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Improved Handling of Silicon and Copper Substrates for Microelectroplating

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EAST-forum – April 2003

silicet
ETCHING TECHNOLOGY FOR MICROSYSTEMS

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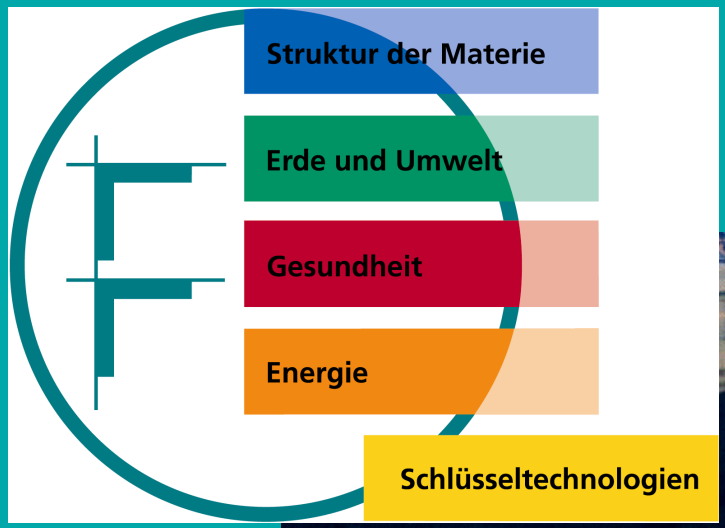

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Institute for Microstructure Technology

R&D, Fabrication: Micro-Structures, Micro-Components, Micro-Systems

Materials: Polymers, Metals, Ceramics

Applications/Technology: Micro-Optics/LIGA and Micro-Fluidics/AMANDA

Industrial Implementation:

TÜV CERT
DIN EN ISO 9001
Zertifikat 09 100 90034

Development, manufacture and sales of complex microsystems, tools for the fabrication of microsystems components, and processes for the microstructuring of metals and plastics

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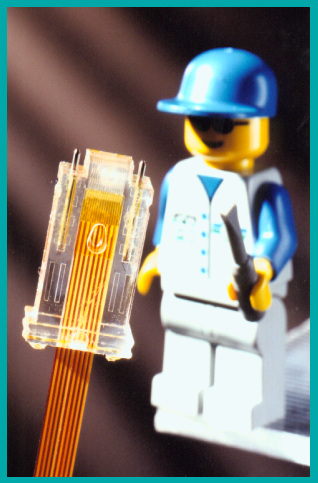
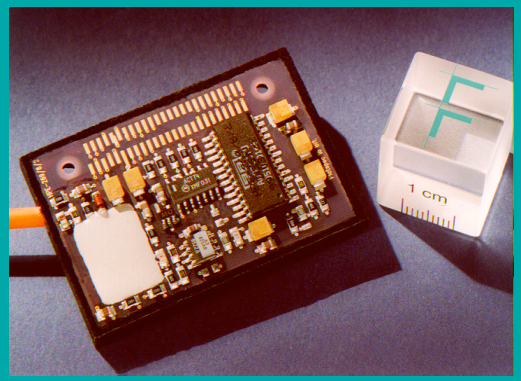
Institute for Microstructure Technology - Optics

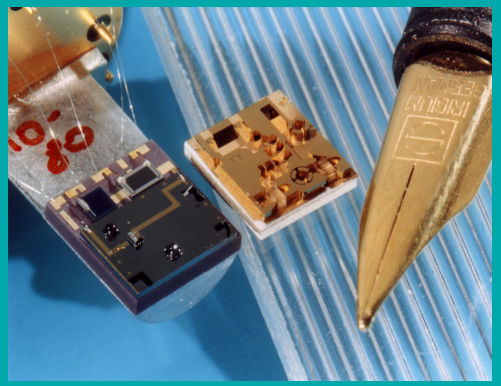
Fiber-Connector



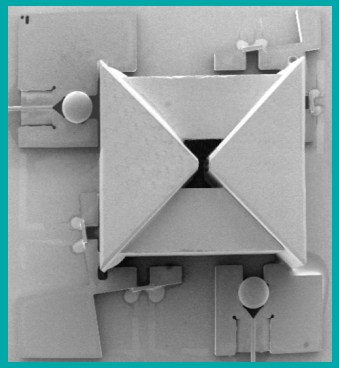
IR-Spectrometer



Distance Sensor



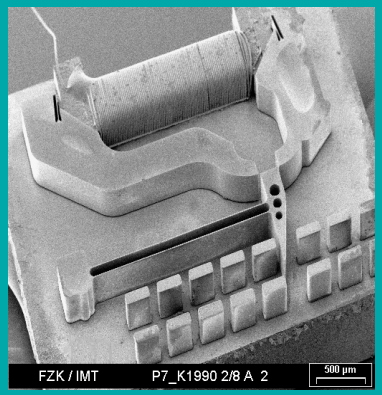
Heterodyne Receiver



Research to Product

2x2 Matrix Switch

Electromagnetic Chopper



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Tools ← **Metallic Microstructures** → **Components**

↓

Microelectroplating

(nickel, copper, gold, nickel alloys)

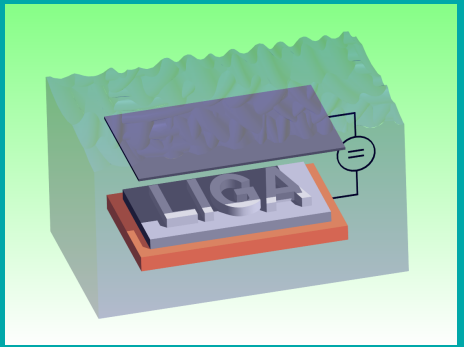
in combination with

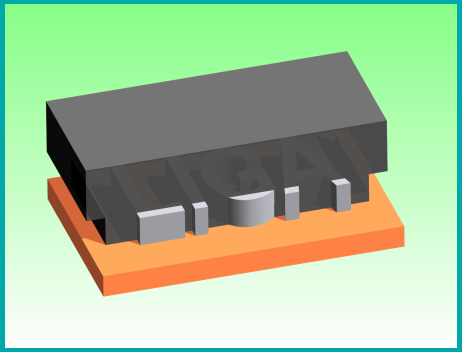
X-ray lithography

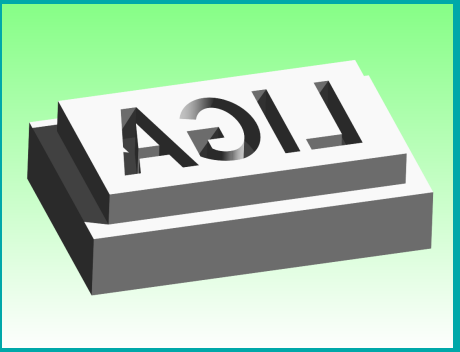
LIGA

UV lithography

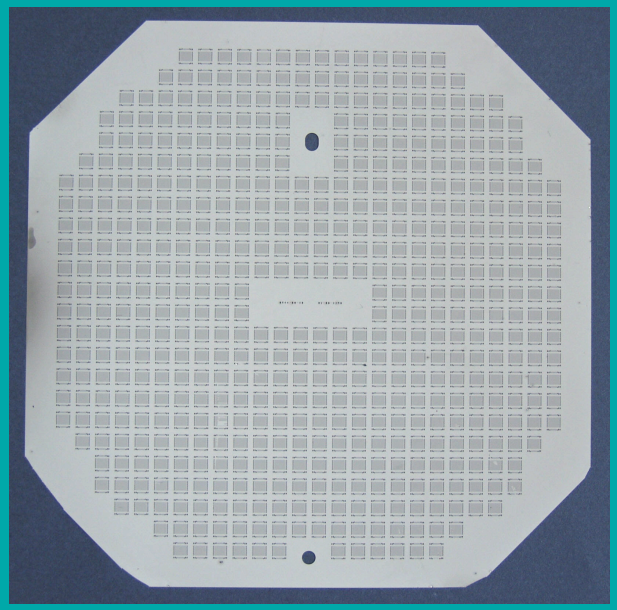
UV-LIGA





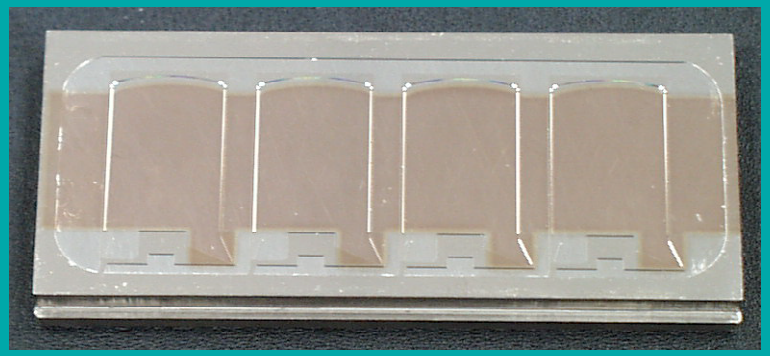


Examples of Metallic Microstructures - Tools



Shadow masks for PVD techniques

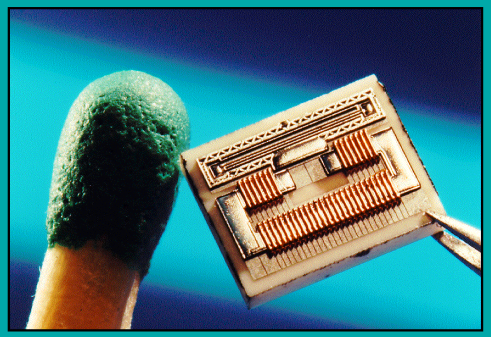
- Fabrication with UV-LIGA technology
- Nickel, thickness 40 µm, aspect ratio 1, formats up to 5 inch



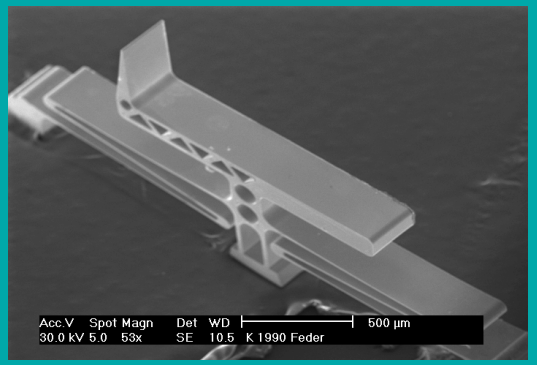
Mold inserts for hot embossing or injection molding

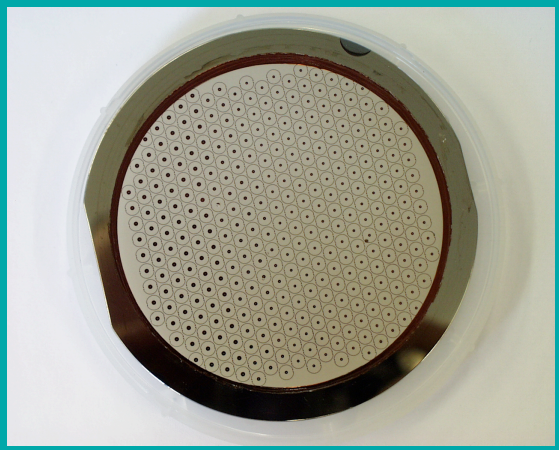
- Fabrication with LIGA technology
- Nickel, thickness 5 mm, aspect ratio 1, structure height up to 400 µm
- e.g., for spectrometers or optical fiber connectors

Examples of Metallic Microstructures - Components



Micro relay





Particle counters

From Research and Development to Product Fabrication

Process transferability to industry

- process optimization
- process stability
- process reproducibility
- yield aspects
- standardization of procedures
- easy materials handling and equipment use

→ **but suitable equipment is insufficiently available**

→ **presently fabrication restricted to technically simple conditions**

From Research and Development to Product Fabrication

Key issues for yield enhancement and reliability

- finding and qualifying external suppliers
- modifying processes to reduce handling
- finding ways to monitor each piece of equipment involved
- establishing quality specifications between process steps
- improving the understanding of each process step

→ finding solutions for improvement of equipment and handling in microelectroplating

From Research and Development to Product Fabrication

- successful cooperation with the company **silicet AG**

> worldwide specialist in high quality etching technology

> development and production of wafer holders and other equipment for chemical and electrochemical wet etching of silicon wafers

> multi-patented holder system available in different formats used in many companies worldwide

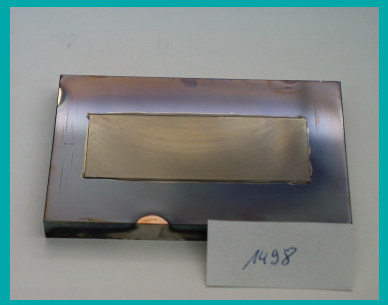
Tasks and aims for cooperation

- Test the compatibility of wafer holder system for use in microelectroplating of nickel
- Design, construction and test of new holder to meet IMT‘s requirements

Substrates for Microelectroplating

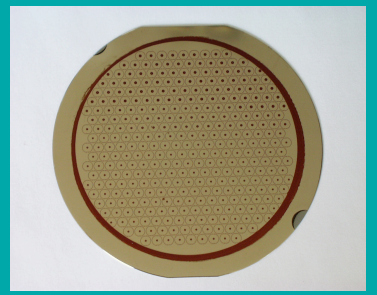
- LIGA

- copper sheets (54 x 86 mm^2, 8 mm thick)
- electroplated with nickel or gold , complete coverage
- one surface polished and coated with titanium or titanium oxide



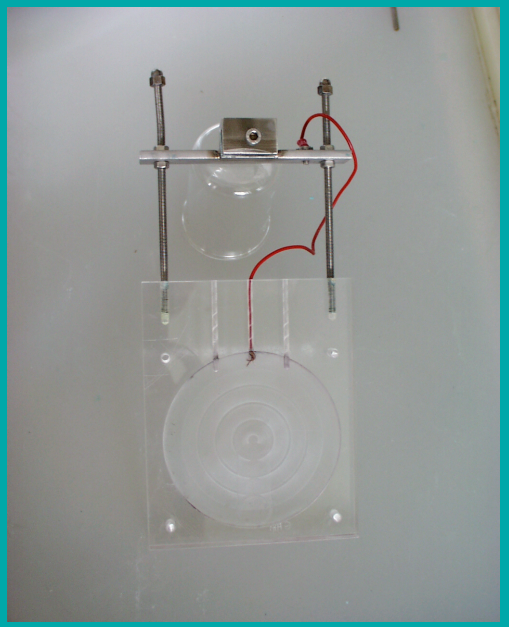
- UV-LIGA

- standard silicon wafers (4-, 6- or 8-inch formats)
- surface coated with titanium (or titanium oxide) as well as chromium/gold

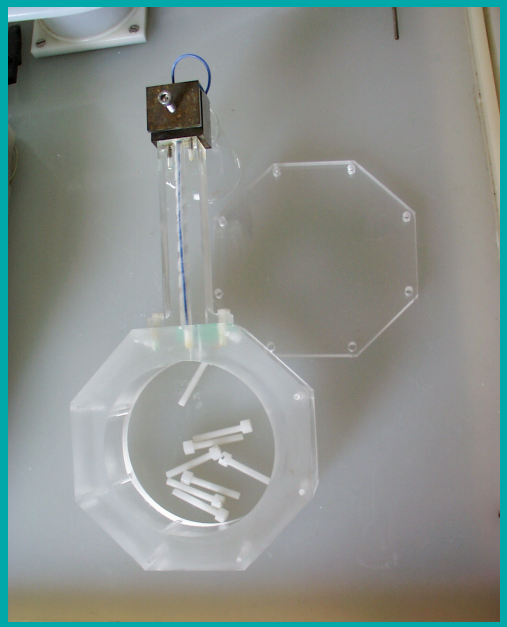


→ Substrate areas needing protection against electroplating must be sealed off

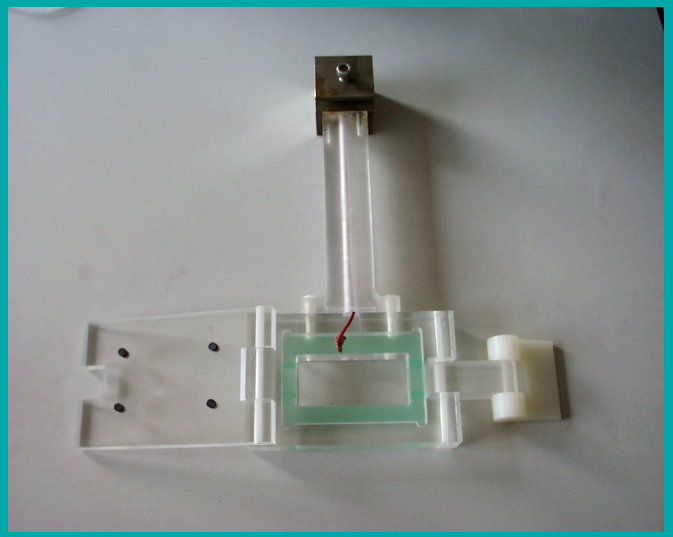
In-house constructed holders ...



- for 4-inch wafers



- for 6-inch wafers



- for LIGA mold inserts

→ to date, a tight seal was obtained by wrapping the whole substrate with polymer tape

... previously used at IMT in microelectroplating

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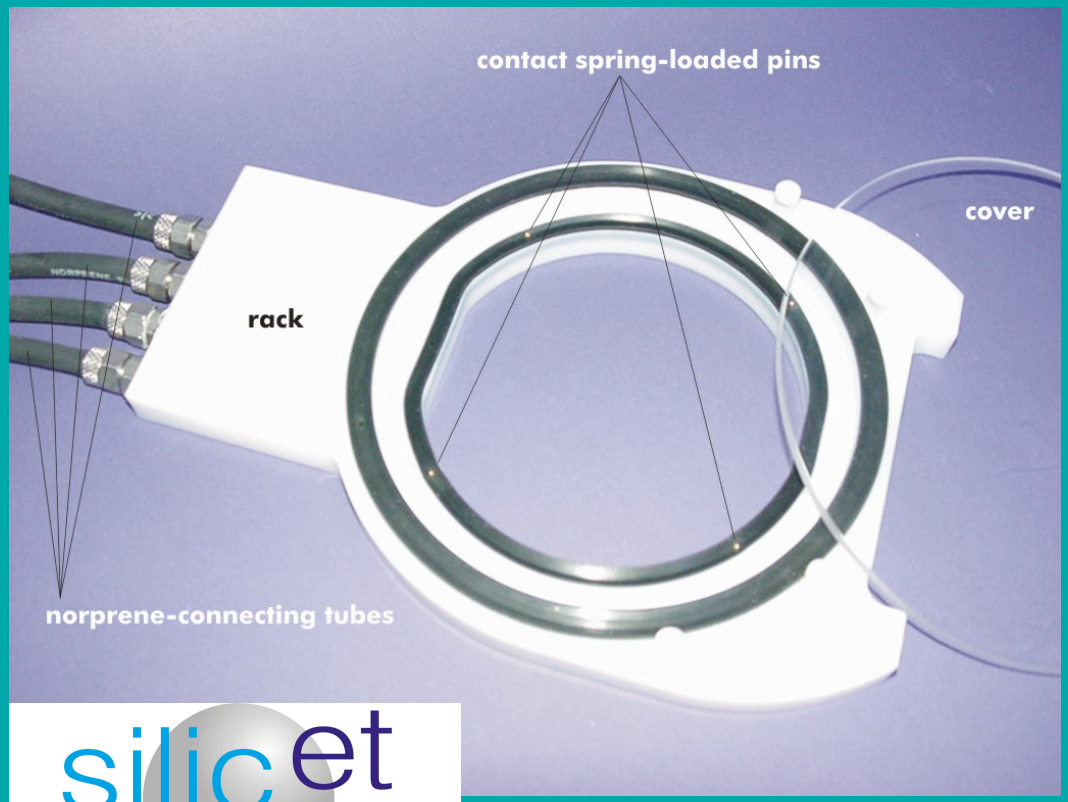
New Holder System for Electroplating from silicet AG



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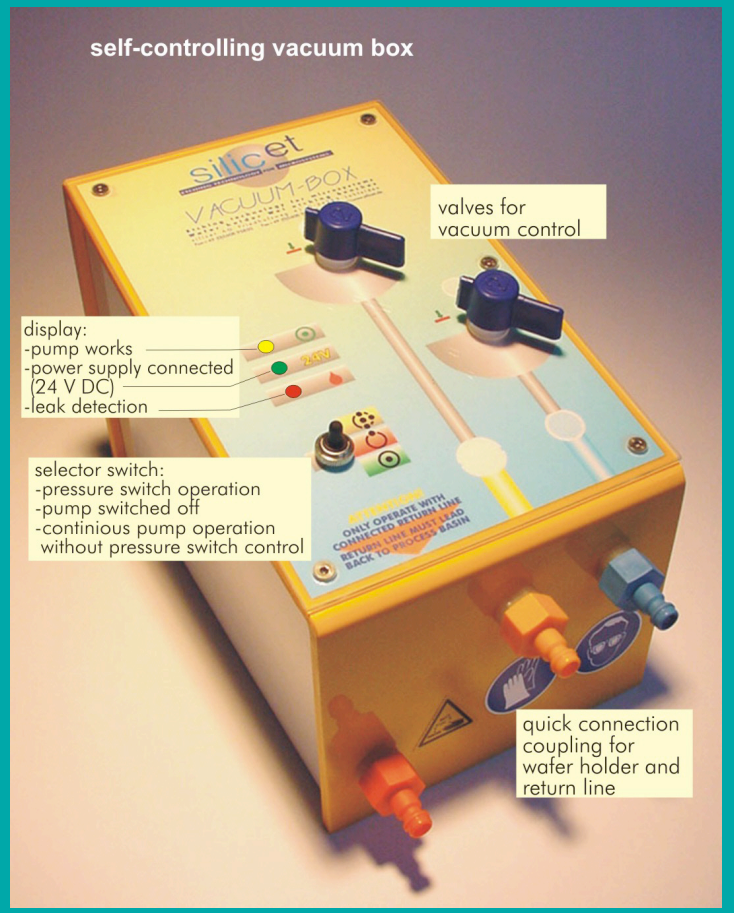
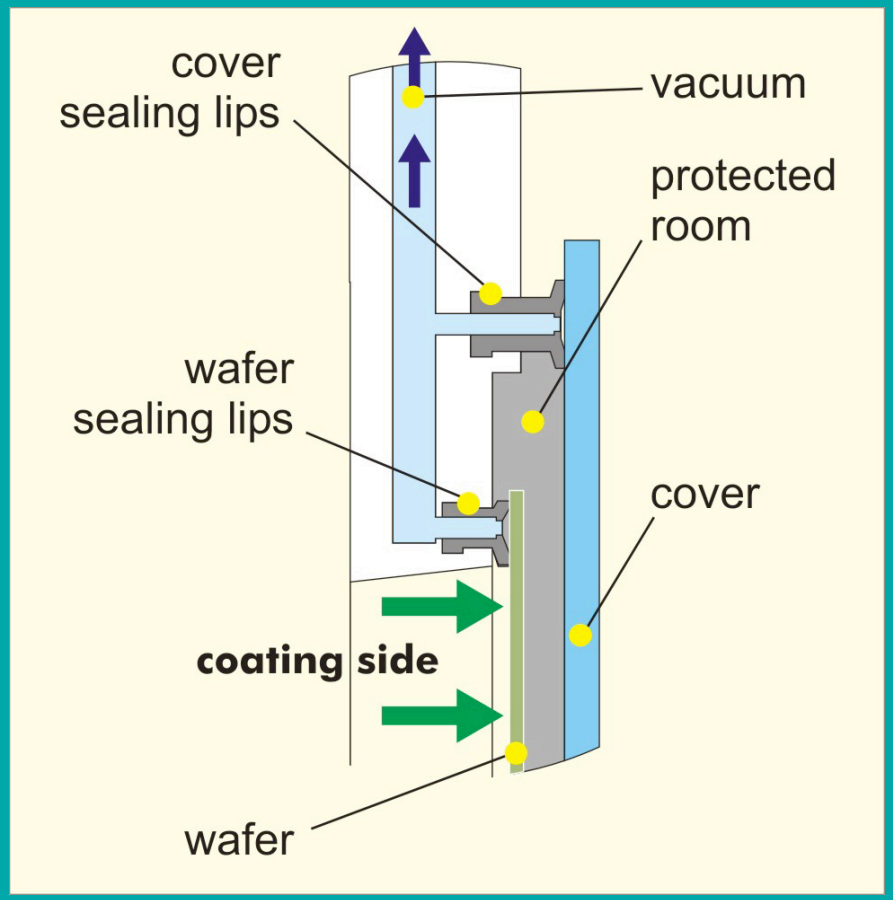
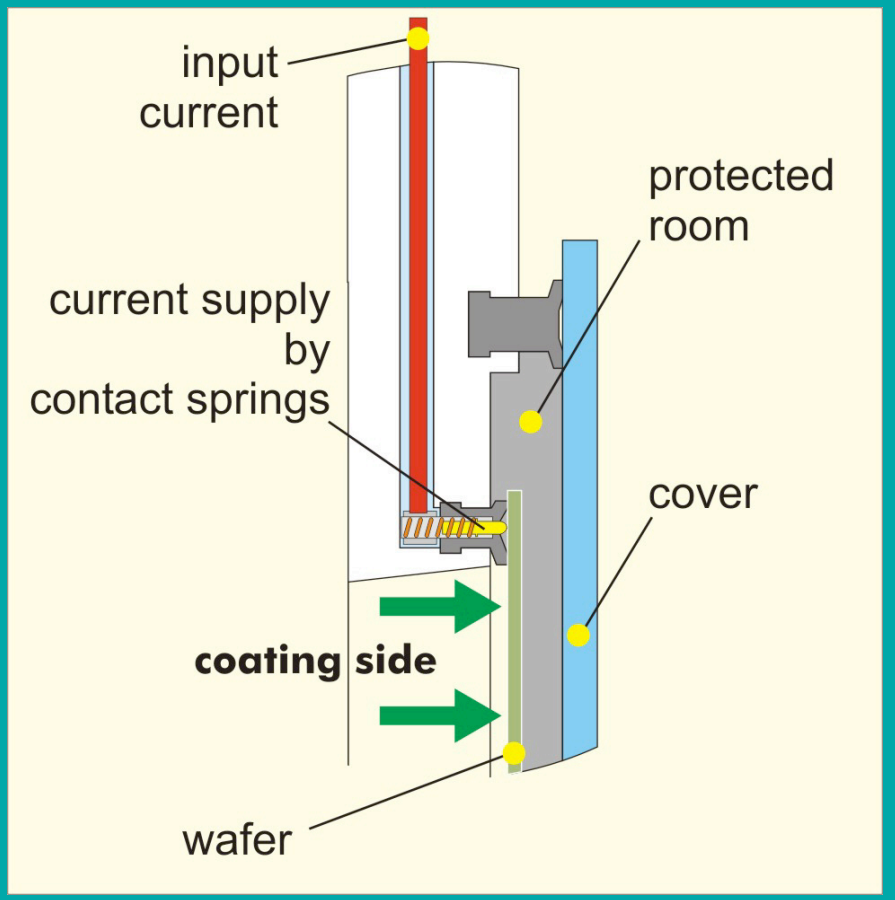
For silicon wafers



New Holder System for Electroplating from silicet AG





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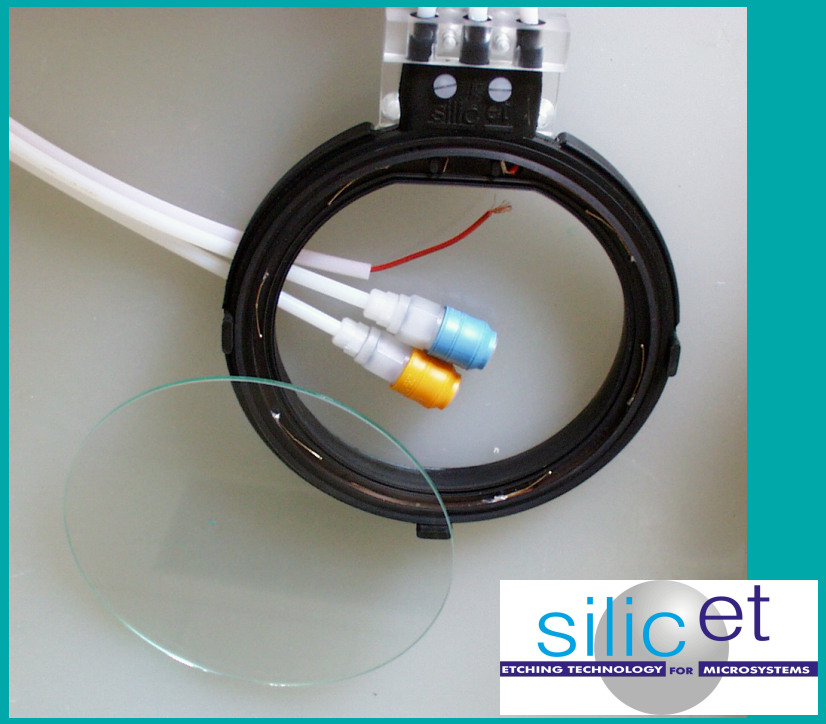
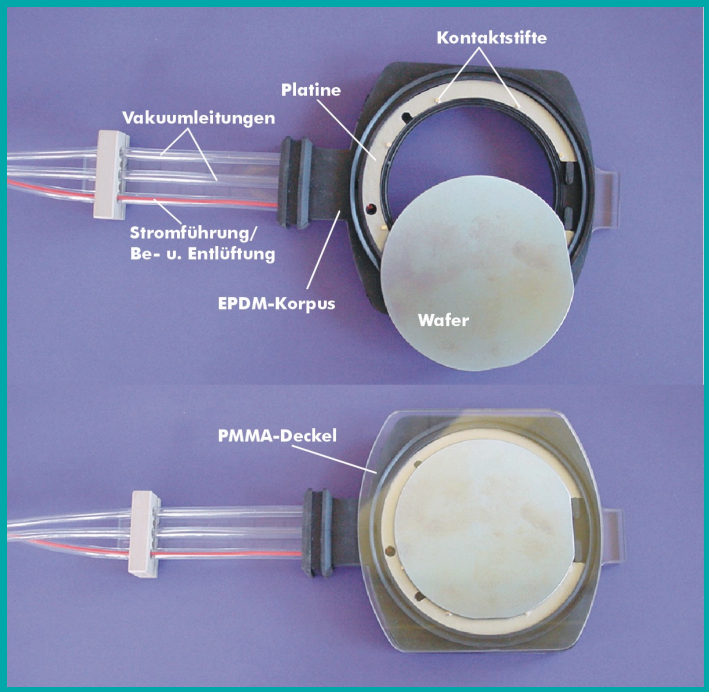
New Holder System for Electroplating from silicet AG



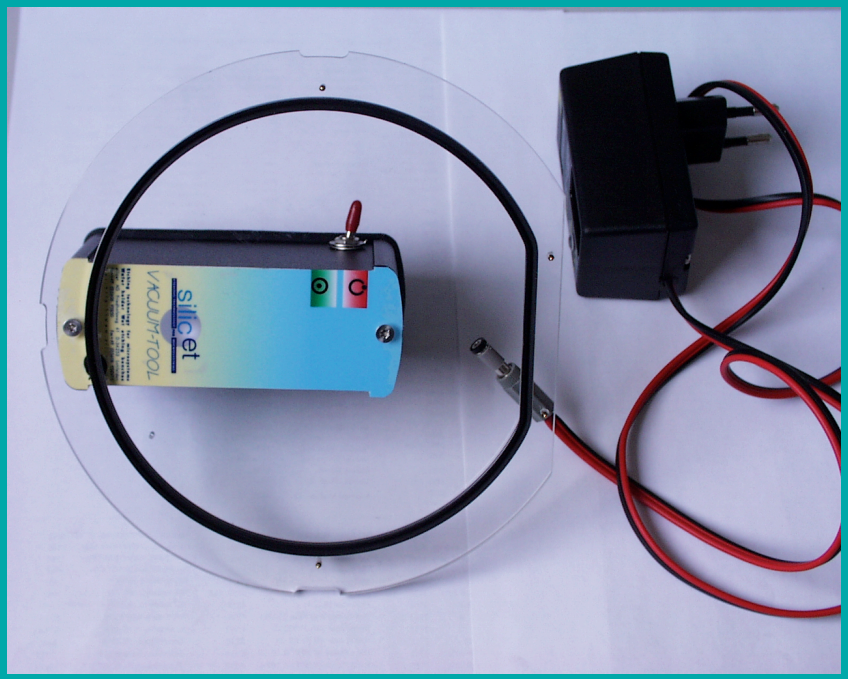
Holder for 6-inch wafers



First holder type for tests with 4-inch wafers in microelectroplating

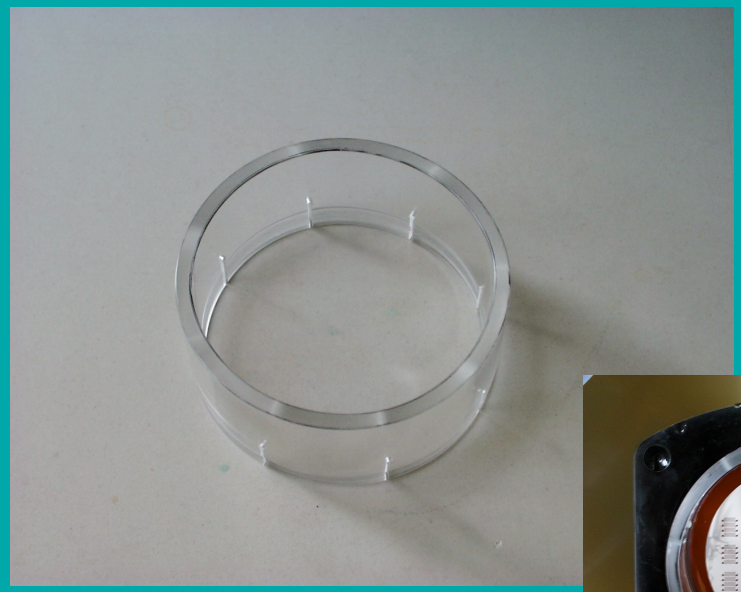
Accessories such as Vacuum Tweezer from silicet AG

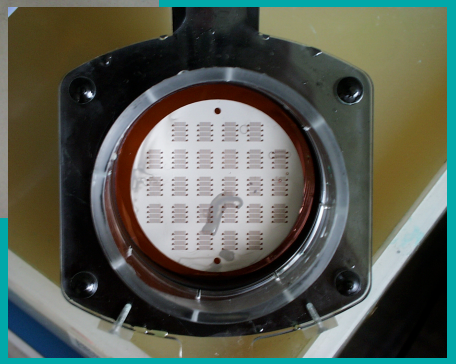
For 4-inch silicon wafers



For 6-inch silicon wafers

Further Accessories from silicet AG





Shield (for more homogeneous layer growth)

Tool for wafer pressing

Using the New Wafer Holder in Microelectroplating

Experiments on titanium or gold-coated unstructured wafers

- no polymer tape wrapping of the wafer
- holder materials are compatible with the electrolyte system
- problem-free electroplating
- no leakage (deposition times up to 42 hours)
- error-free deposited layers (up to 500 µm nickel)

→ simplified and faster loading and unloading of the holder than previously

Using the New Wafer Holder in Microelectroplating

Experiments on titanium-coated unstructured wafers – **Layer homogeneity**

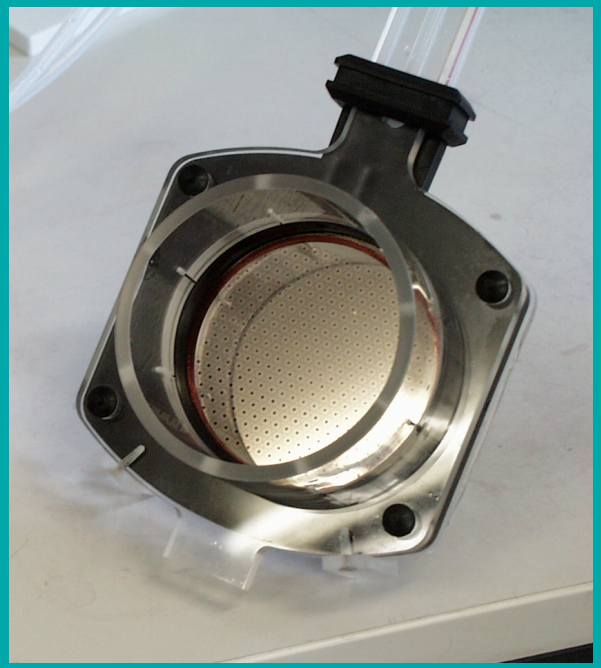
Calculated thickness	Electroplating without shield		Electroplating with shield	
	Layer edge	Layer center	Layer edge	Layer center
1 A/dm^2				
20 µm	22	13	21	16
50 µm	57	45	54	47
100 µm	108	85	109	95
200 µm	213	176	214	182
500 µm	539	430	542	465
0,5 A/dm^2				
20 µm	22	17	23	18
200 µm	205	172	201	175

Using the New Wafer Holder in Microelectroplating

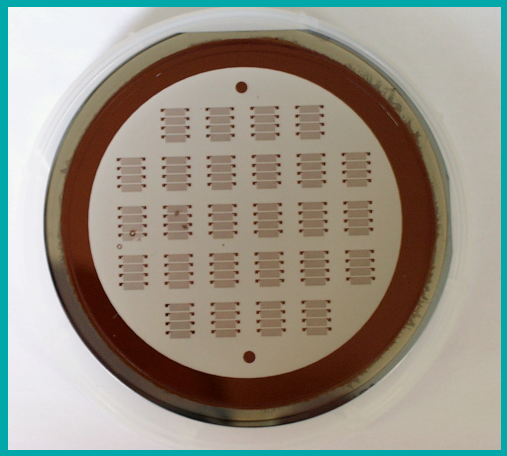
Experiments on titanium-coated unstructured wafers – **Wafer curvature**

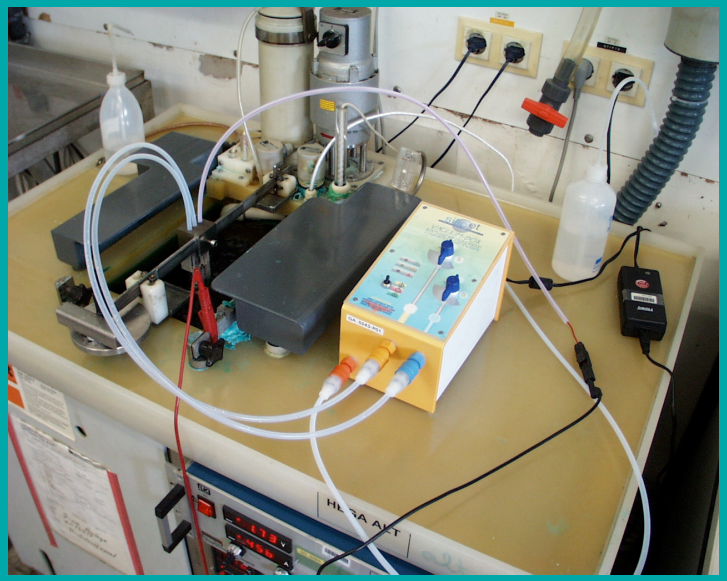
Calculated thickness	Electroplating without shield	Electroplating with shield
	Increase in curvature	Increase in curvature
1 A/dm^2		
20 µm	10 µm/cm *	16 µm/cm
50 µm	19 µm/cm	30 µm/cm
100 µm	25 µm/cm	43 µm/cm
200 µm	32 µm/cm	58 µm/cm
0,5 A/dm^2		
20 µm	8 µm/cm	15 µm/cm
200 µm	49 µm/cm	54 µm/cm
* Scan length 8 cm perpendicular and parallel to wafer flat (through wafer center)		

Using the New Wafer Holder in Microelectroplating



Fabrication of shadow masks





- nickel galvanic deposition with sulfamate electrolyte
- 1 A/dm^2; pH 3.5 ... 3.8; 52 °C
- nickel thickness 27 µm → 2,5 hours

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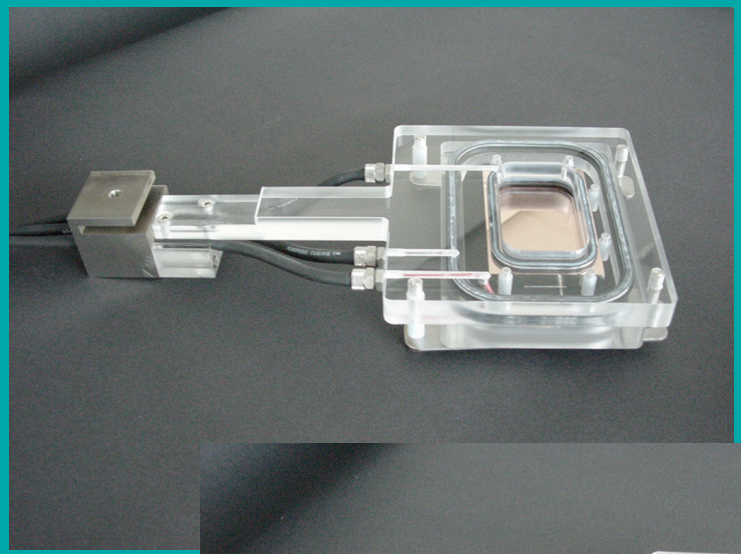
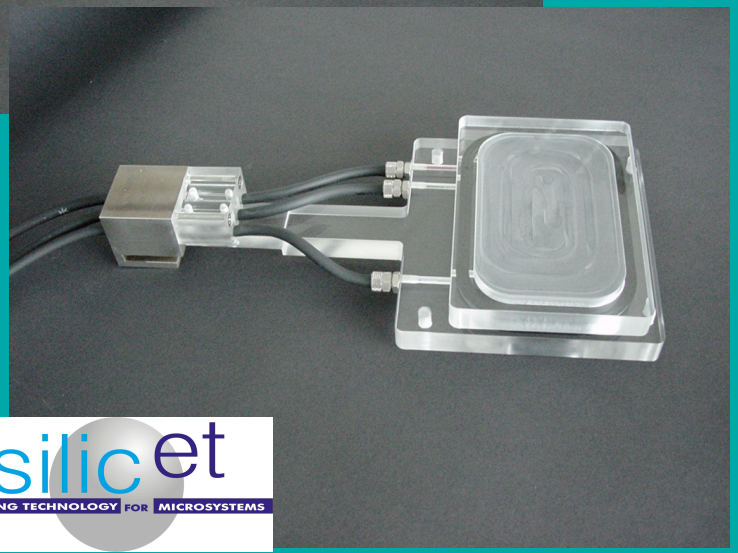
New LIGA Holder System for Microelectroplating from silicet AG





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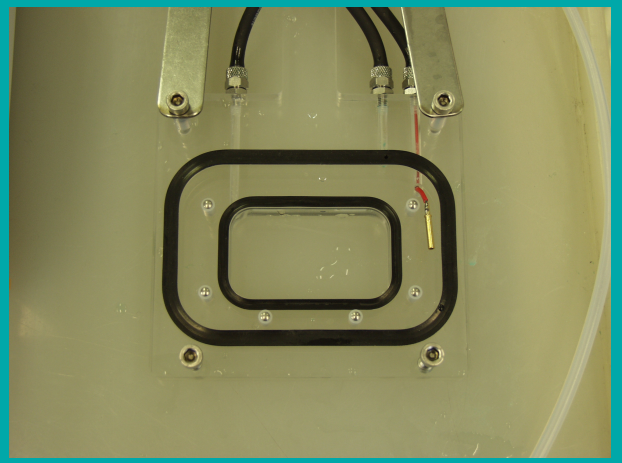
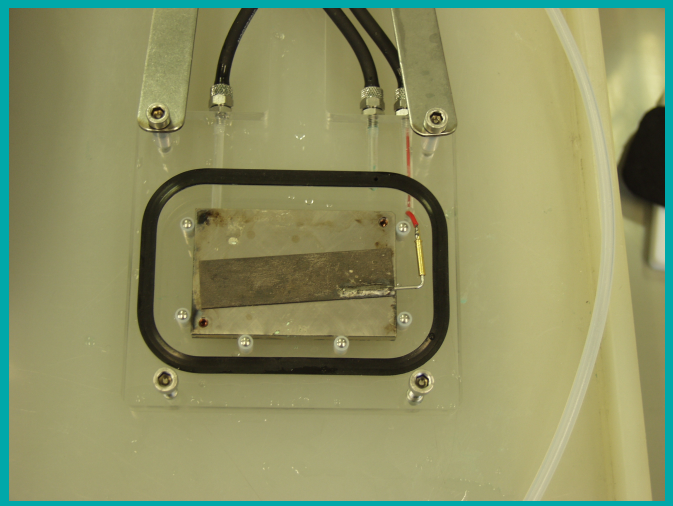
For copper sheets





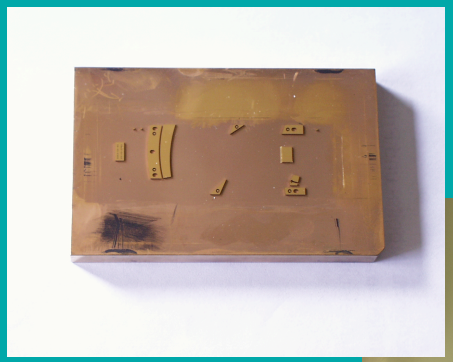
Using the New LIGA Holder in Microelectroplating

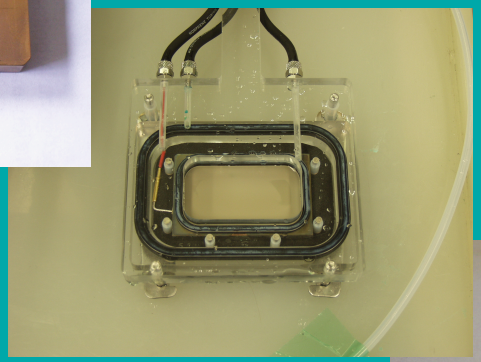
Experiments on unstructured / structured copper substrates

- no polymer tape wrapping of the copper sheets
- holder materials are compatible with the electrolyte system
- problem-free electroplating
- no leakage (deposition times up to 10 days)
- error-free deposited layers (up to 6500 µm nickel)

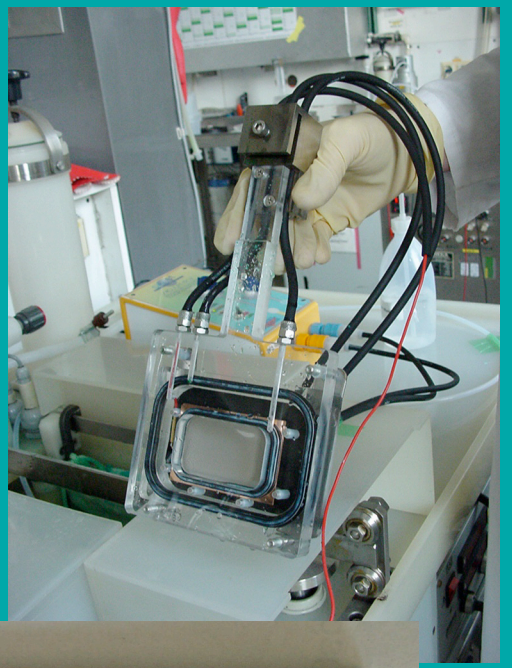
→ simplified and faster loading and unloading of the holder than previously

Using the New LIGA Holder in Microlectroplating





Fabrication of LIGA mold inserts



- nickel galvanic deposition with sulfamate electrolyte
- 1 ... 1,8 A/dm^2; pH 3.5 ... 3.8; 52 °C
- nickel thickness 6 mm → 10 days

Using the New LIGA Holder in Microelectroplating

Experiments on unstructured copper substrates – **Layer homogeneity**

Calculated thickness	Electroplating with shield		
	Layer edge	Layer center	Difference
99 µm	99	95	4
269 µm	262	253	9
489 µm	485	452	31
1044 µm	1039	1000	89
3110 µm	3184	2786	398
4686 µm	5007	4101	906
6380 µm *	6741	5404	1337
* Substrate with structured resist			

Conclusions

- wafer holder and LIGA holder are suitable for nickel electroplating
- holder system ...
  - ... is easy to to use in operation and handling
  - ... avoids manual preparatory work
  - ... leads to simpler fabrication logistics
  - ... can be adapted to different substrate types and substrate formats

→ **Increase in reliability and process stability in micro-manufacturing**

Thank you for your participation !

More informations available from

- www.silicet.de

- www.fzk.de/imt/

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