

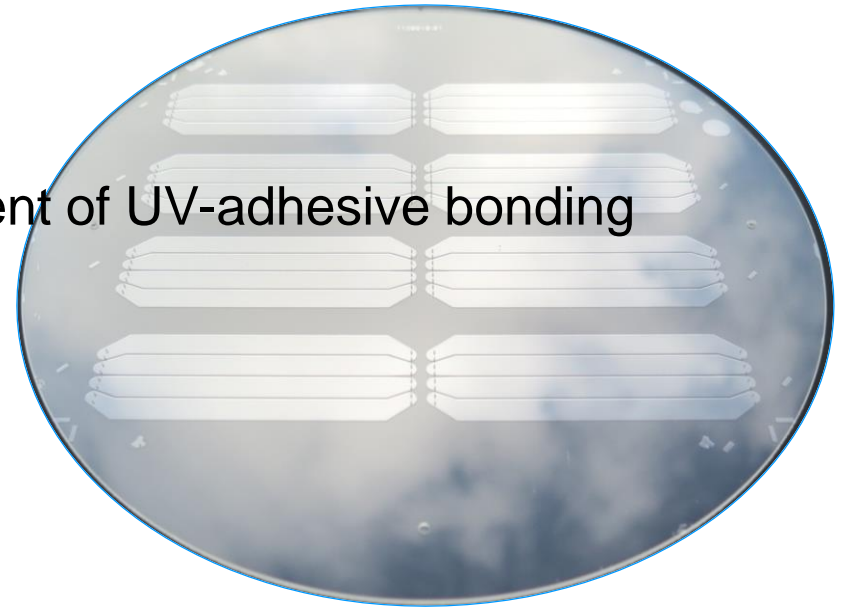
# Structuring and bonding of glass-wafers

Dr. Anke Sanz-Velasco



P R E C I S I O N   O N   G L A S S

- **IMT**
  - Why glass?
  - Components for life science
  - Good bond – requirements and evaluation
  - Wafer bonding
    - 1. Fusion bonding
    - 2. UV-adhesive bonding
  - Customer-specific development of UV-adhesive bonding
  - Laser dicing



## IMT Masken und Teilungen AG - Keydata

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Foundation	Dr. Rüst AG, Stäfa in 1959
Ownership	HEIDENHAIN Group since 1994
Employees	107
Revenue 2016	CHF 25 Mio.
Investment ratio	15% of total revenue
Cleanroom	1500 m <sup>2</sup>
Substrates	70.000 / year
Components	1.4 Mio. pcs / year
	Traceable to METAS, ISO 9001:2000 and NIST certification

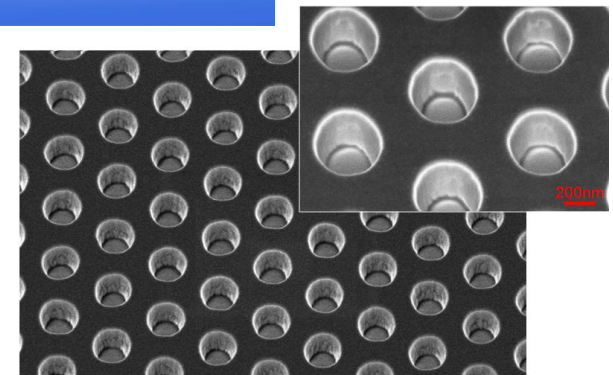
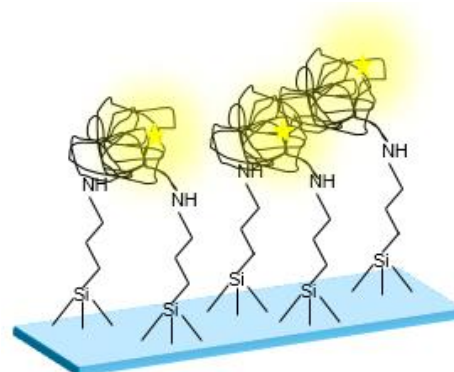
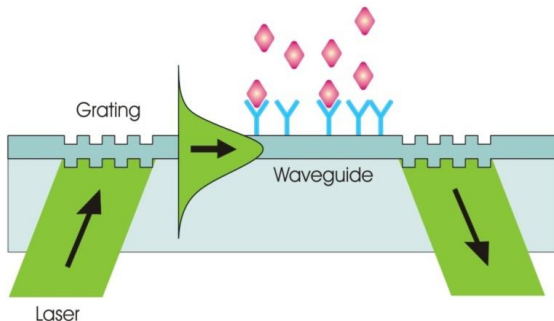
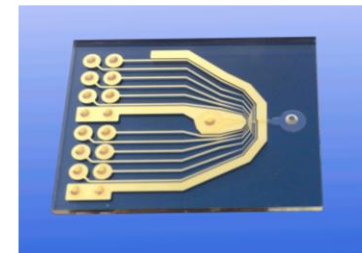


**Consumables in glass  
for  
Life Science applications**

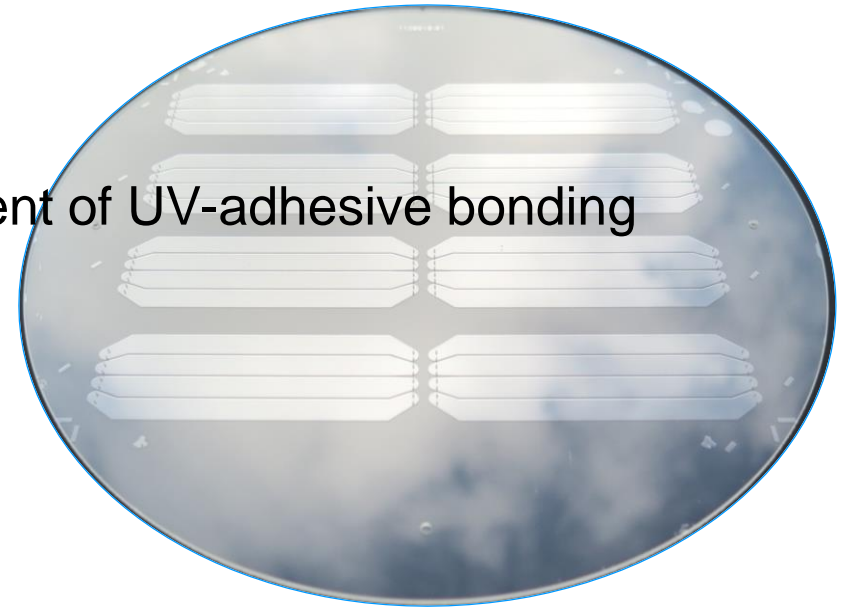
## Services for Life Science industry

Development and large scale manufacture of cost effective glass consumables


- Complete assembled flow cells
- Nano- and micro-patterns on glass
- Nano-wells and channels in glass
- Nanopillars in glass
- Structured electrodes on glass
- Planar or structured Waveguides and phase gratings to guide and couple light
- Structured polymers (photoresists)
- Covalent bond chemistry
- Through-holes
- In-house master manufacture
- Bonding of glass substrates



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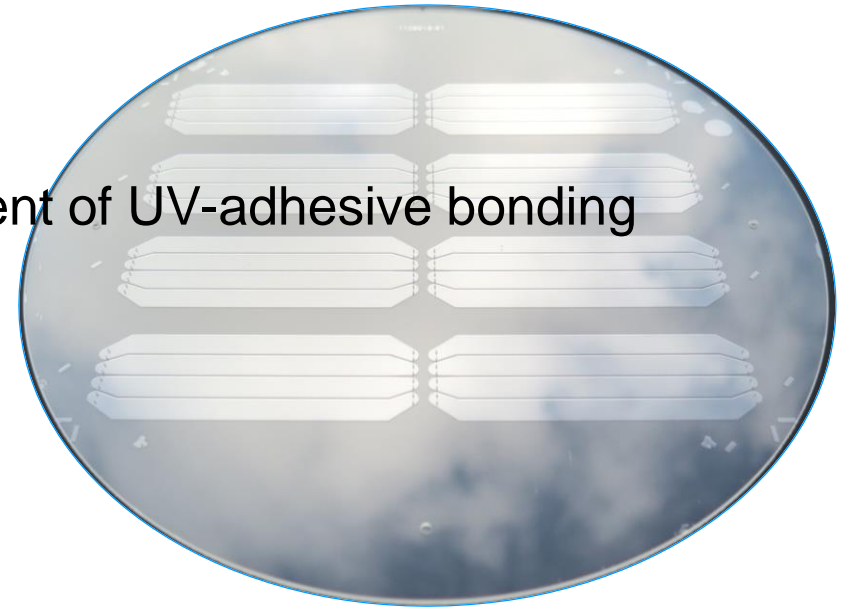


# Why glass?

Excellent physical properties	Other benefits
<b>Mechanical:</b> Homogeneous and isotropic Good mechanical stability Light weight (density = 2.5 g/cm <sup>3</sup> )	Cost efficient Good process ability (polishing, grinding, dicing, breaking, etc.) Available in different forms (flat glass, tubes, etc.) Many variants (float-, silicate-, flint-glass, glass ceramics, quartz etc.)
<b>Optical:</b> High transparency (visible to IR) Low fluorescence	
<b>Electrical:</b> Low thermal expansion Electrical isolator	
<b>Chemical:</b> High chemical resistance Chemically inert	

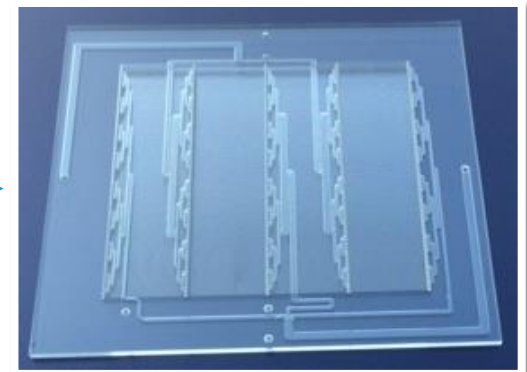
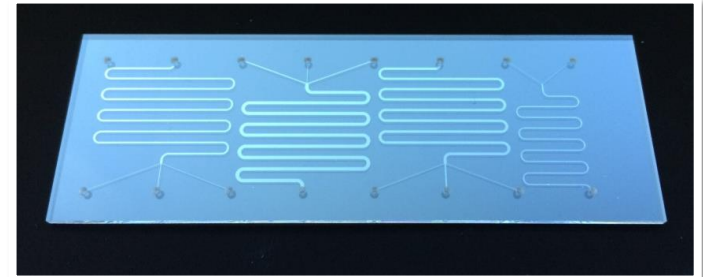
MEMpax® Borosilicate glass wafers Schott

- IMT
- Why glass?
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## Components for life science

Etched channels  
Micro- and nanostructures  
Holes and via holes

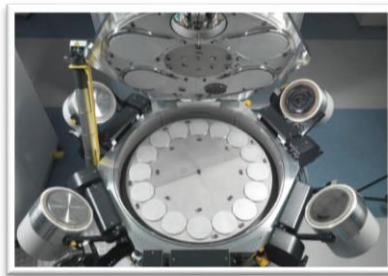




## Components for life science - automated process line for $\varnothing$ 200 mm



**Cleaning**



**Coating**



**Lithography:  
resist coating**



**Lithography:  
exposure**



**Lithography:  
developing,  
etching and  
cleaning**

**Prozessablauf**

## Components for life science - microchannels and -wells

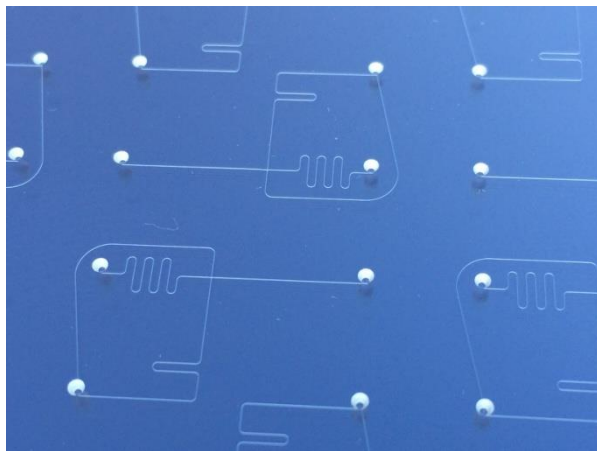
### Microchannels and -wells in glass using wet etching (HF)

#### Advantages:

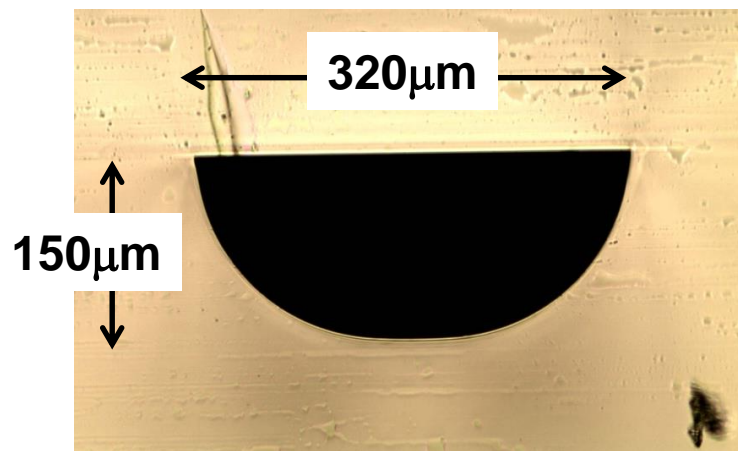
- Cost effective
- Homogeneous etching, i.e. surface roughness <50 nm
- High degree of freedom in the pattern design

#### Limitations:

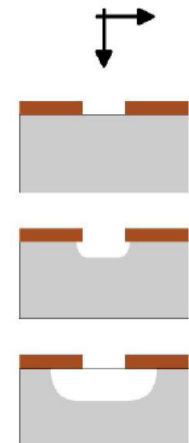
- Vertical walls and high aspect ratios not possible
- Isotropic process, i.e. the channels are always broader than deep and wider than the structures in the etching barrier (Masking).



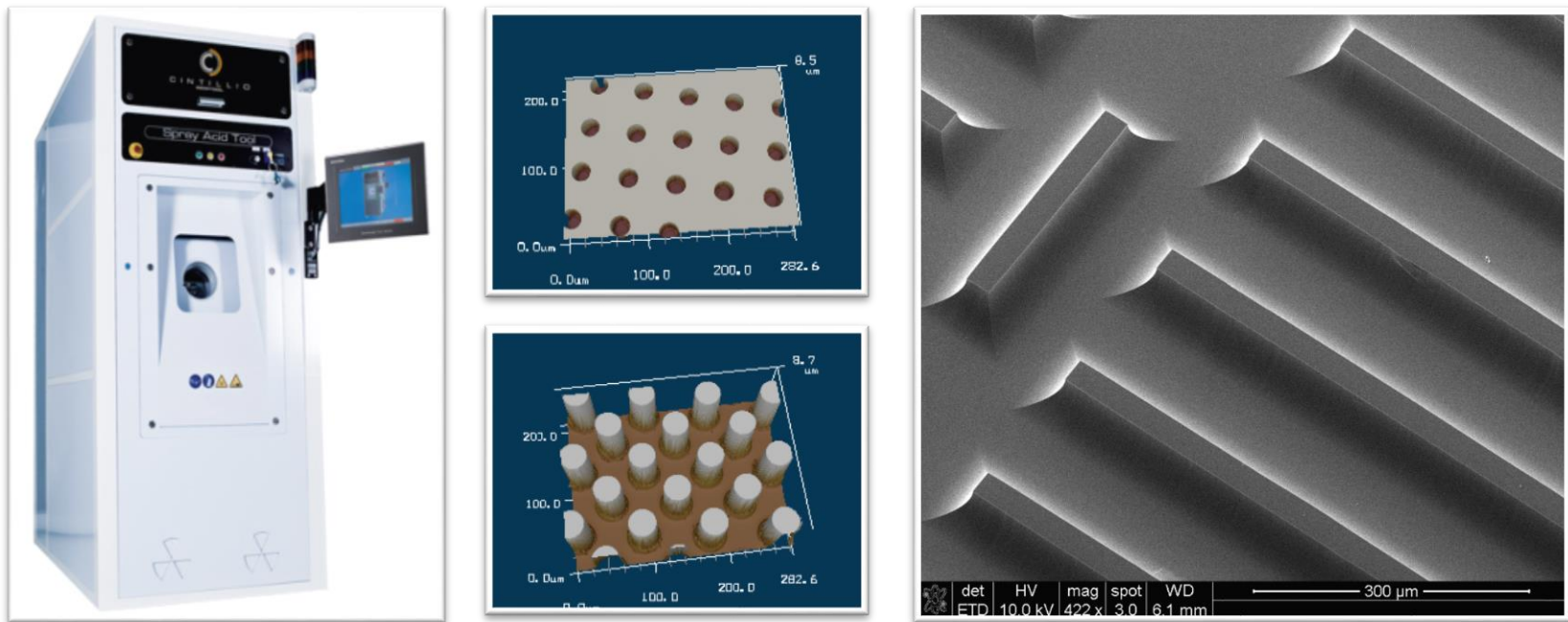
**Glass micro-reactor**



**Smallest feature size 10µm**



## Components for life science - glass etching - HF spray



Etching of microstructures in glass 16 x Ø 200mm wafer / batch with excellent homogeneity ( $\pm 1\%$  within the batch)

Complete processing dry-in – dry-out

Use of different

- Chemistries and concentration (HF, HNO<sub>3</sub>, HCl,...) and
- Glass types (B270, D263, Borofloat, Mempax)

## Components for life science - glass etching - HF spray

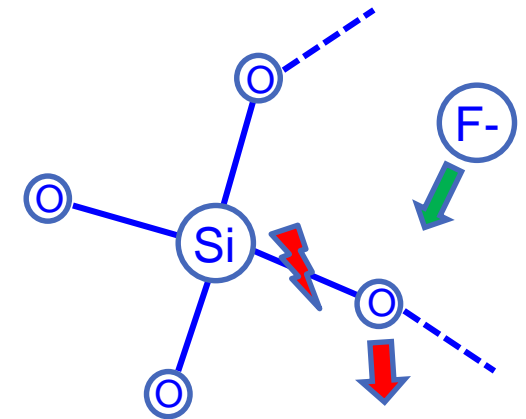
### Reaction



### Spray acid process

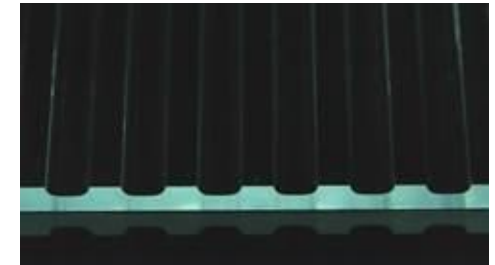
Chemistry (temperature variable)

Circulation (defined flow) guarantees homogeneity



### Masking

Stressfree	↔	Layer thickness
Pinholefree	↔	Layer composition
Free from scratches	↔	Cleanliness
Good adhesion	↔	Chemical binding, surface

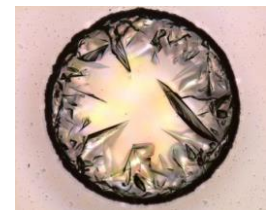


### Etch quality

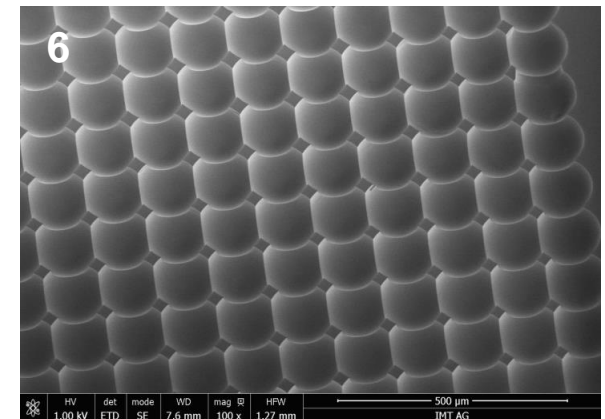
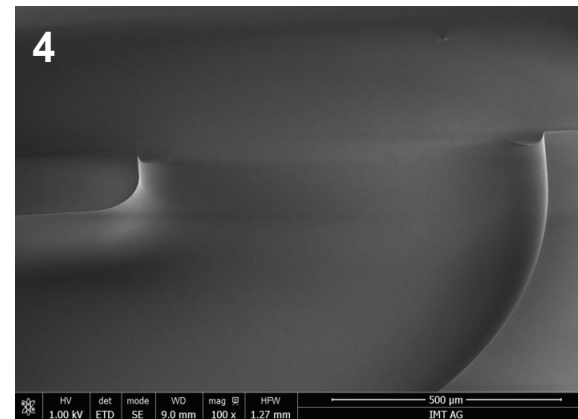
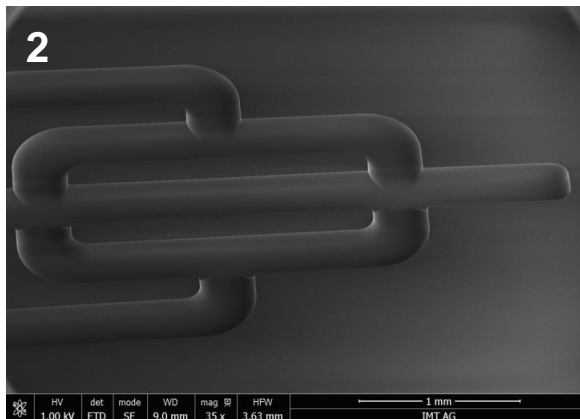
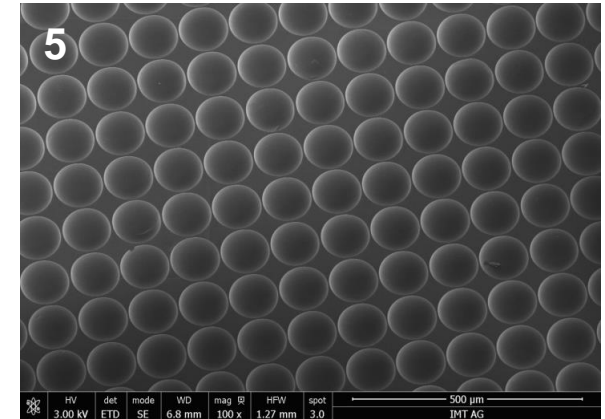
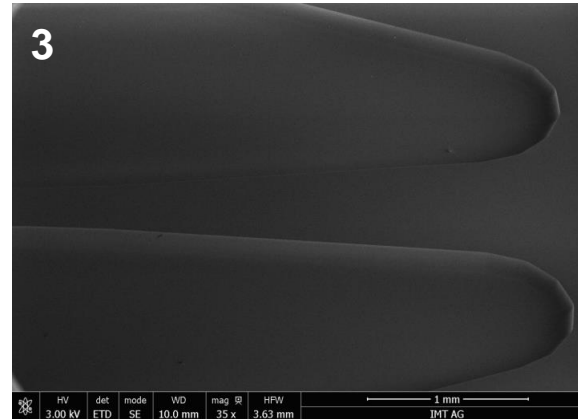
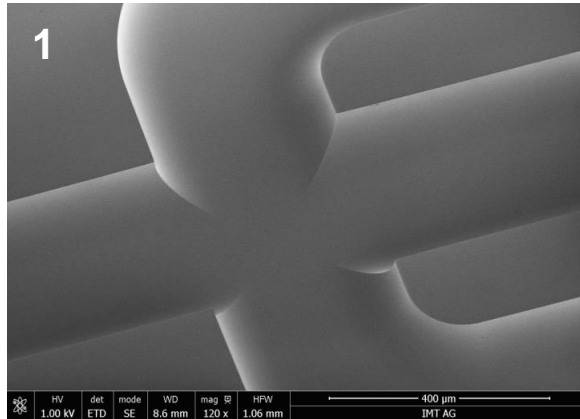
- Adequate etch rate
- No crystallites
- Surface roughness



HF-concentration & mixing ratio



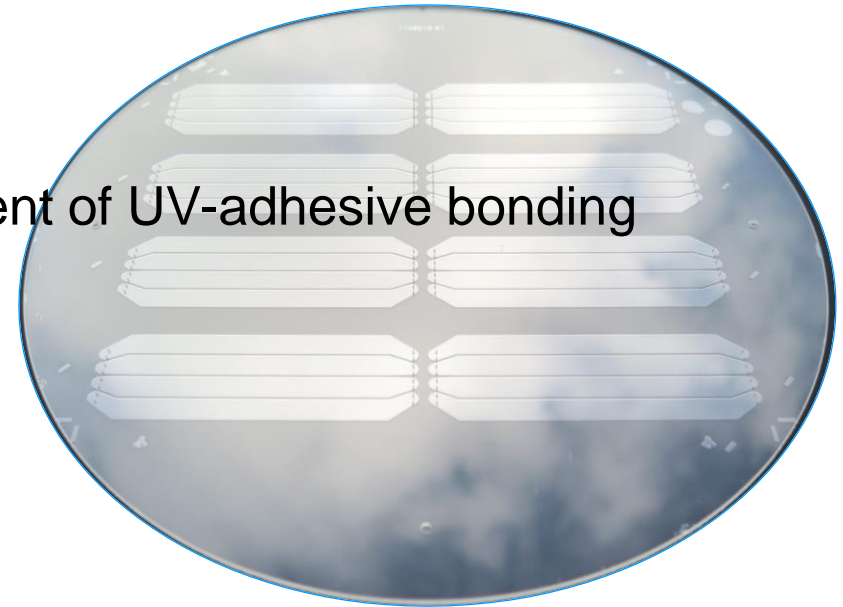
# Components for life science - glass etching - HF spray



(1-5) Microfluidic structures

(6) Overetched grid

- IMT
- Why glass?
- Components for life science
- **Good Bond – requirements and evaluation**
- Wafer bonding
  1. Fusion bonding
  2. UV-adhesive bonding
- Customer-specific development of UV-adhesive bonding
- Laser dicing





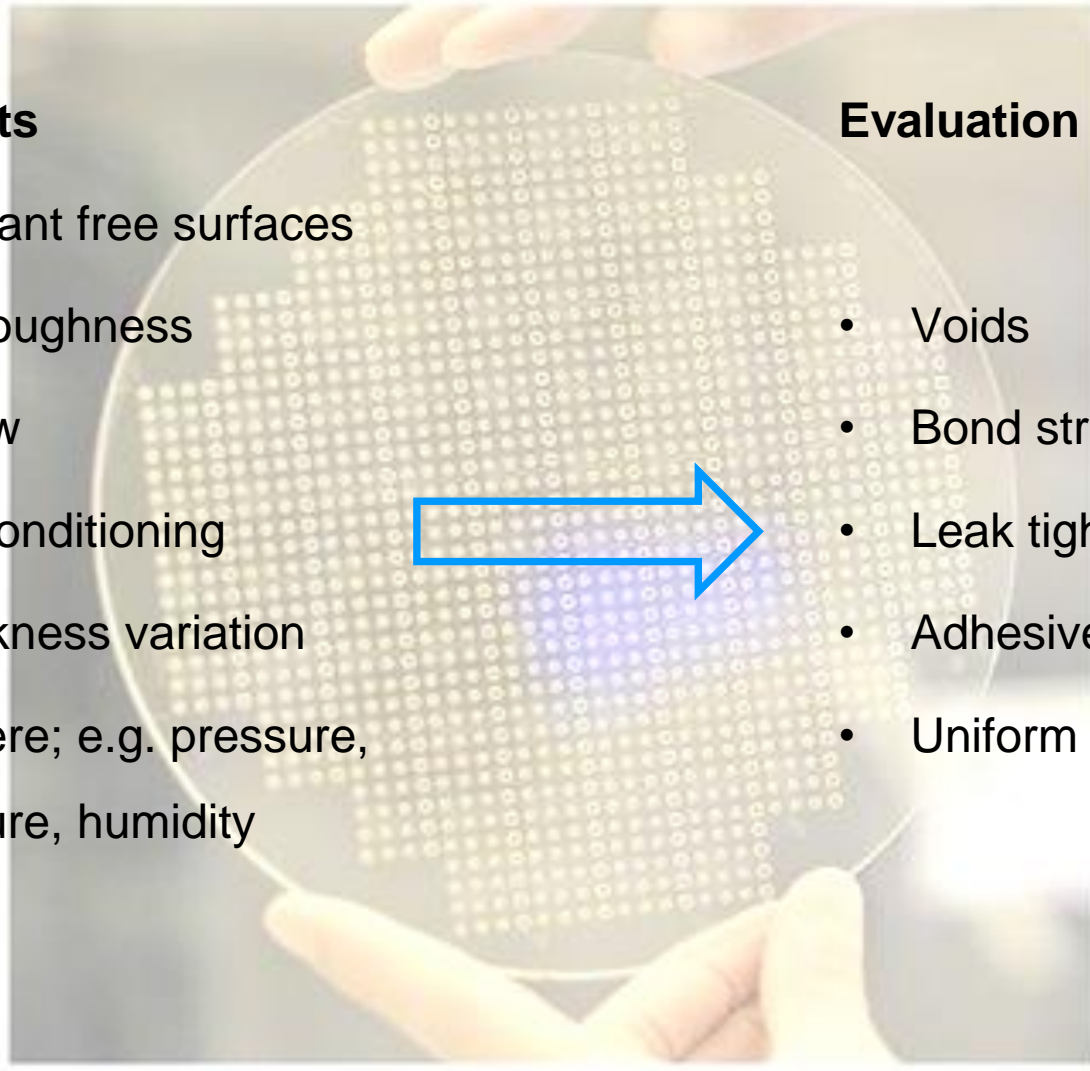
## Requirements for a good bond

### Requirements

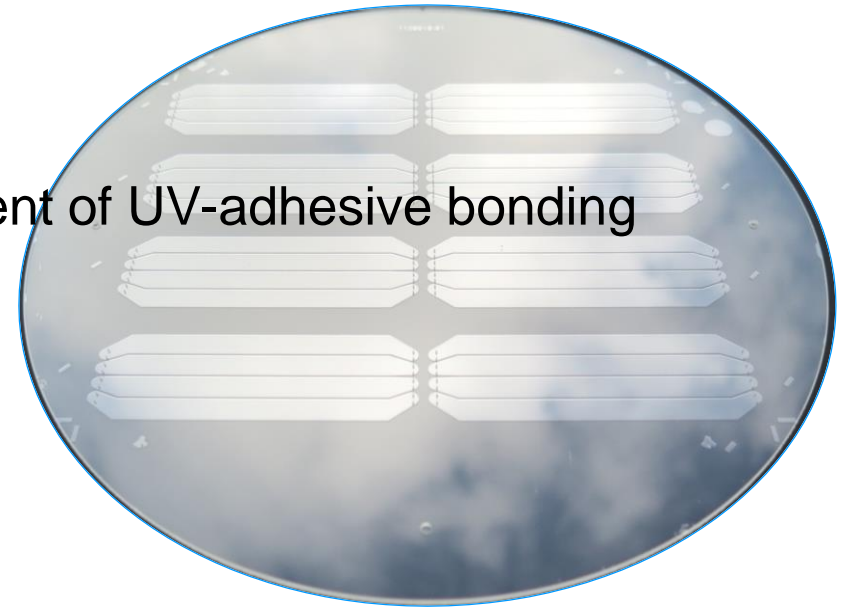
- Contaminant free surfaces
- Surface roughness
- Wafer bow
- Surface conditioning
- Total thickness variation
- Atmosphere; e.g. pressure, temperature, humidity

### Evaluation

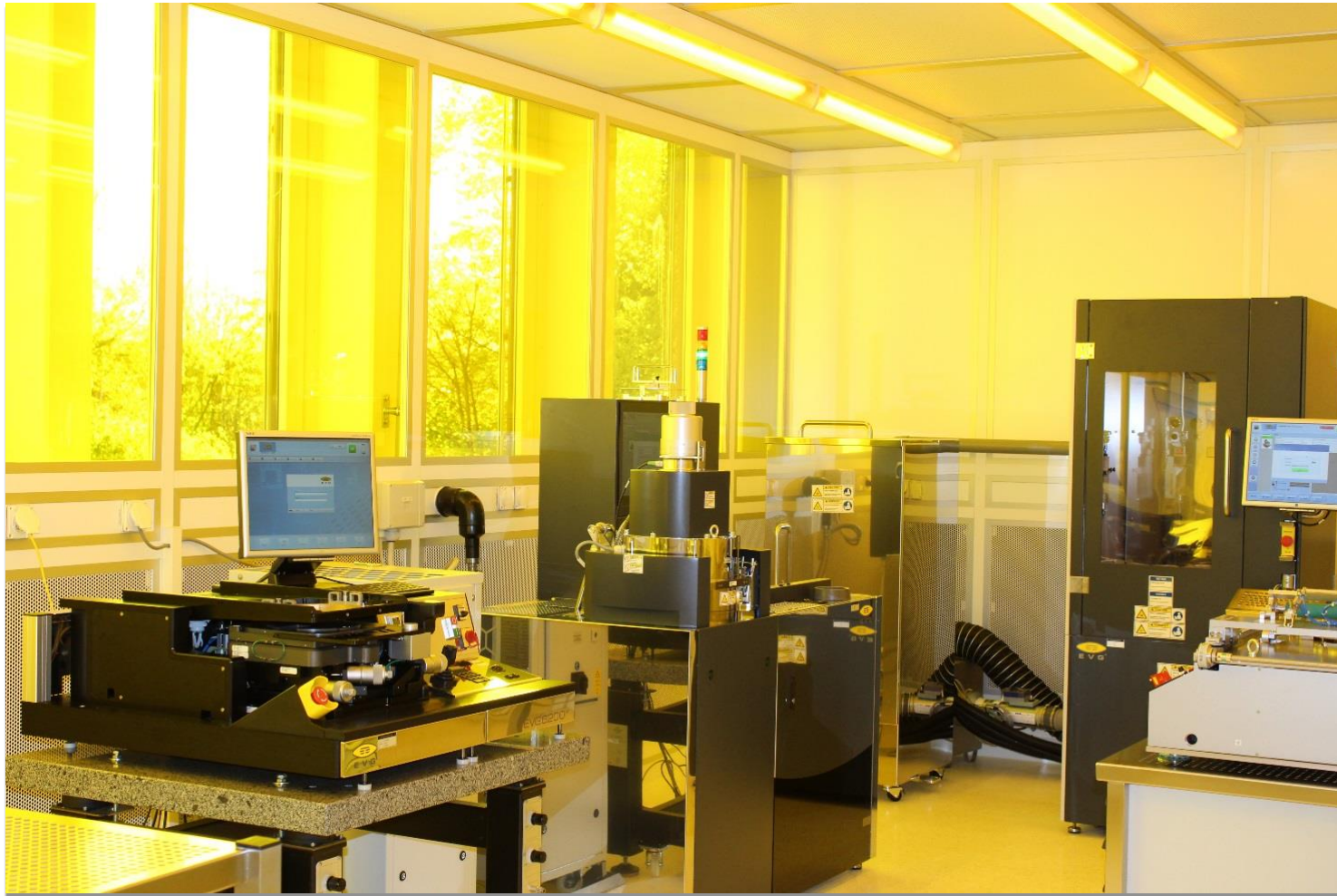
- Voids
- Bond strength
- Leak tightness
- Adhesive profile
- Uniform bond interface



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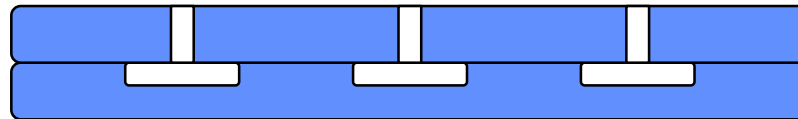






**ISO class 4**

## 1. Fusion bonding:



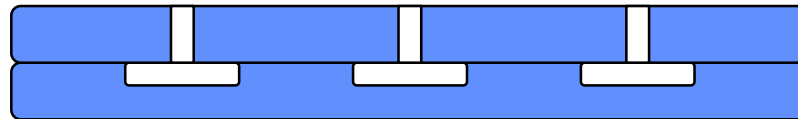
Glass

Laminate

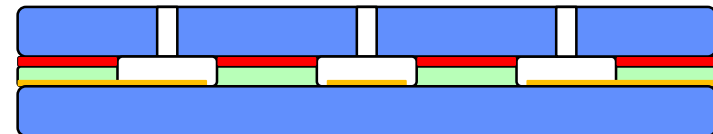
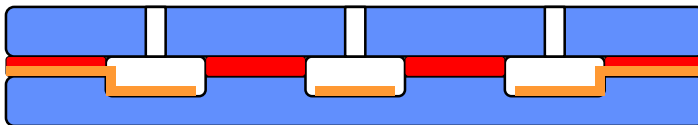
Metal

Adhesive

## 1. Fusion bonding:



## 2. UV-adhesive bonding:



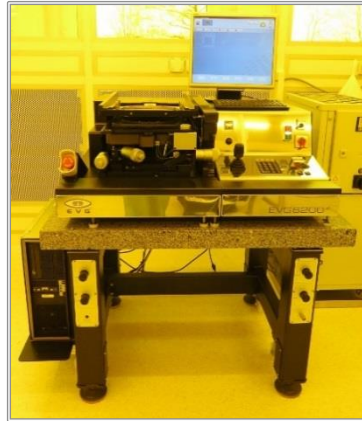
Glass

Laminate

Metal

Adhesive

# Wafer bonding - Fusion bonding



Cleaning



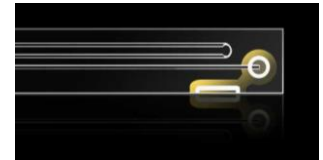
Alignment

Bonding

Annealing

**Process flow**

@300°C



@500°C



### Advantages

- Room-temperature processes allowing for encapsulation of bio-materials
- Compatible with a wide range of materials
- Insensitive to surface roughness
- Ultra-thin selective adhesive transfer technology with excellent uniformity over large areas

## Wafer bonding - UV-adhesive bonding



Cleaning 

Coating

Adhesive transfer

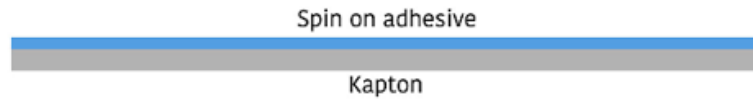
Alignment

Bonding

Curing

Process flow

## Wafer bonding - UV-adhesive bonding

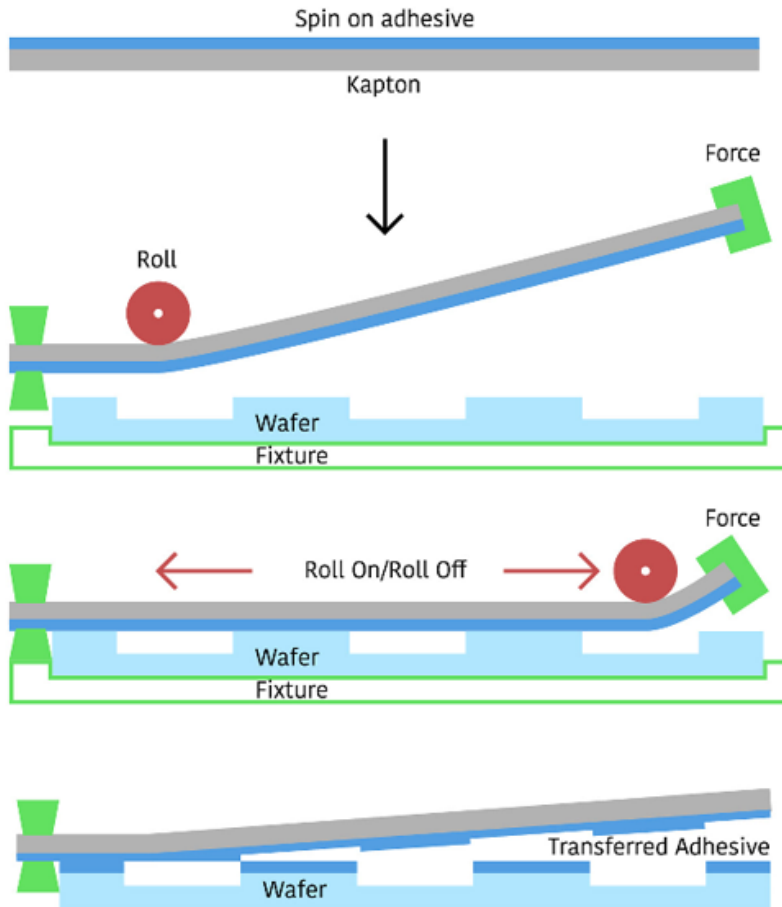


Spin on adhesive  
onto foil

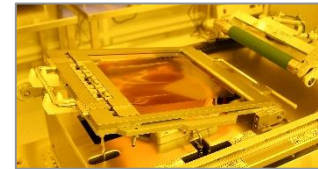




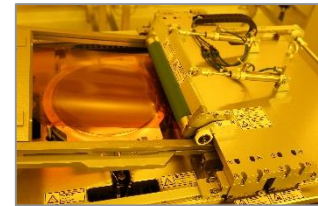
## Wafer bonding - UV-adhesive bonding



Spin on adhesive  
onto foil

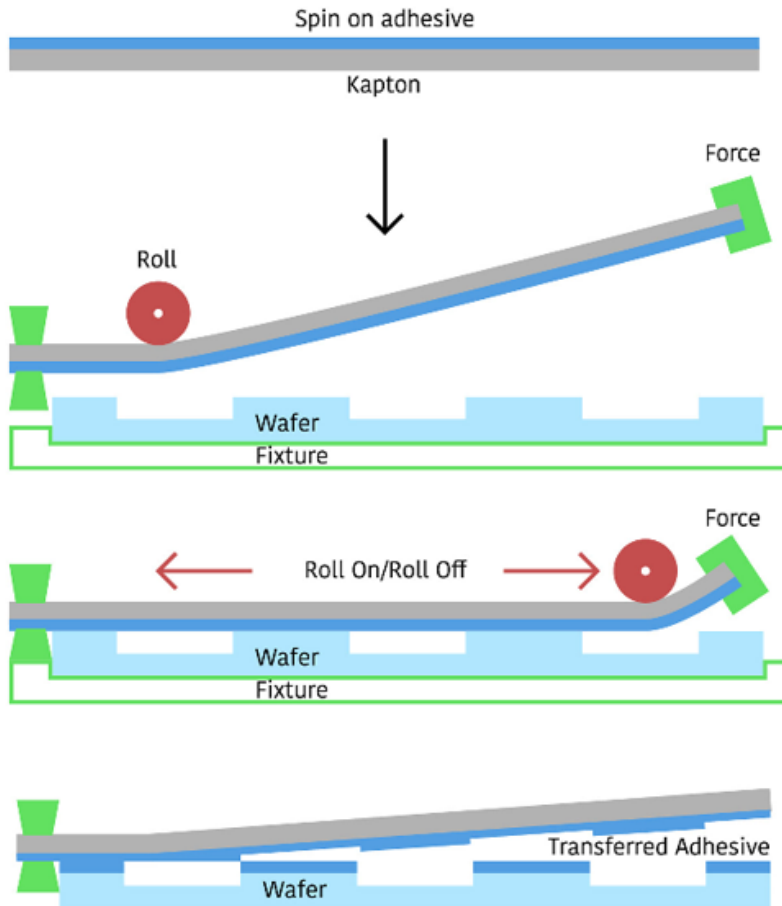


Adhesive transfer





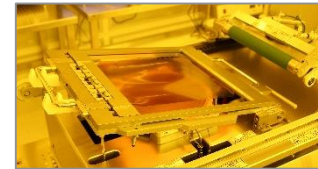
## Wafer bonding - UV-adhesive bonding



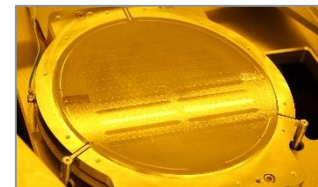
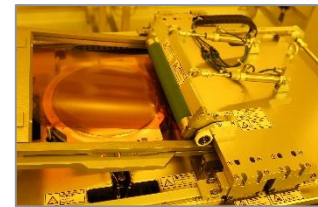
Spin on adhesive  
onto foil



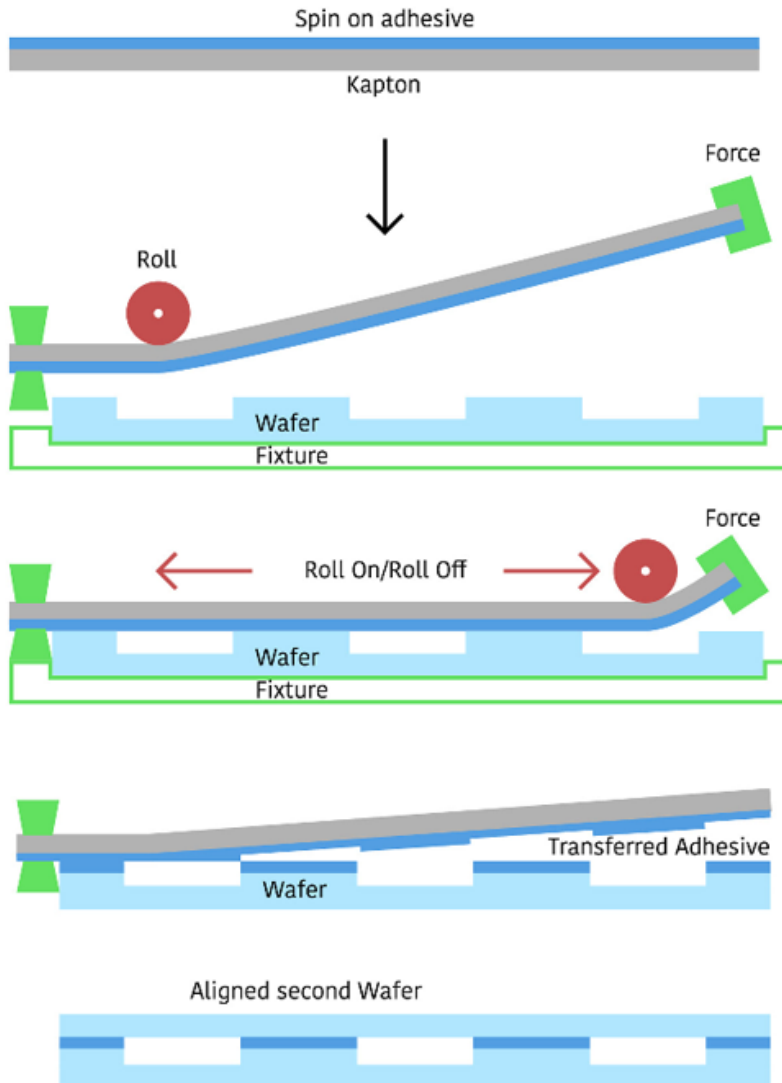
Adhesive transfer



Wafer with adhesive



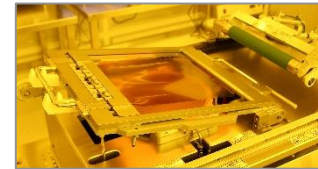
## Wafer bonding - UV-adhesive bonding



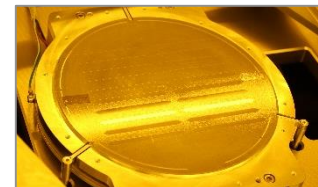
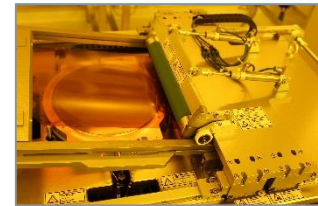
Spin on adhesive  
onto foil



Adhesive transfer

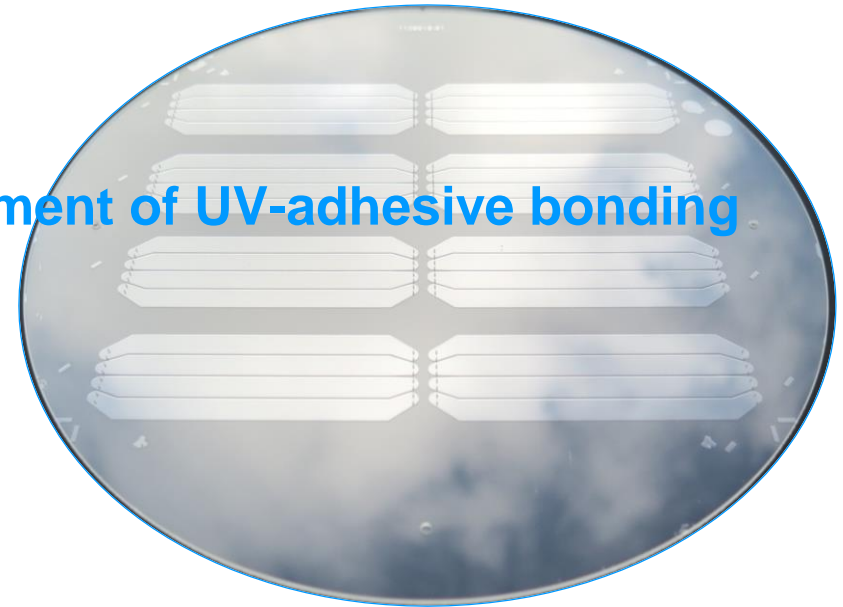


Wafer with adhesive



Bonded wafer

- IMT
- Why glass?
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- **Customer-specific development of UV-adhesive bonding**
- Laser dicing



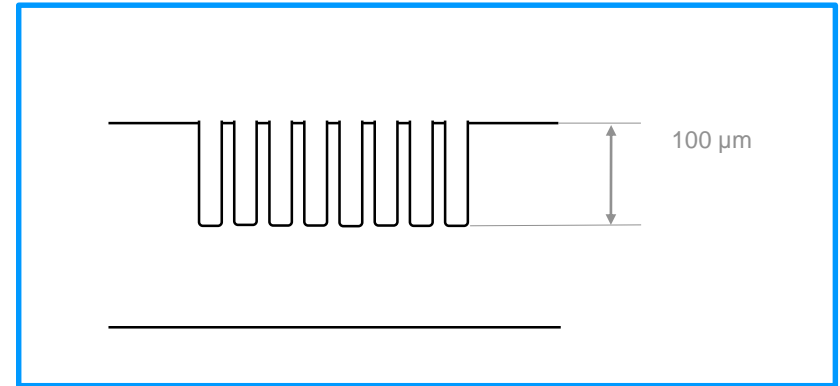
## Customer-specific development of UV-adhesive bonding

### Requirements on UV-adhesive

- Non fluorescent
- Moisture resistant
- Chemical inert
- Mechanical stable

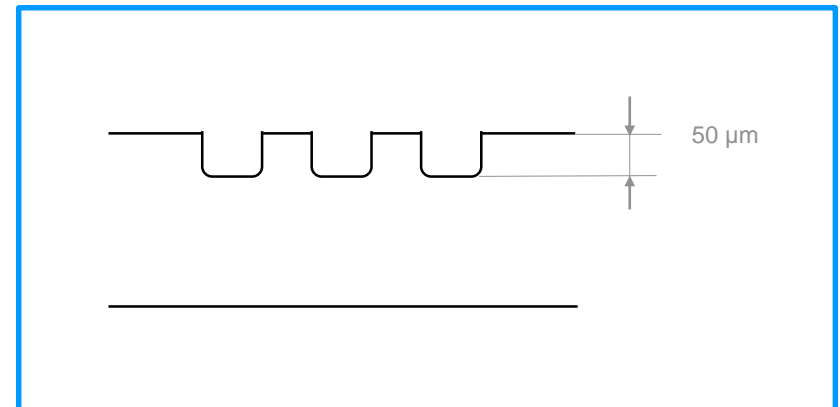
### Adhesive 1

- UV-hardening urethan acryl adhesive

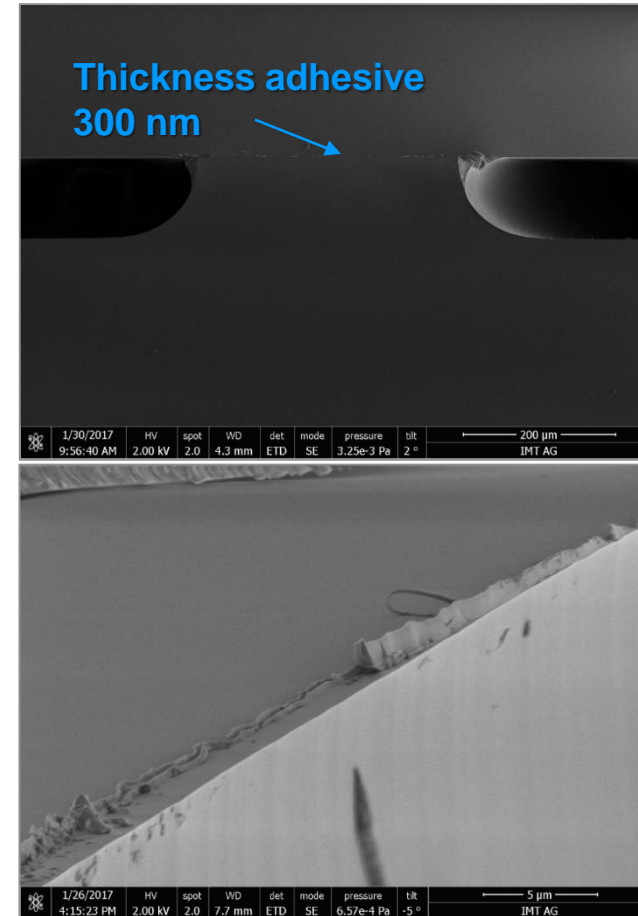
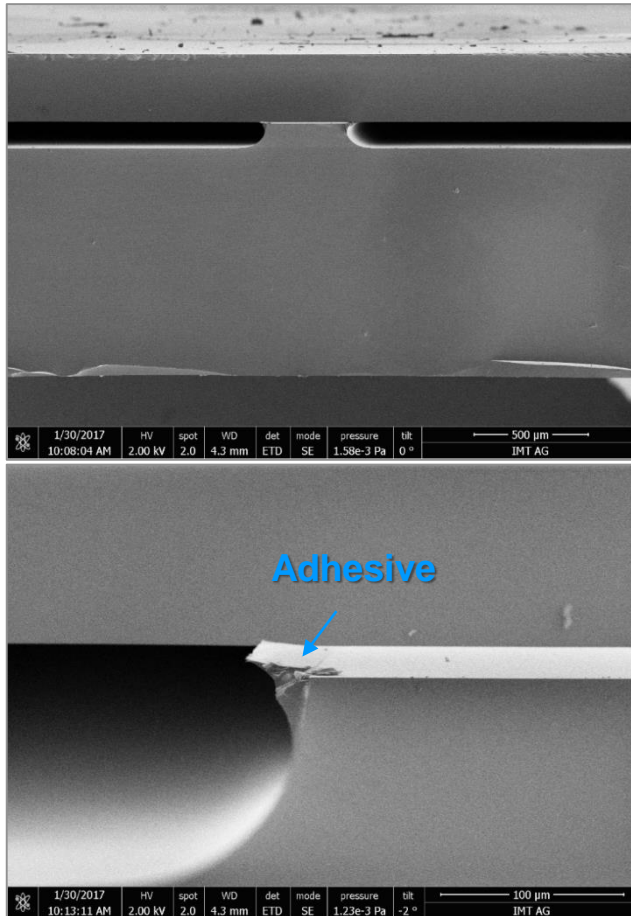


### Adhesive 2

- UV-/ thermal hardening epoxy adhesive

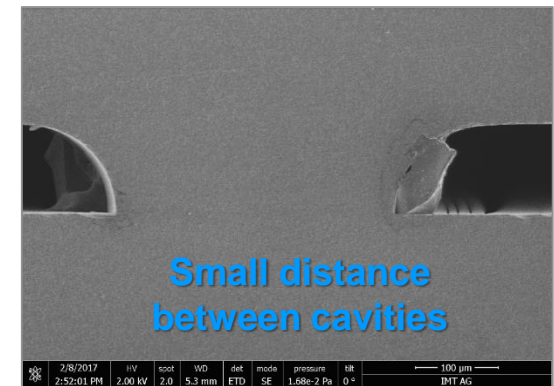
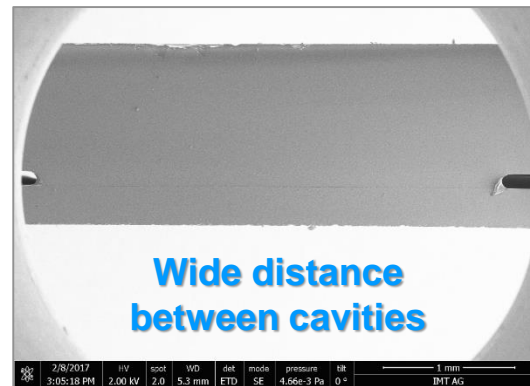
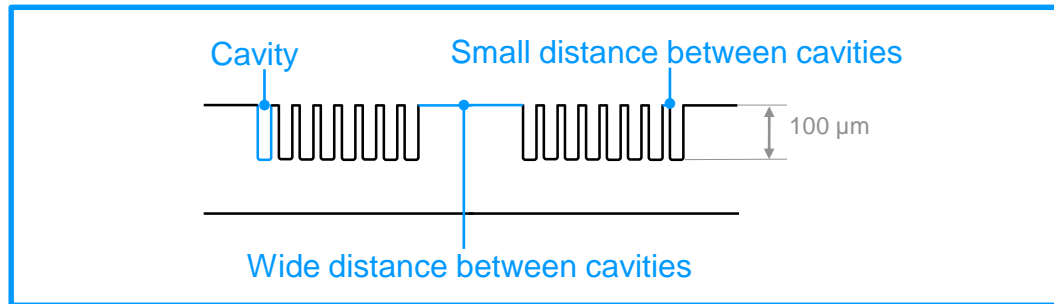


## Customer-specific development of UV-adhesive bonding



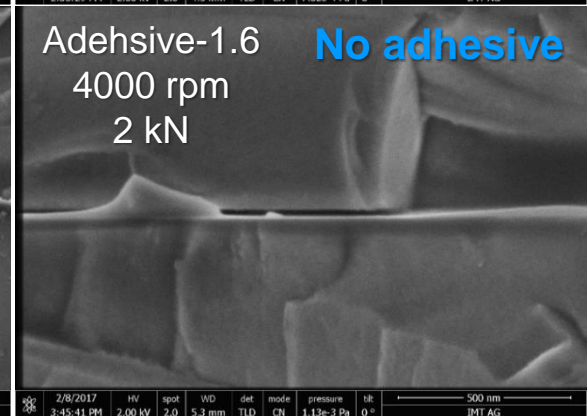
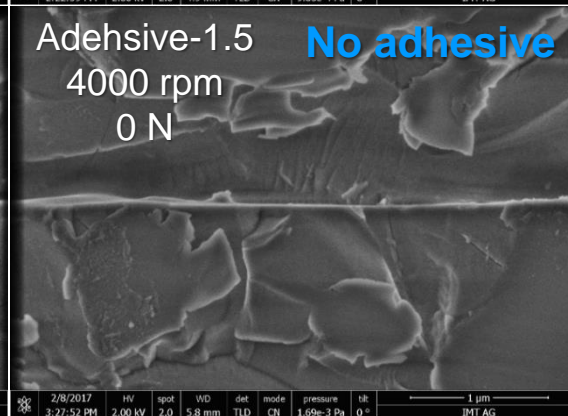
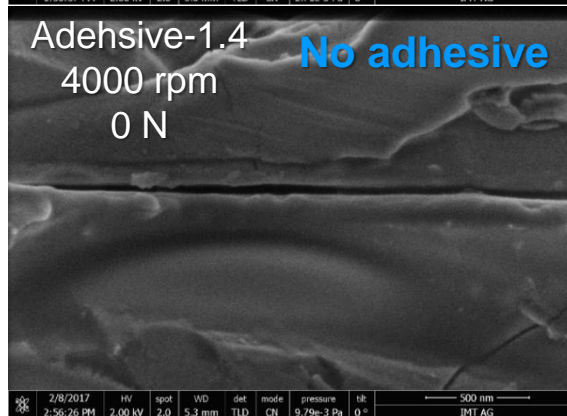
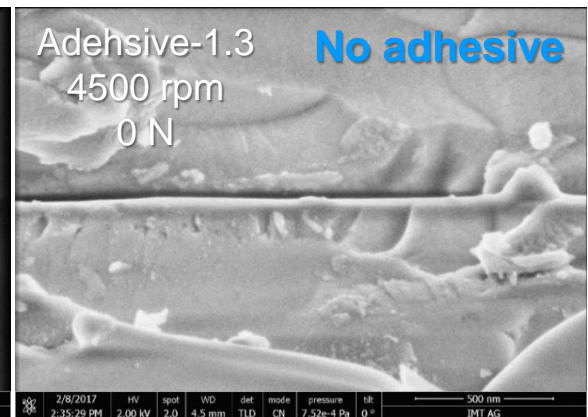
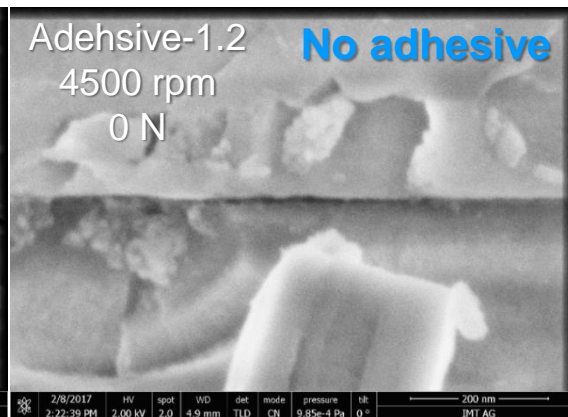
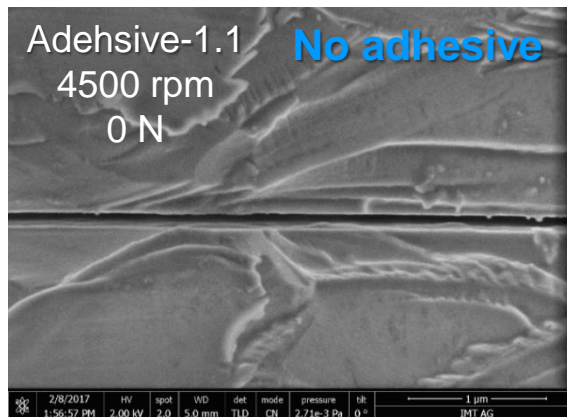
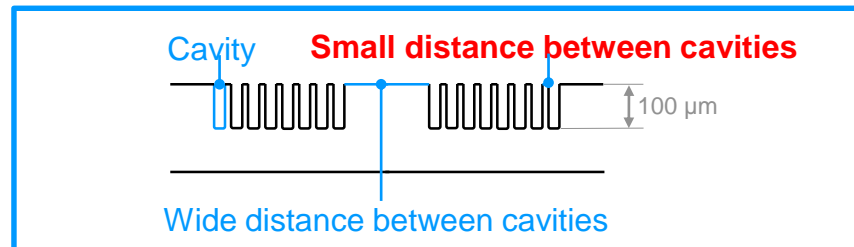
## Customer-specific development of UV-adhesive bonding

Aim:	Adhesive layer thickness	3.5 $\mu\text{m}$
	Variation target value	$\pm 1.0 \mu\text{m}$
	Wafer uniformity	$\pm 1.5 \mu\text{m}$

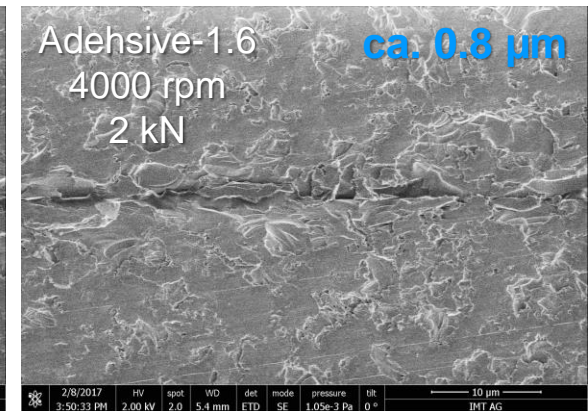
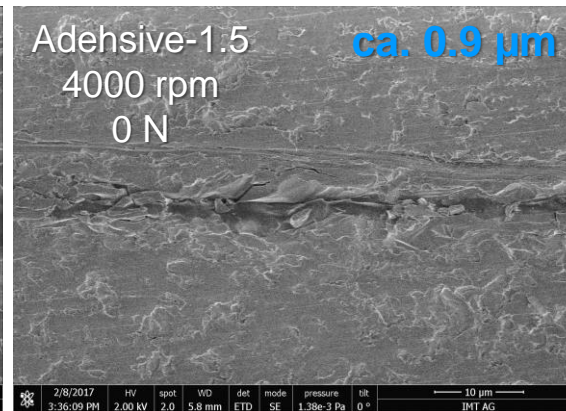
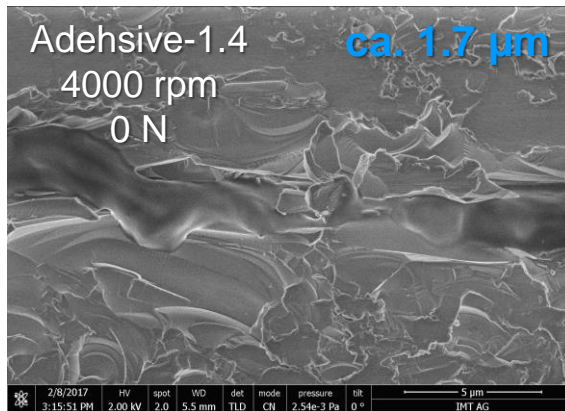
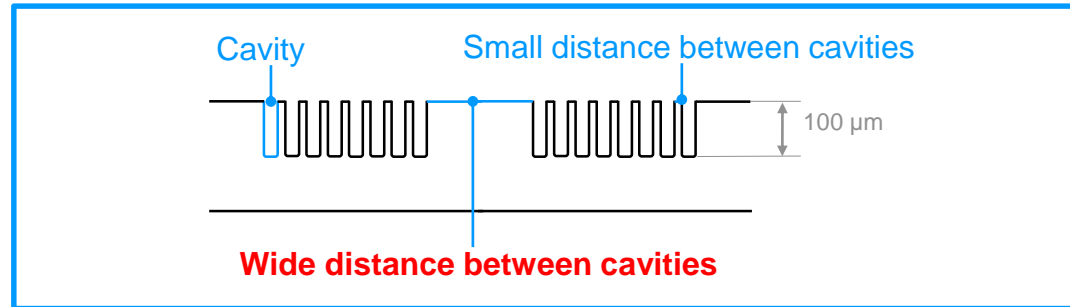




# Customer-specific development of UV-adhesive bonding



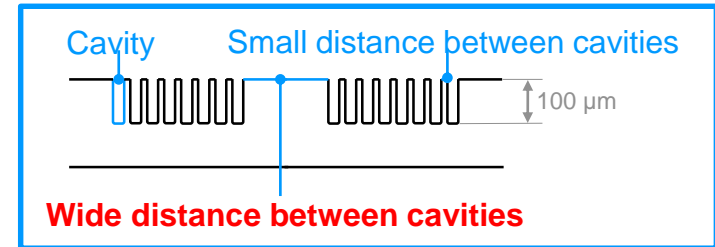
# Customer-specific development of UV-adhesive bonding



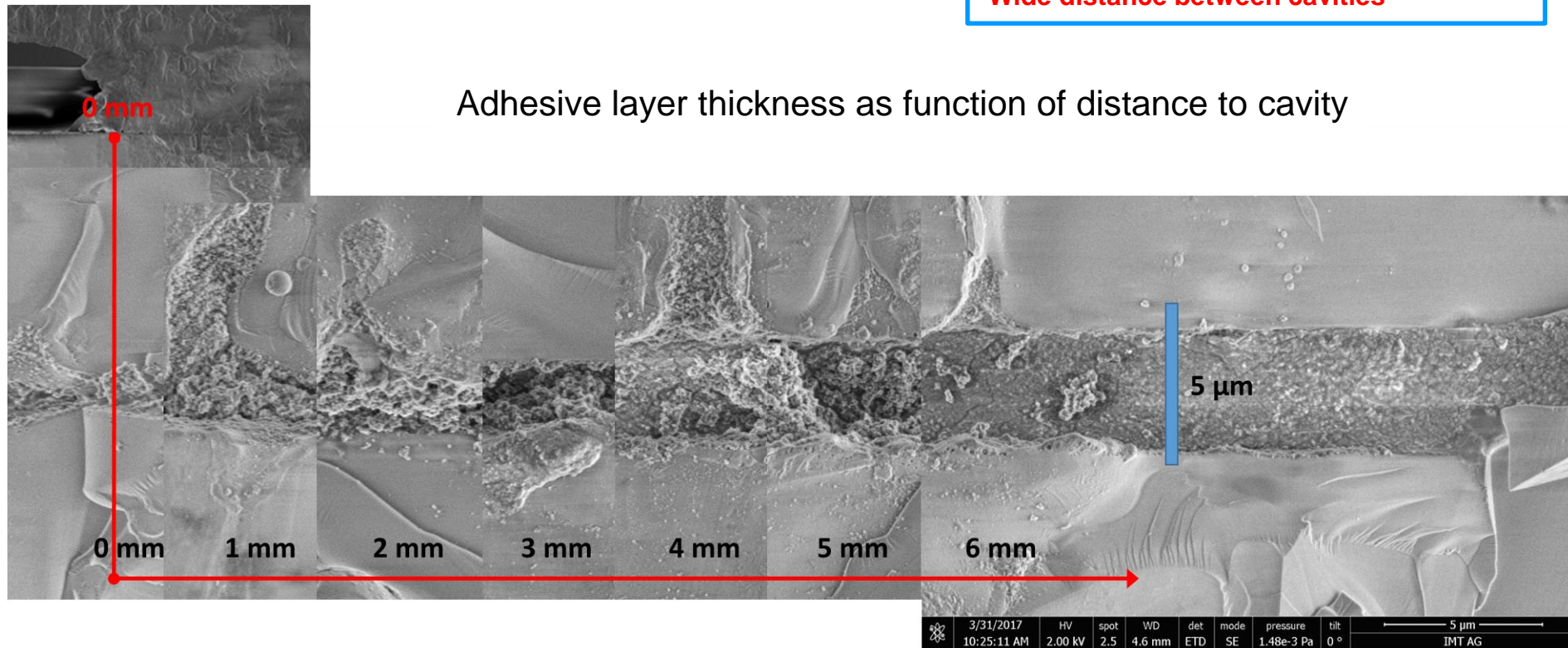


# Customer-specific development of UV-adhesive bonding

**Adhesive 1:** D263; 4500 rpm; 0 kN



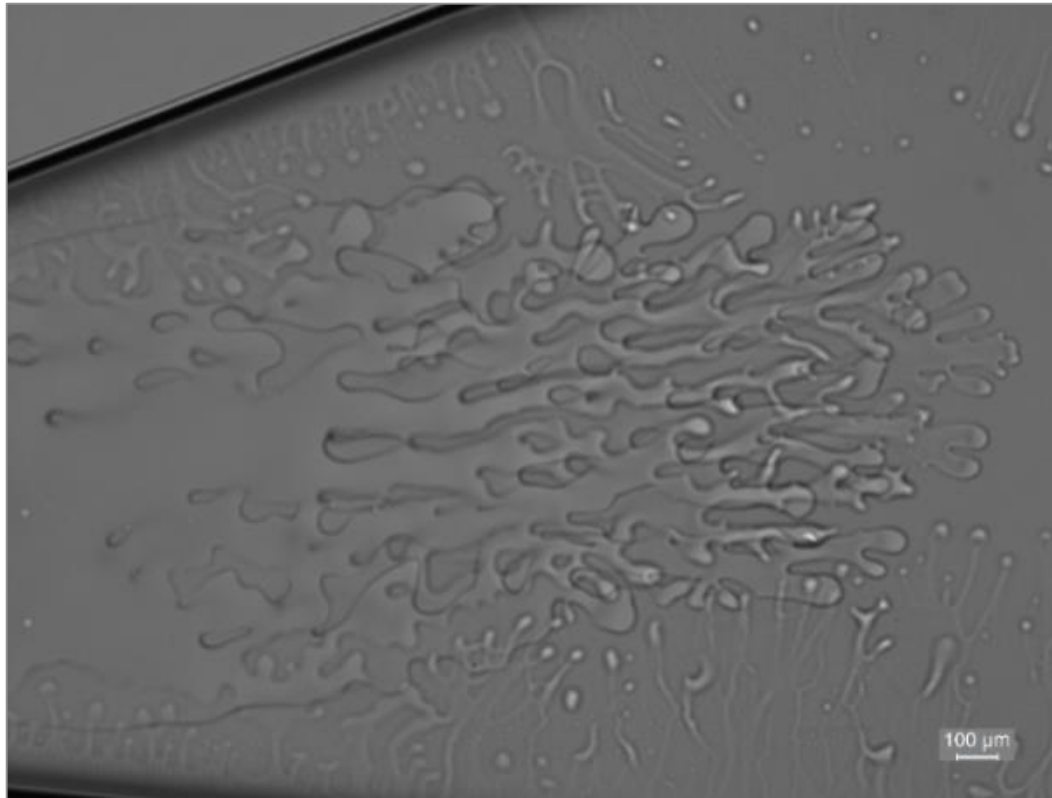
Adhesive layer thickness as function of distance to cavity



## Customer-specific development of UV-adhesive bonding

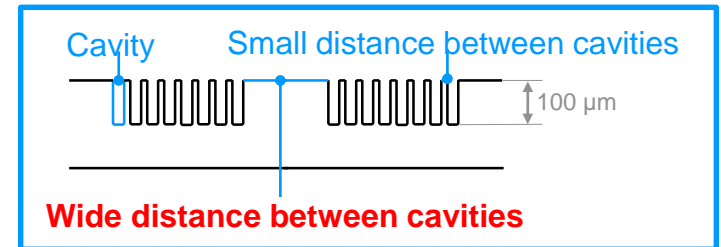
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### Adhesive 2 blends into cavities

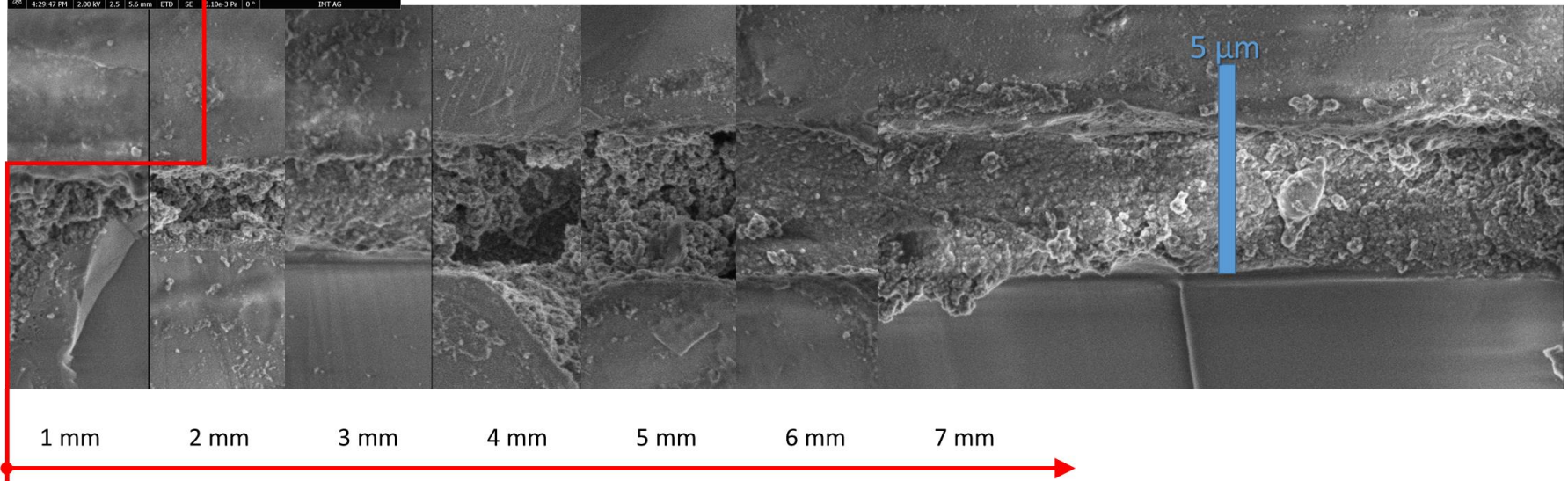
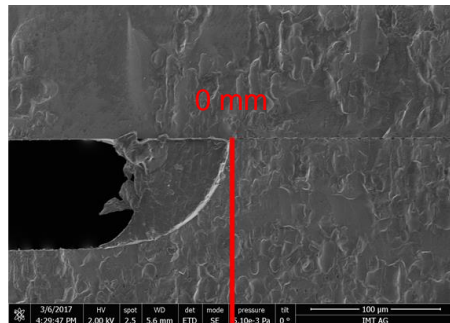


# Customer-specific development of UV-adhesive bonding

Adhesive 2: D263; 4500 rpm; 0 kN



Adhesive layer thickness as function of distance to cavity



## Customer-specific development of UV-adhesive bonding

### Parameter

#### Pre-treatment

- Wafer
- Foil

#### Adhesive transfer

- Volumen adhesive
- Acceleration speed
- Revolution speed

#### Adhesive transfer

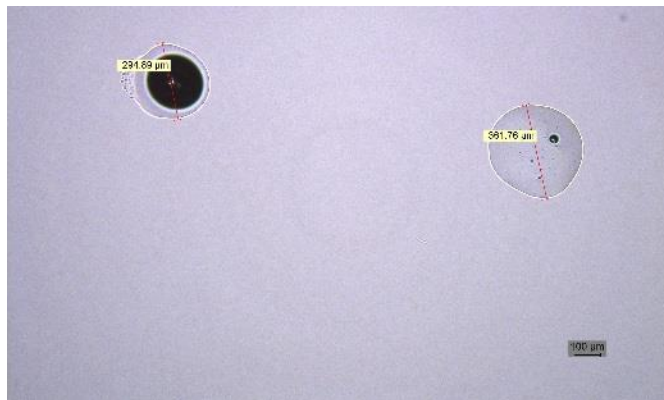
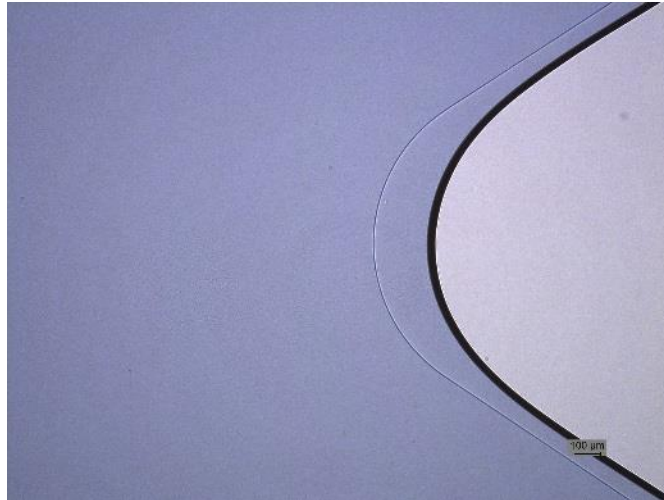
- Contact pressure
- Speed
- Mechanical adjustments

#### Bonden

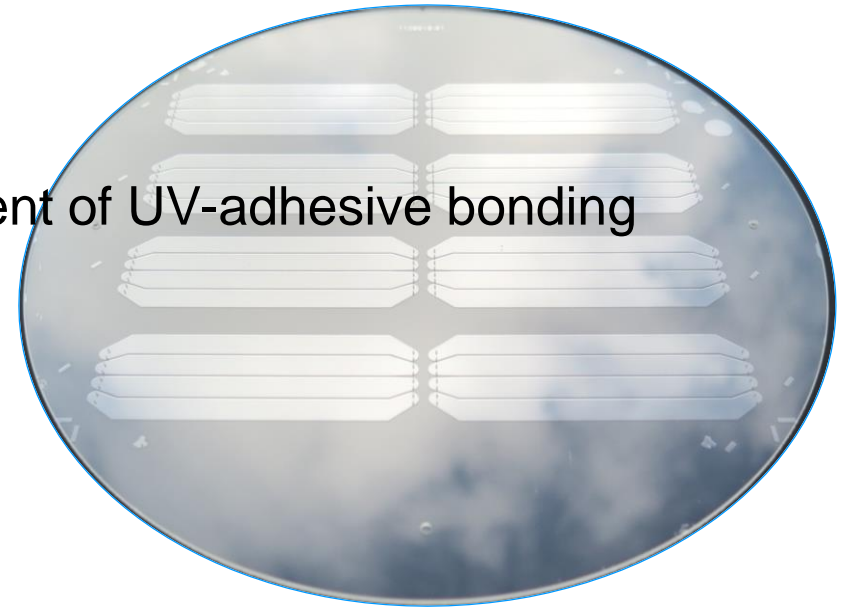
- Mechanical adjustments
- Atmosphere
- Contact pressure

#### Curing

- Intensity
- Duration



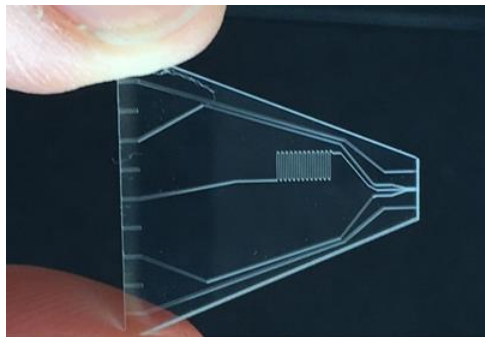
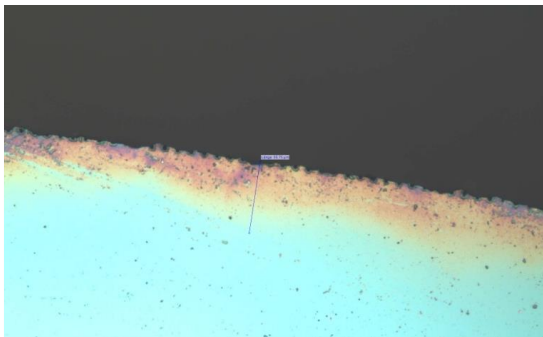
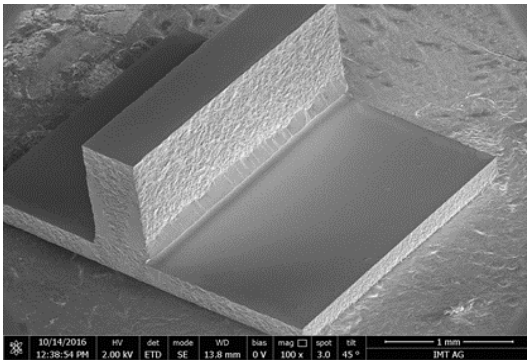
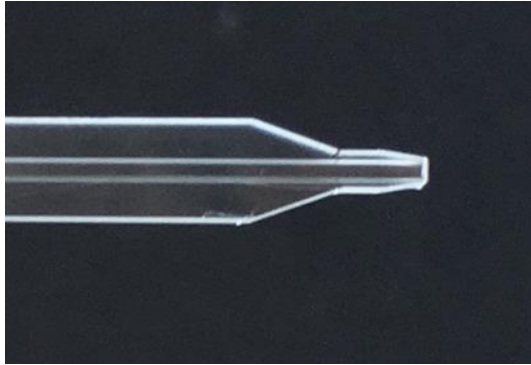
- IMT
- Why glass?
- Components for life science
- Good Bond – requirements and evaluation
- Wafer bonding
  1. Fusion bonding
  2. Adhesive bonding
- Customer-specific development of UV-adhesive bonding
- **Laser dicing**





## Laser dicing

- High dicing accuracy
- Minimal chipping
- No material waste
- Cut through metallic & DE coatings



**Thank you for your attention!**



**IMT is a member of the Microfluidics Consortium.**