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MEMS Testing:
Industry challenges

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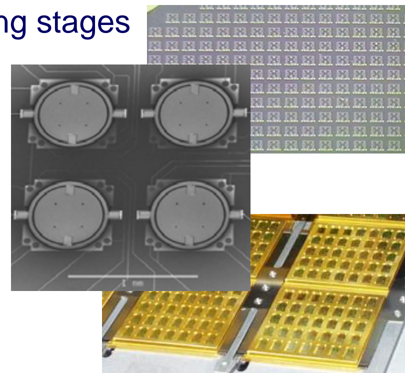
What means wafer level MEMS test

1. Test using non-electrical stimuli and measuring non-electrical parameters
2. Test on all MEMS manufacturing stages before packaging:
   - dies on wafers
   - dies on blue foil (wafer frames) after dicing
   - dies on special carriers (Waffle pack)



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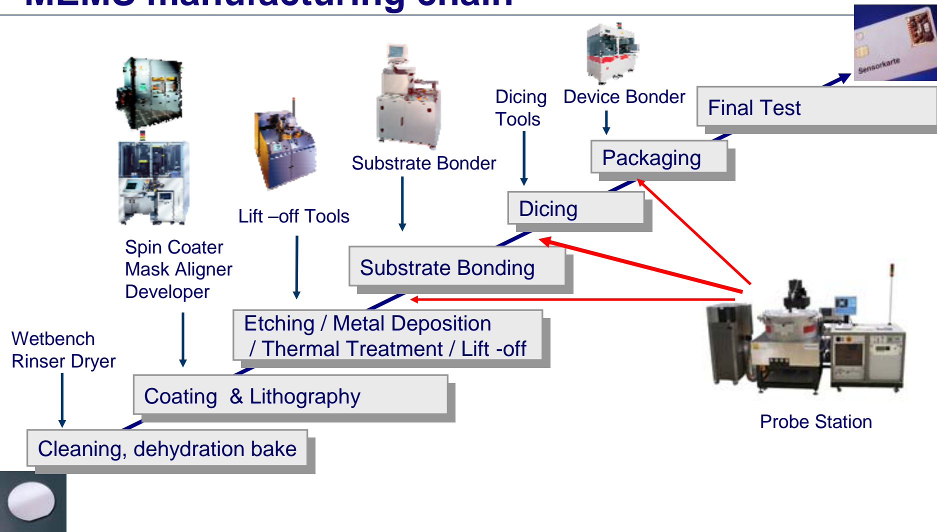
MEMS manufacturing chain



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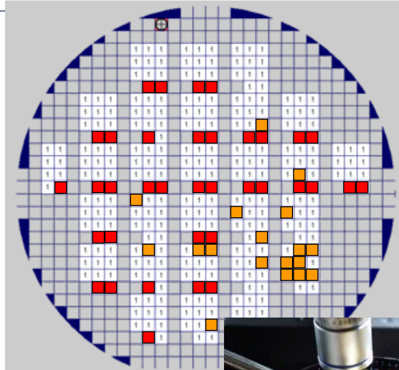
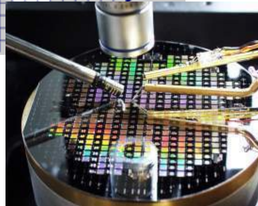
Advantages due to wafer level test

- in R&D
  - measure the real device behavior w/o package effects
- in pre- production
  - short feedback loops
- in production
  - cost reduction
  - process control
  - failure analysis
  - test influence of several manufacturing stages

Results from Si-Microphone Testing

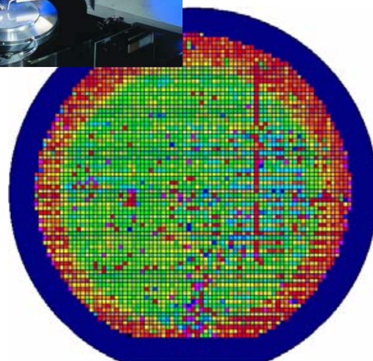




- Top-side electrical and acoustical test with reference microphone
- ☐ Passed all tests – 251 dies
- Failed electrical test – 18 dies (6.7%)
- Passed electrical but failed acoustic test – 36 dies (13,4%)

➢ If only an electrical test was carried out, more than double the amount of the bad devices would have been packaged!

Results from Pressure sensor Testing



- Piezoresistive differential pressure sensor (2,5bar)
- Applying pressure by nozzle from top (SUSS Pressure Probe module)

DUT within spec

DUT out of spec

➢ The non-electrical test identifies the sensitivity problem.

MEMS wafer test is a challenge

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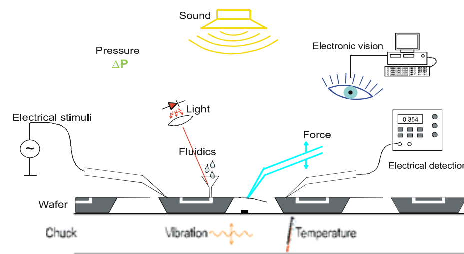
Today

- only electrical test at wafer level
- non-electrical testing mainly carried out after packaging
- use of non-electrical stimuli or detection is uncommon

Because

- combination of inputs, outputs, environment
- lack of standards
- device must be testable



Design for Testability

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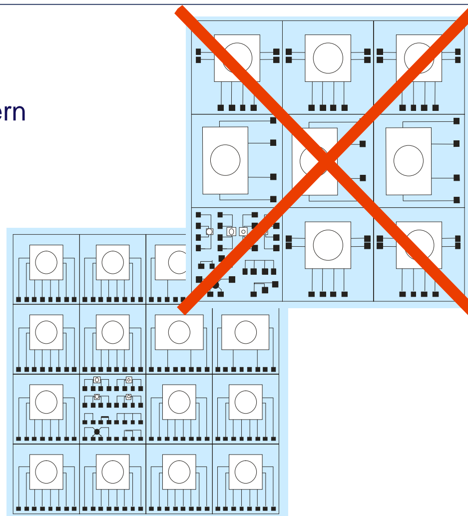
- Place dies in a chessboard pattern
- Separate bond and test pads
- Space for stimuli
- No rotation of dies
- Use pads of sufficient size & spacing
- Use identical pad layouts for all components and test structures



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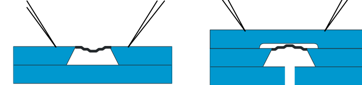
Design for Testability

- Try to avoid double-side device designs were not necessary
- Compared to a single sided setup:
  - difficult wafer handling
  - more cost intensive
  - less flexible
  - slower

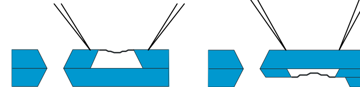
Different pressure sensor designs

Differential sensor

Absolute sensors



Perforated wafers



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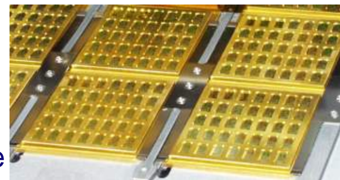
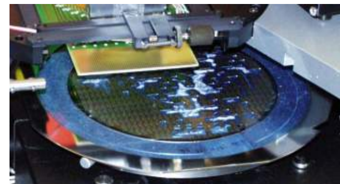
When to test

- Non-electrical stimuli on
  - Wafer
  - Blue foil
  - Waffle Packs
  - Modules – chips on substrate





The Task:

Find the optimal test point to minimize production costs !!

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Known Good Die and Known Bad Die

Known good die

The die can be considered to be ***good*** after test.

- high requirements for test accuracy, repeatability of the the setup

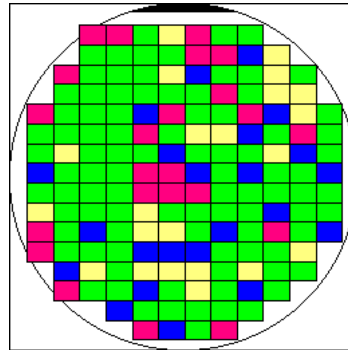
- reduced final packaged test

Known bad die

The die can be considered to be ***bad*** after test.

- lower requirements for test accuracy, repeatability of the setup

- packaged test is required



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Available solutions today

Test Solutions for:

- ✓ Pressure Sensors
- ✓ Gas Sensors
- ✓ Acceleration Sensors
- ✓ Gyroscopes
- ✓ RF MEMS
- ✓ Micro-Bolometer
- ✓ Si-Microphones
- ✓ Micro-Mirrors

Integration of 3rd-party Tools:

- ✓ Mechanical Motion Analysis
- ✓ Topology Measurement
- ✓ Mechanical Stimulation
- ✓ Feature Recognition
- ✓ Automated optical inspection

- ➢ device characterization
- ➢ failure analysis
- ➢ reliability tests
- ➢ functional testing

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Continuing tasks

Analytical probing:

- develop further MEMS testing methods & modules for the right applications

Volume production:

- standardize tests
- adapt new test technologies to high volume production needs
  - ➢ high throughput
- move from KBD test to KGD test
  - ➢ minimize final package test

MEMUNITY
The MEMS Test Community

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- founded in the “Microtest EM63” project by SUSS & DELTA
- General Information open to all interested by a free membership
- Seminars, workshops to bring MEMS test engineers together
- Test services & equipment offered
- Key members provide product information to help develop future products
- http://www.memunity.com

DELTA Fraunhofer IZM Institut Zuverlässigkeit und Mikrointegration Polytec SÜSS MicroTec

MEMUNITY Platform Model

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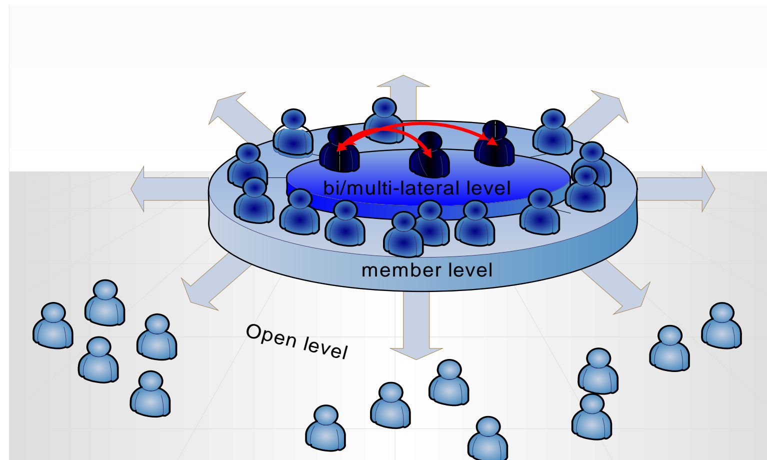

MEMUNITY
The MEMS Test Community

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- A Community aimed at sharing knowledge between members
- A Community aimed at providing a knowledge-base for all interested in MEMS testing
- A Community aimed at developing test systems for MEMS probing through partnerships

DELTA Fraunhofer IZM Institut Zuverlässigkeit und Mikrointegration Polytec SÜSS MicroTec

PAR-Test

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- BMBF Project (German ministry of Education and Research) "Development of methods & equipment to define & measure manufacturing relevant material parameters of MEMS devices"
- Consortium:
  - Equipment suppliers (SUSS, Polytec)
  - MEMS manufacturers (Bosch, CiS, Elmos, Melexis, XFab)
  - Research institutes (FhG IZM, FhG IWMH)

Conclusion

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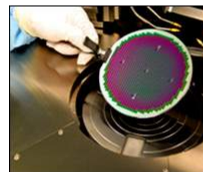
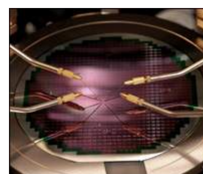
- Wafer level MEMS test has well known advantages
- Wafer level MEMS test should be considered during design
- Many test solutions are available
- MEMUNITY supports the industry in needed continuing development





Thank you

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