Flexible Systems

Fraunhofer Research Institution for Microsystems and Solid State Technologies EMFT, Munich, Germany

Danish-Bavarian Workshop on Robotics ICT in Horizon 2020

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Application scenarios for thin and flexible electronic systems

- **Reduce package thickness**; main driver: smart phones
- **Healthcare&Food:** point of care diagnostics (PoC), sensors for food packaging
- **Wearables:** electronic functions in textiles or sports gear
- **Sensors on curved surfaces:** to be adpated or integrated to machines, buildings, robots, housings
- **Large area electronics**: e. g. bendable displays, flexible LED lighting and photovoltaic modules
- Technology candidate for **Internet of Things** applications

fitbit

Moticon

Plastic Logic

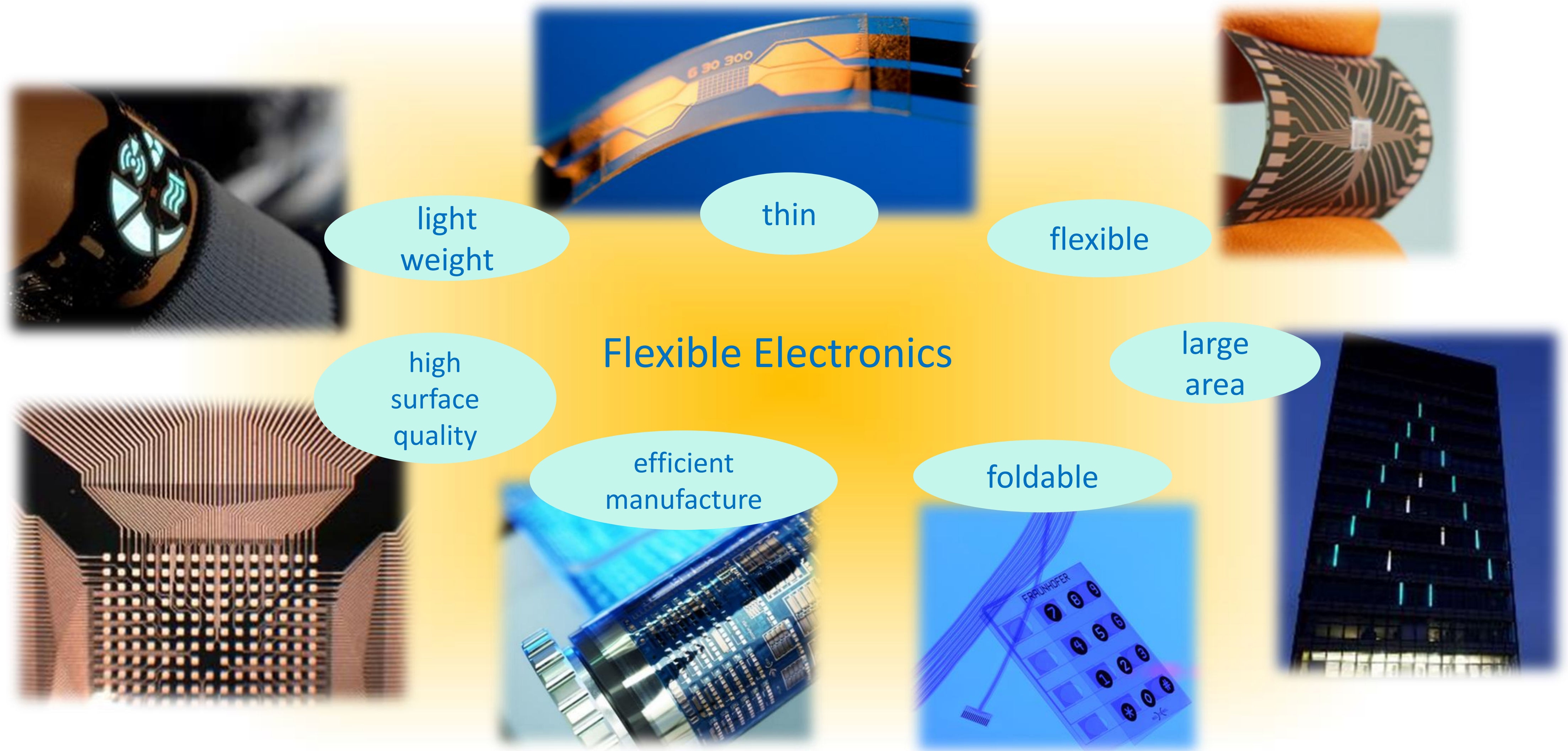
EMFT: sensors on curved surfaces

TUM ICS

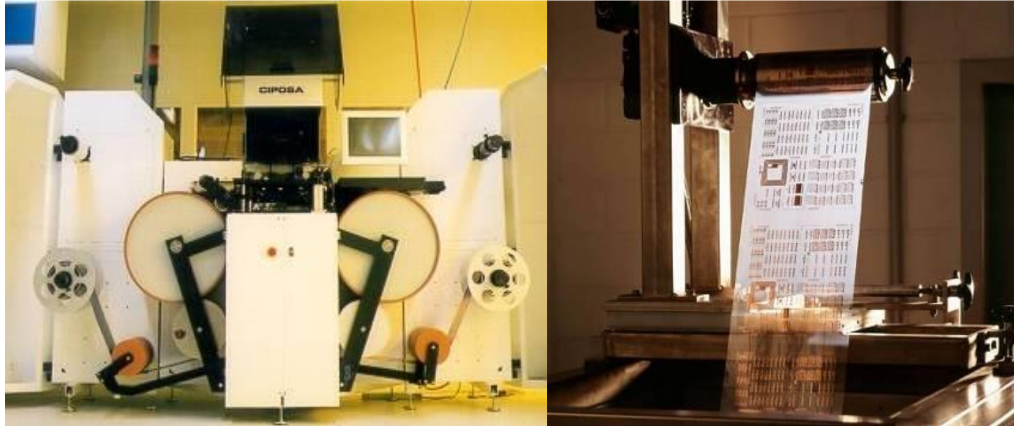
Interactive Wear

Pictures from companies websites

Plastic film substrates as an integration platform for flexible electronics



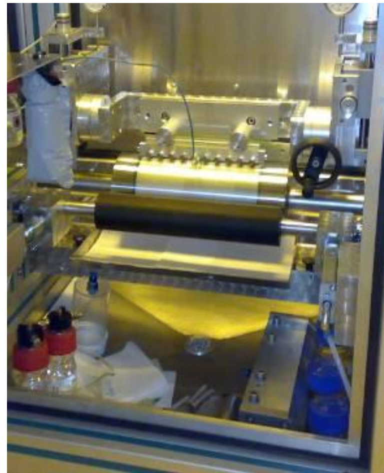
Roll-to-Roll Line at the Fraunhofer EMFT



Fine-line patterning of metallized plastic films

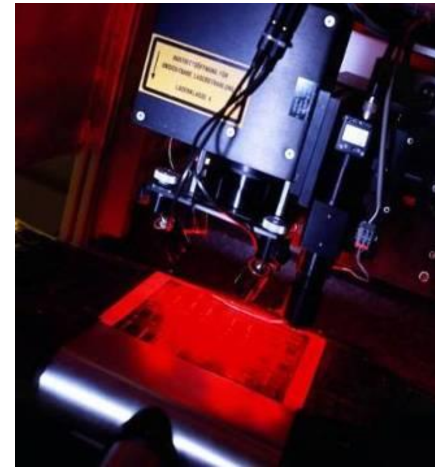
Thick-film screen printing on sheets and rolls

Sputter deposition



Web coating

Foil lamination



Laser processing

Electrical testing

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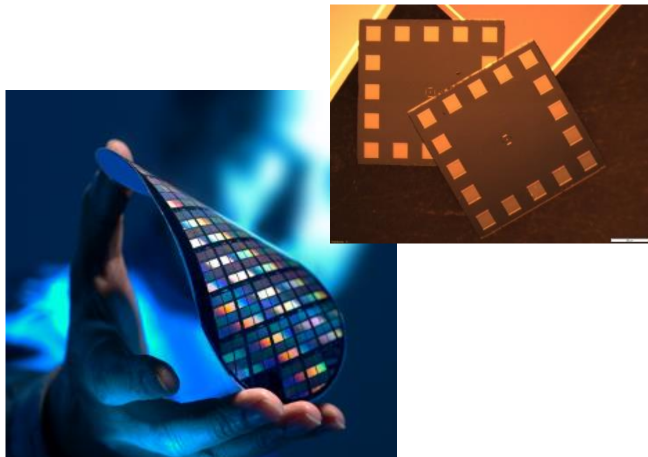
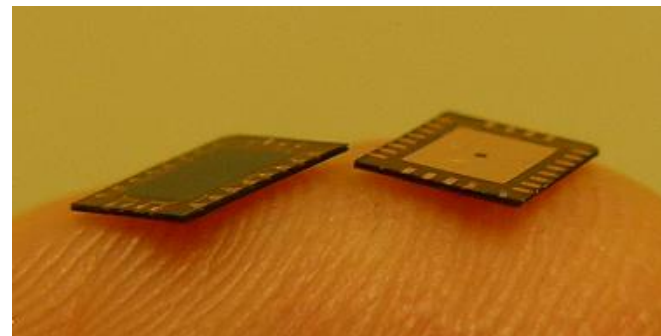
Technological approach at EMFT:

Modular system integration for System-in-Films (SiF)

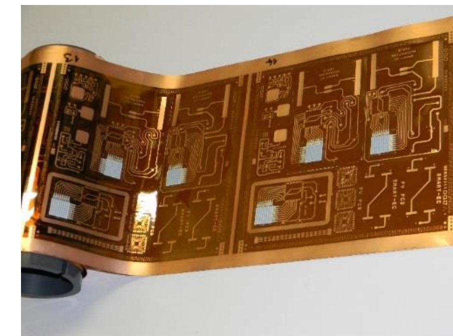
Wafer thinning and plasma dicing



Preparation of small area chip film packages by lithographic patterning in dense configuration



PCB type technologies for fast assembly and component integration



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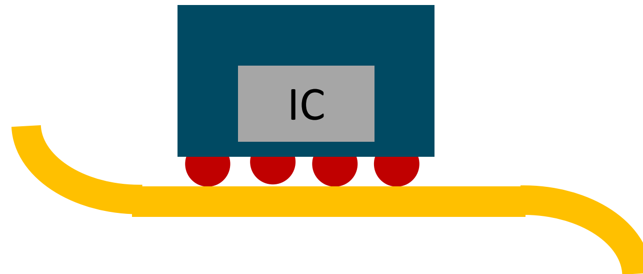
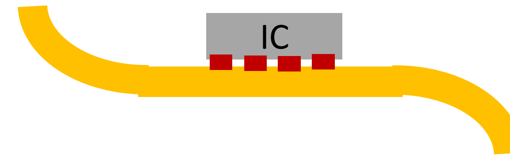
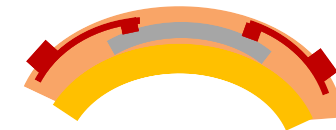
How to integrate silicon IC on or in film substrates

	SMD Assembly	Chip-on-Flex (CoF)	Embedding in Flex

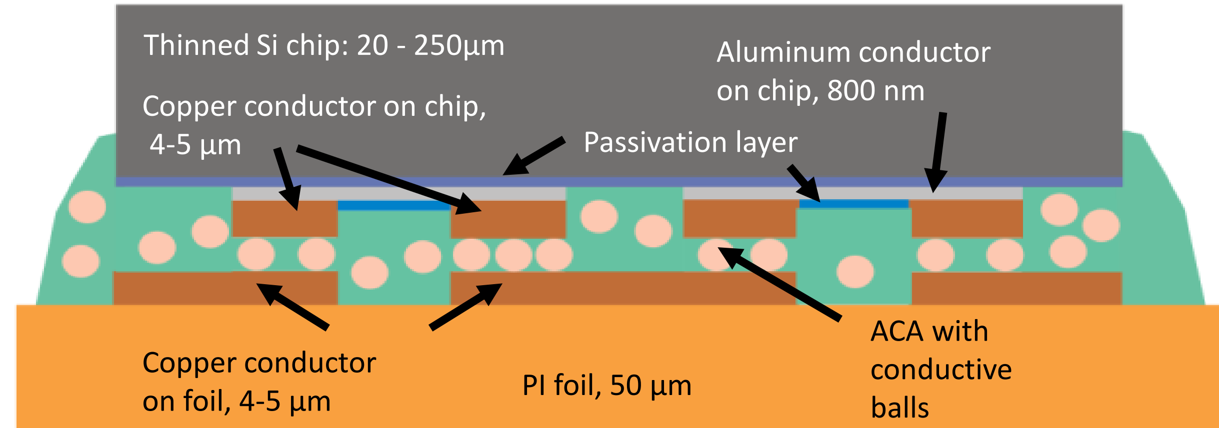


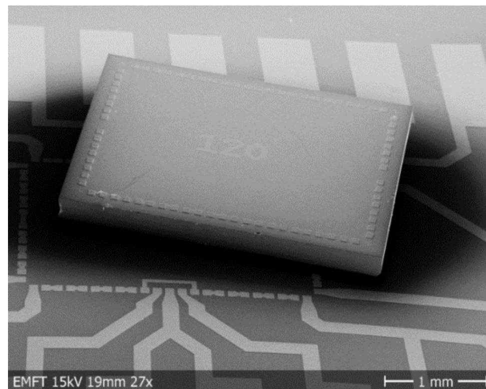




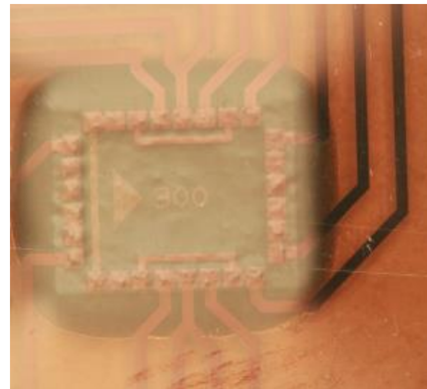
	SMD type	CoF	Embedded
IC thickness	> 200 µm	70 … 150 µm	10 … 30 µm
Package height	1 mm	< 0,5 mm	< 0,2 mm
Flexibility	only between components	partly flexible	fully flexible
TRL	in production	in production	Demonstrators, R&D
Availability of components	very good; simply buy SMD	good; needs bare dies	difficult; needs ultra-thin dies (or full wafers)

ACA Flip Chip Assembly on Film (CoF)
Sample preparation for bending test with online electrical monitoring

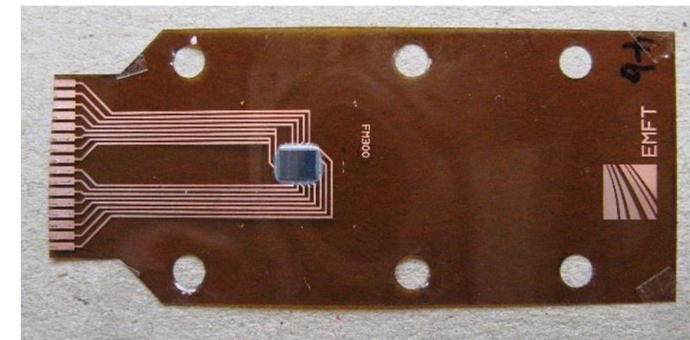




Test chip and pattern on film



Bonded die, view from rear side of film



Test stripe with bonded die used for bending tests

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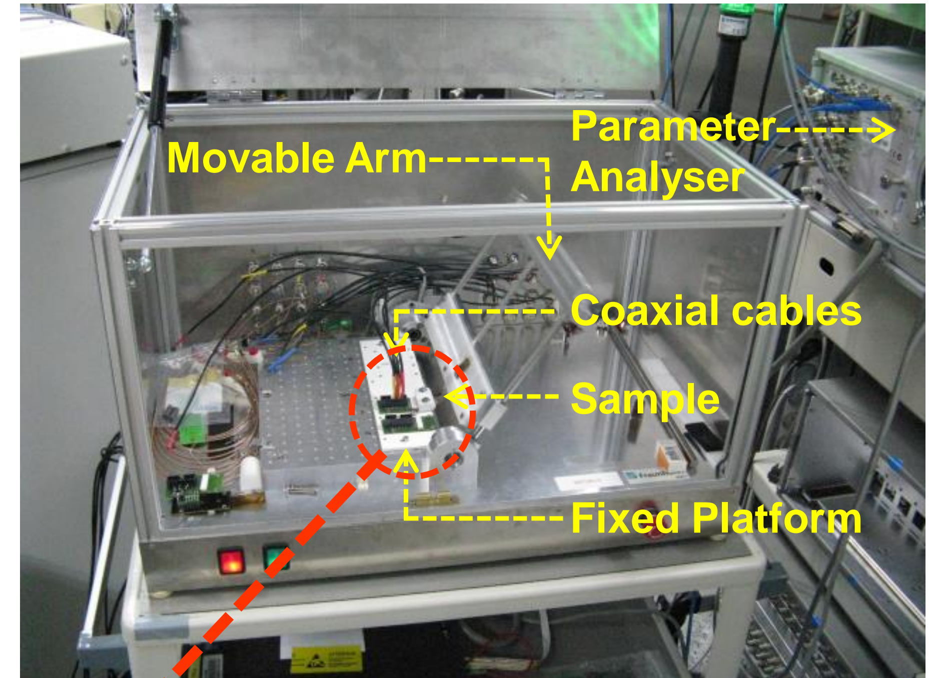
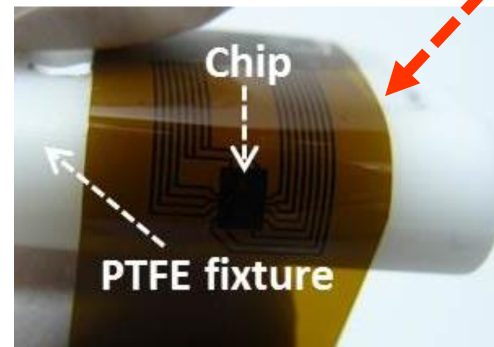
Mechanical and electrical bending test apparatus at EMFT for thin chip foil assemblies

- No existing standardized test set-up/method

  ⇒ In-house built test equipment
- Online electrical measurement
- Parallel testing of 4 samples
- Bending radius defined accurately by PTFE fixture
- Monitor daisy chain resistances during repeated bending cycles





Ref.:
N. Palavesam et al., IEEE SIITME, Brasov, Romania, 2015.
N. Palavesam et al., IEEE ECTC, Las Vegas, USA, 2016.

Bending test: Comparison w/o encapsulation of thin dies

Resistance of Daisy Chain during fixed radius bending tests

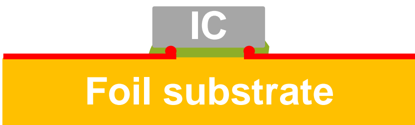
Chip thickness: 12 µm
Diced by sawing

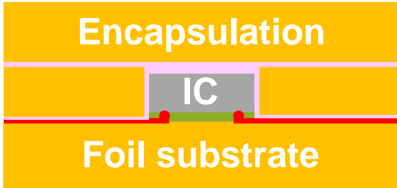
Without encapsulation

With encapsulation

R_{chain} (Ω)

Bends x 1000 (#)





Die embedding increases robustness by factor of 3.

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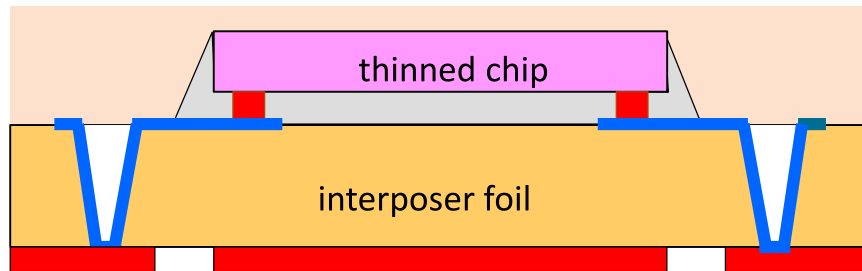
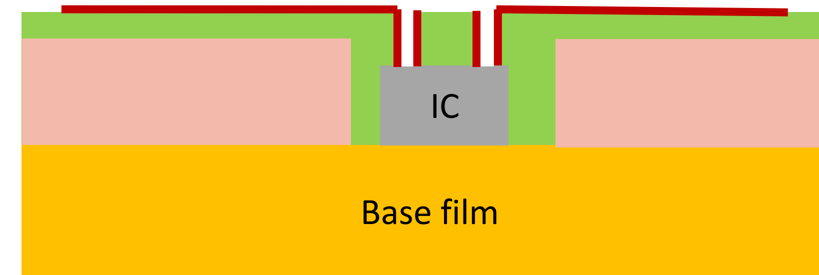
Two basic concepts for hybrid integration of thinned IC in film substrates

Flip-Chip die attach
RDL first, chip last



- Electrical interconnection by ACA / ACF bonding
- Mainly production ready technologies

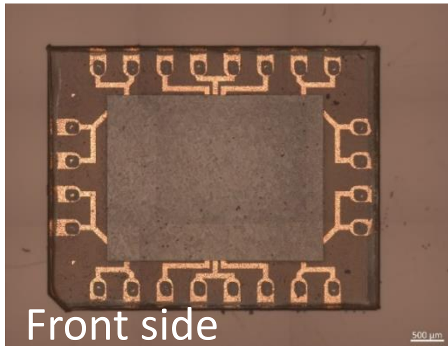
Face-up die mounting
Chip first, RDL last

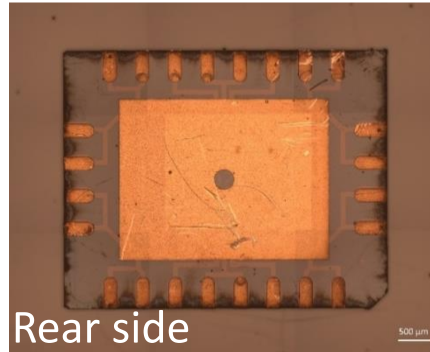


- Electrical interconnection by direct sputtered metal interconnects
- Challenge: dimensional changes of film substrates need to be compensated

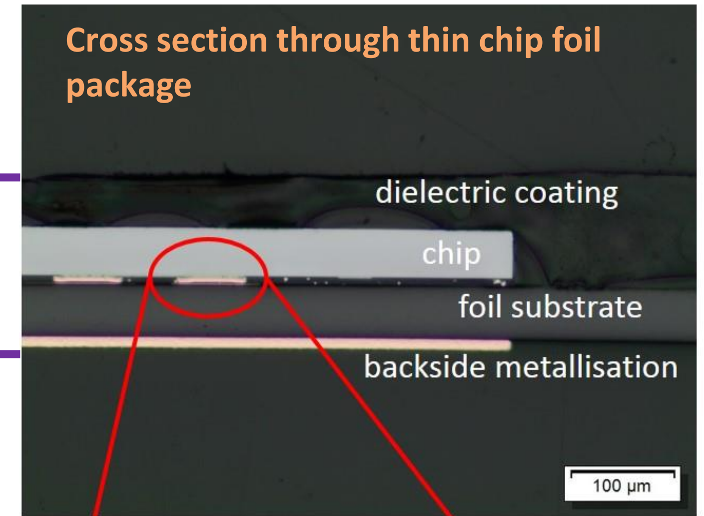
Thin Chip Foil Packages by Flip-Chip Bonding

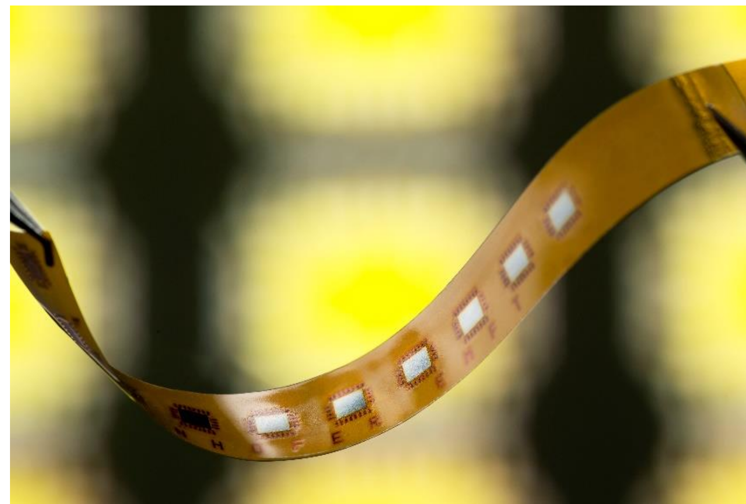
Processing on sheet level

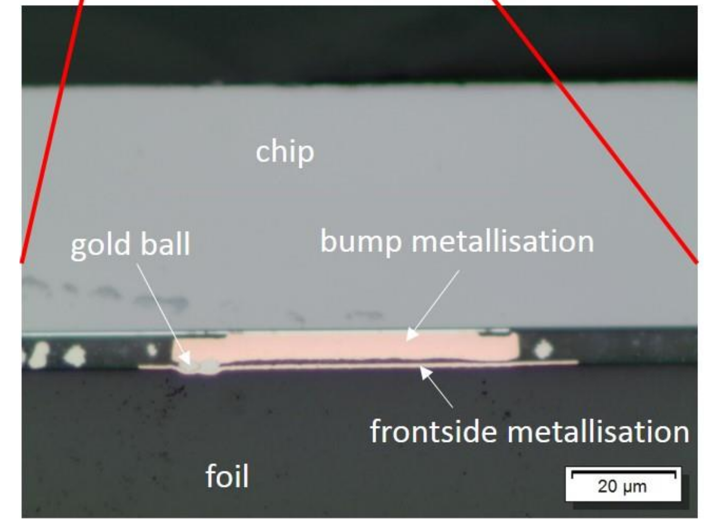




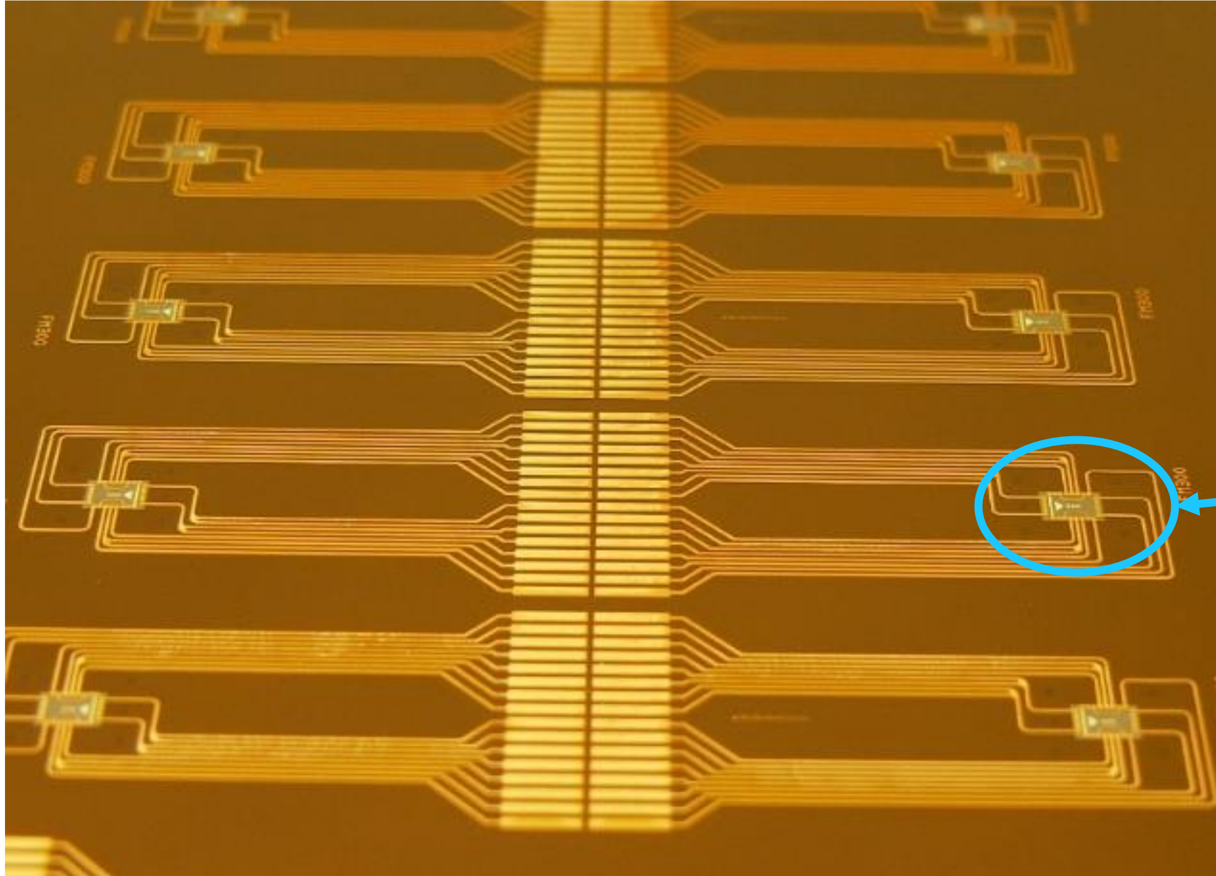
Package thickness ca. 150 µm



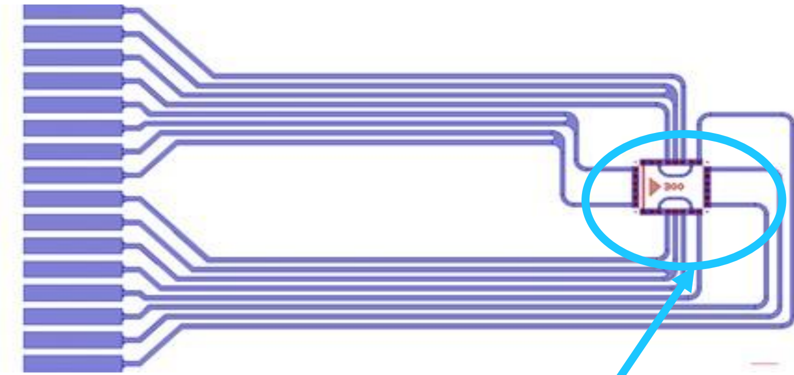


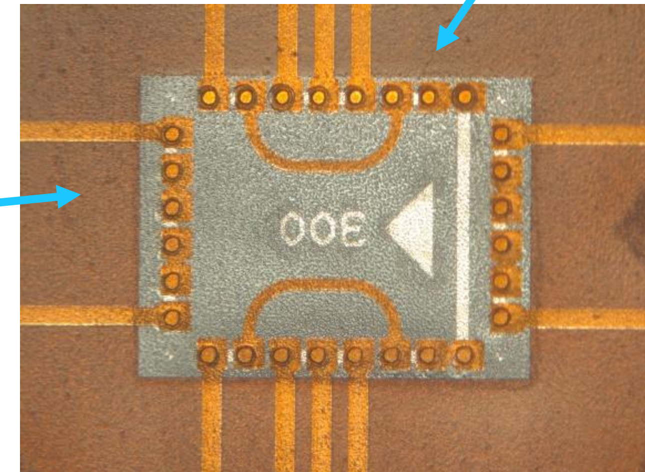


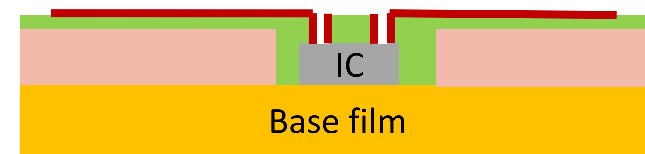
Thin Chip Foil Packages by face-up die bonding – prepared on sheet level
Chip first, RDL last



Face-up embedding of thin dies on film substrates







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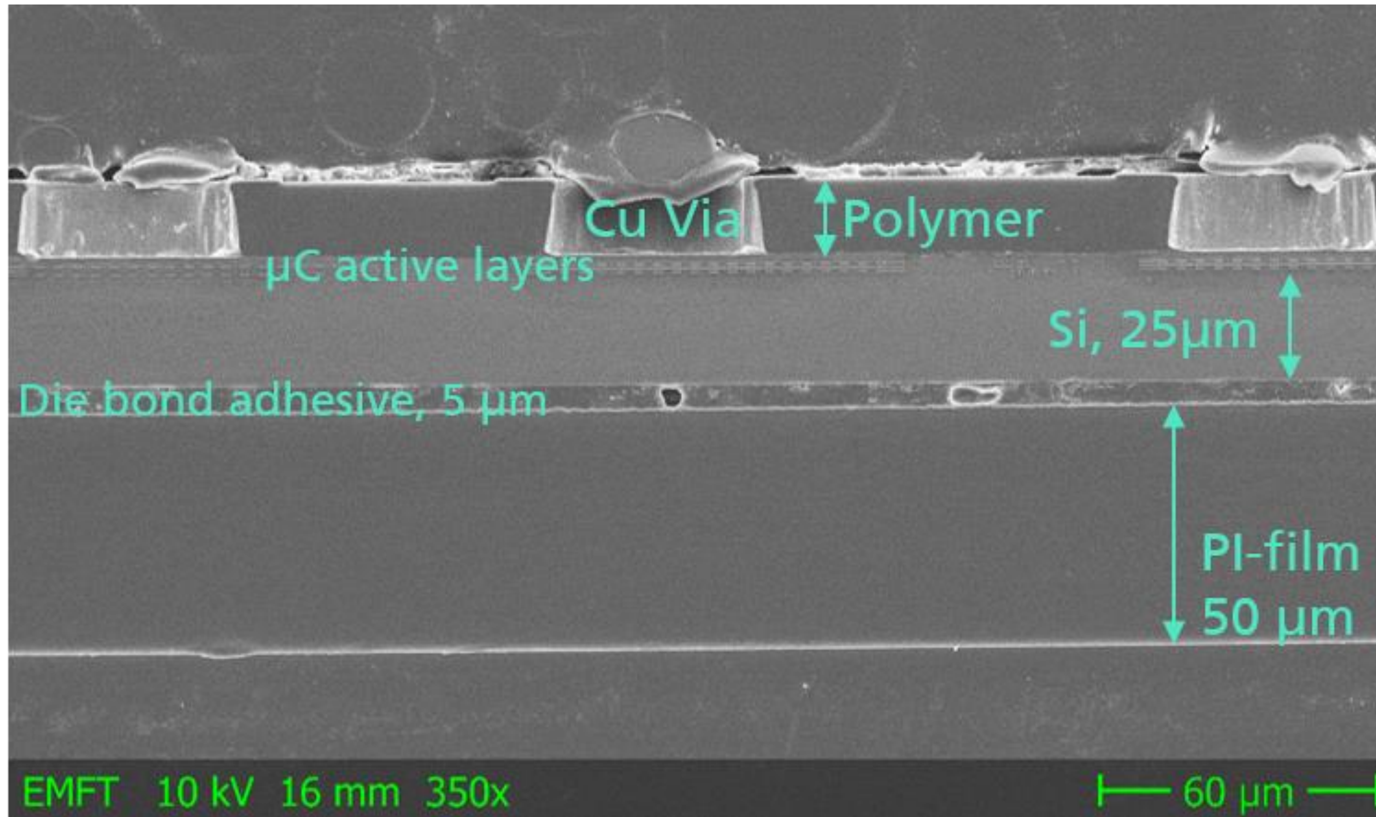
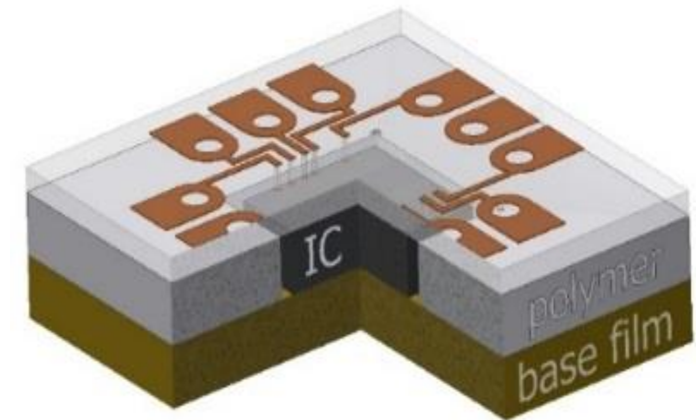
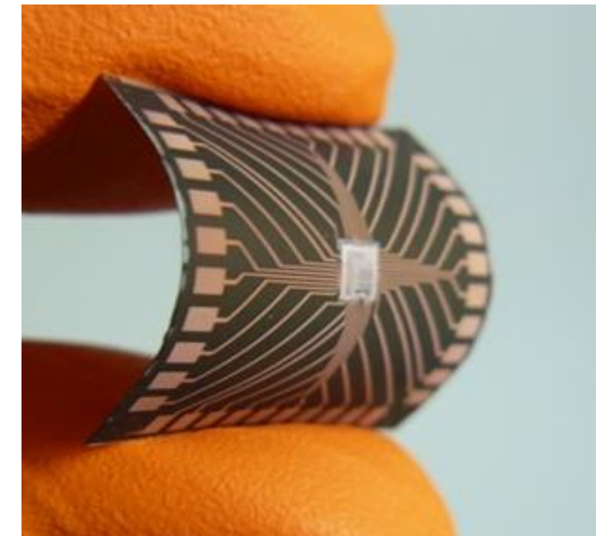
SEM image of cross-section of Thin Chip Foil Package



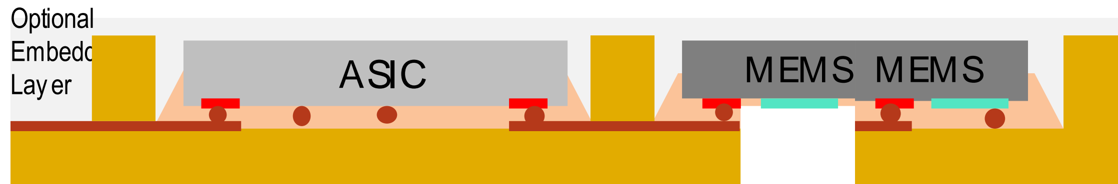




Ref.: C. Landesberger et al., ICEP 2016, Sapporro, Japan.

Application example:

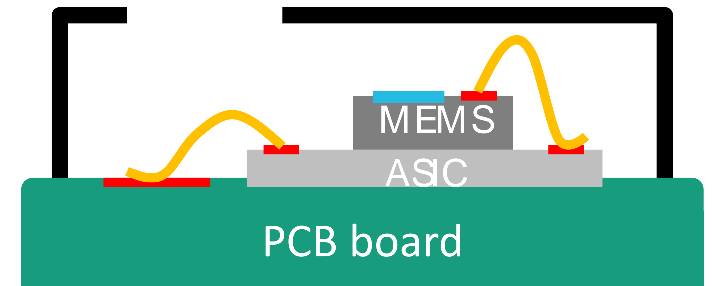
Thin and flexible foil package for MEMS pressure sensor / ASIC



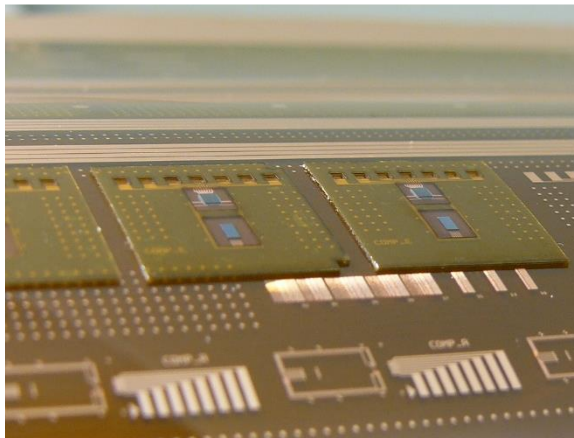
Thin MEMS foil package, opening through film

Thickness:

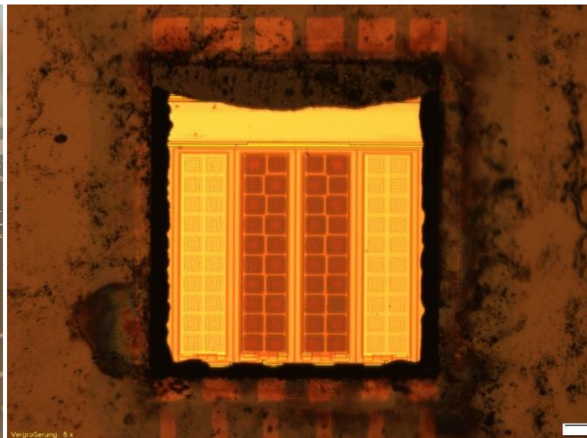
< 500µm 1 mm



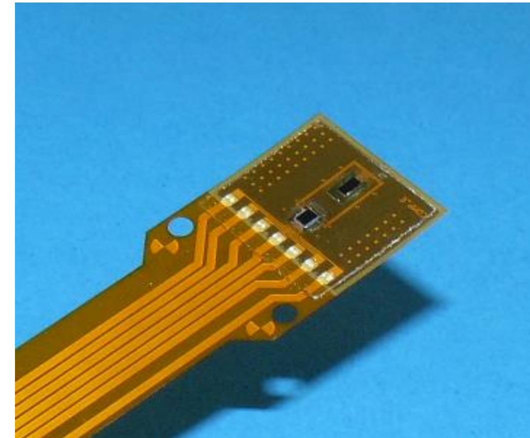
Standard mold package with open lid



Foil packages prepared on sheet level

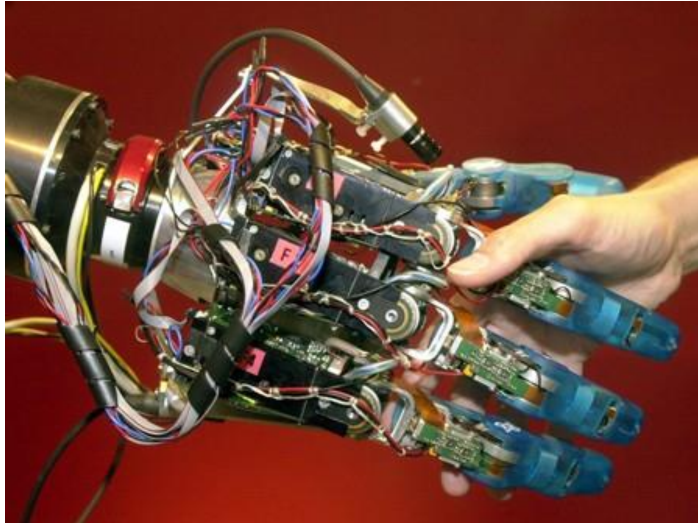


View through film onto MEMS sensor area



Film stack: sensor/ASIC module on wiring stripe

Challenge: Miniaturised and mobile 3D electronics
Example: Robotic hand



(picture alliance / dpa - Bernd Thissen)

https://www.shadowrobot.com/

Possible solutions through flexible electronics:

- Very compact, light and conformal wiring systems
- Integration of large-area sensorics (proximity, touch, force, stretch sensing)
- Integration of microelectronics; e.g. bare die microcontrollers in flex package

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Thank you for your attention!

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