.)
b) take the shuttle bus to airport railway station.
   In the following use the train to Duisburg Central Station.

Access by train
arrival Duisburg Central Station
a) Taxi (duration 5 min.)
b) Bus number 924 (direction »Sportpark«), exit at station »Universität«, duration about 8 min.
   Bus number 933 (direction »Universität«). Exit at station »Universität«, duration about 11 min.