Workshop on

"Smart Systems for Healthcare and Wellness"

Brusselles 4.2.2014

Hosted by the CATRENE Scientific Committee

Integration and Packaging

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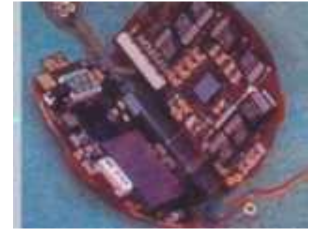
Technische Universität Berlin
Forschungsschwerpunkt
Technologien der Mikroperipherik

Fraunhofer IZM

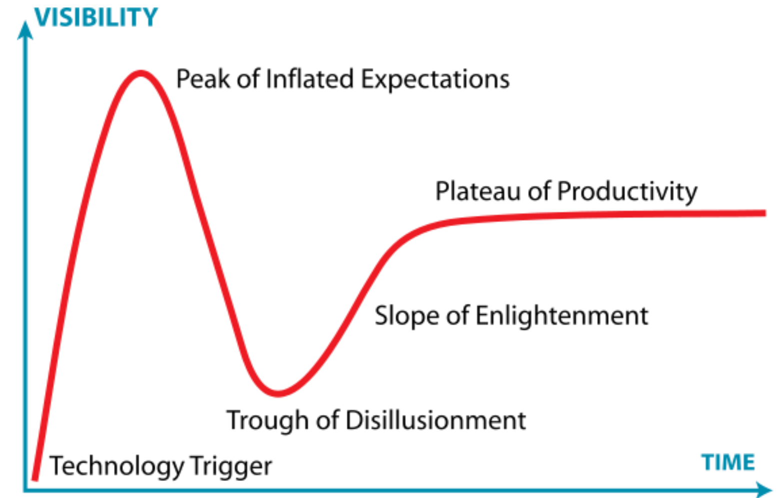
Medical Innovations….
…. and requirements



Medical technology uses micro devices already as components (ASICs, power ICs, accelerometers, pressure sensors)

Typically well known and understood technologies and components (risk minimization) are used

Innovative components and technologies need to prove both function and robustness prior integration into a system – which again needs to prove funtion and robustness as a whole



Mechanical design more difficult under DfM constraints than pure electronic design

Medical devices operate under conditions, which cannot be controlled by the manufacturer -> can result in very individual requirements (surgeon´s skill, patient behaviour)

-> sluggish adoption of novel integration and packaging technogies into the medical market

Technologies from MST which lend themselves for the medical arena

Component Development

- Low Power ASICs
- Sensor devices
- Power supply

Component enhancement

- Functionalization
- Rewiring, TSV
- Heterointegration @ Level Zero

Advanced Substrate Technology

- 3D Flex
- MID/MDD, Textiles
- Surface Modifications

Micro Assembly and Encapsulation

- Heterointegration in 3D
- Ultrasmall form factor assembly
- Mechanical Protective Layer
- Silicone biocompatibility layer

Barrier Layer Deposition

- Parylene conformal coating
- DLC deposition
- ALD of Al2O3

Functional Layer Deposition

- PEG, DEL, HAD

3D Free Form Generation

- Rapid prototyping/manufacturing
- Embedded electronic funtionality

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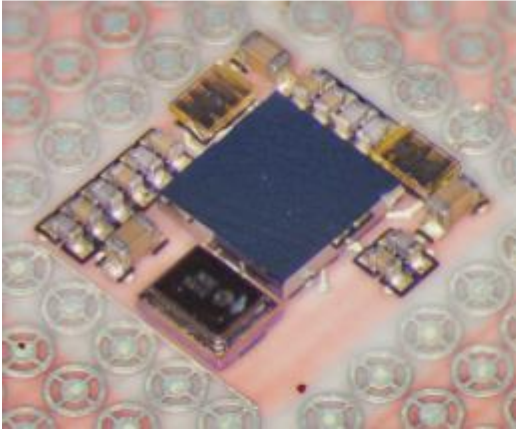

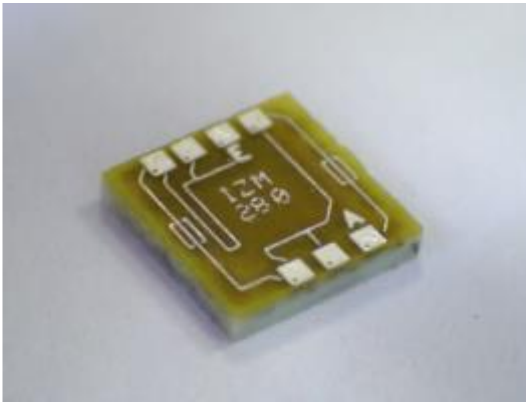

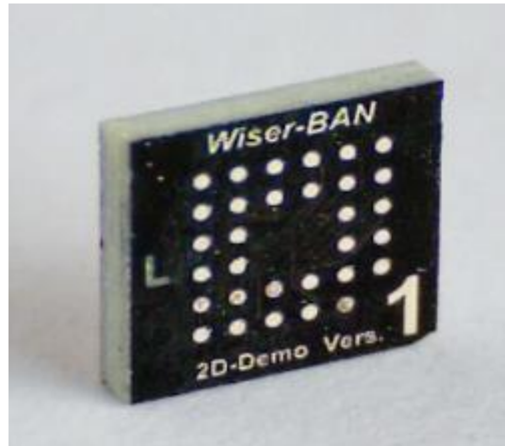

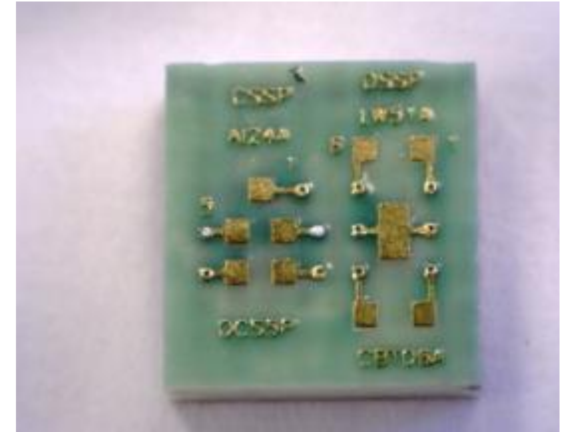

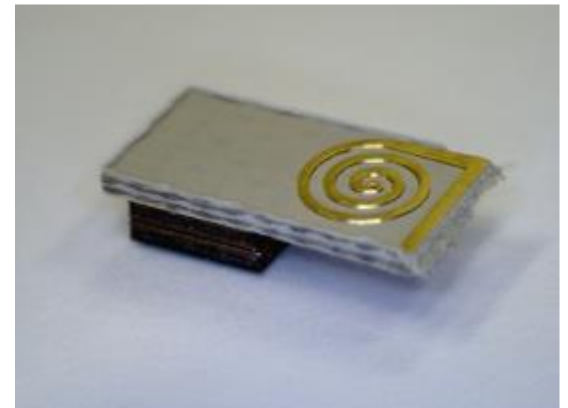

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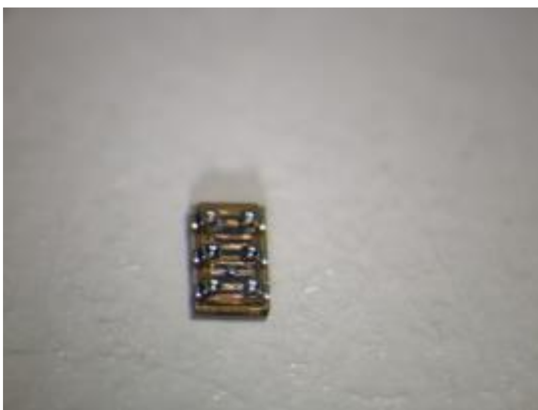
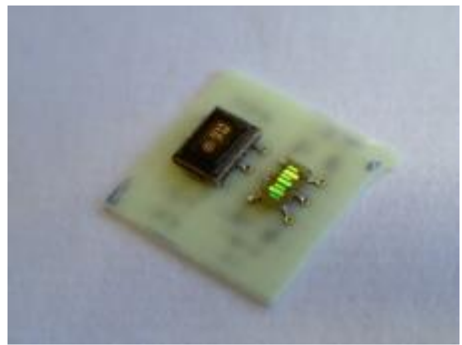
SiP modules with embedded SAW filters

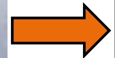
CSSP Cu frame
- 1.4x1.1x0.4mm
- 5 contacts
- Ni/Au



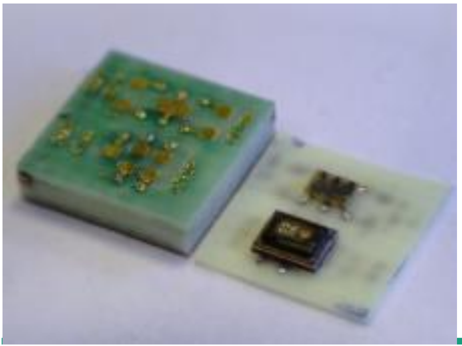
DSSP
- 0.95mmx0.6mmx0.21mm
- 6 contacts
- lead-free bumps

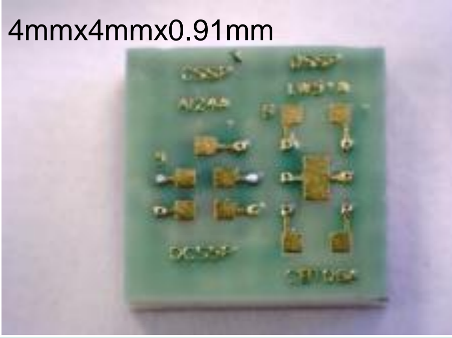


Assembly DSSP&CSSP



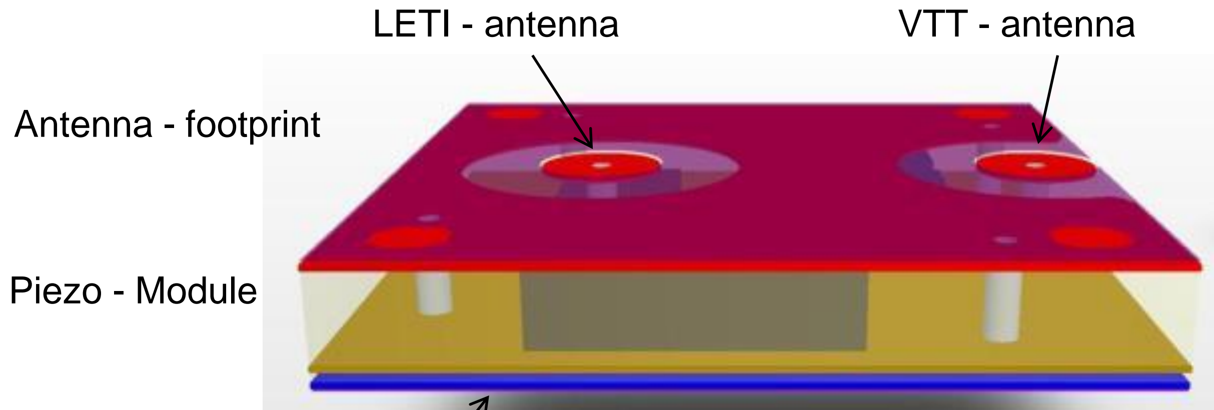
Cross section of module

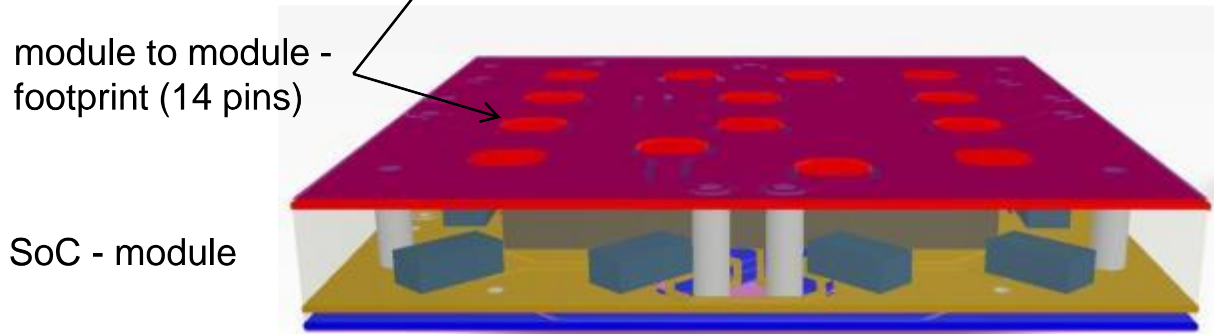


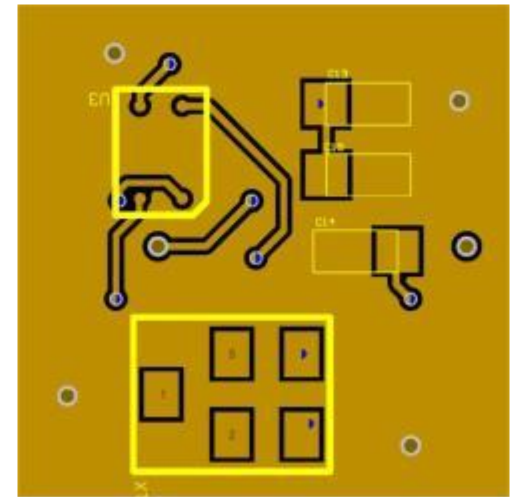


- Embedding feasible(✓)
- EPCOS testing (✓)

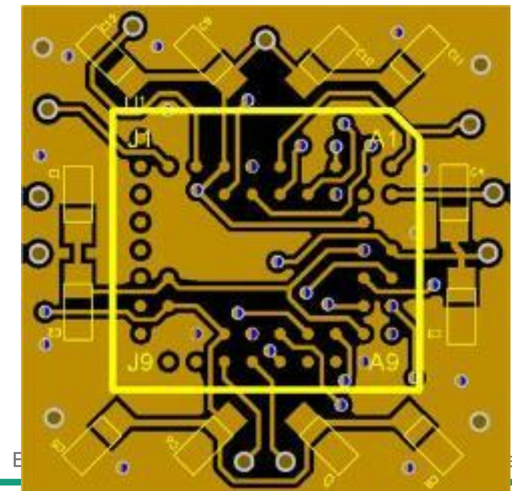
3D-SiP Design / Layout







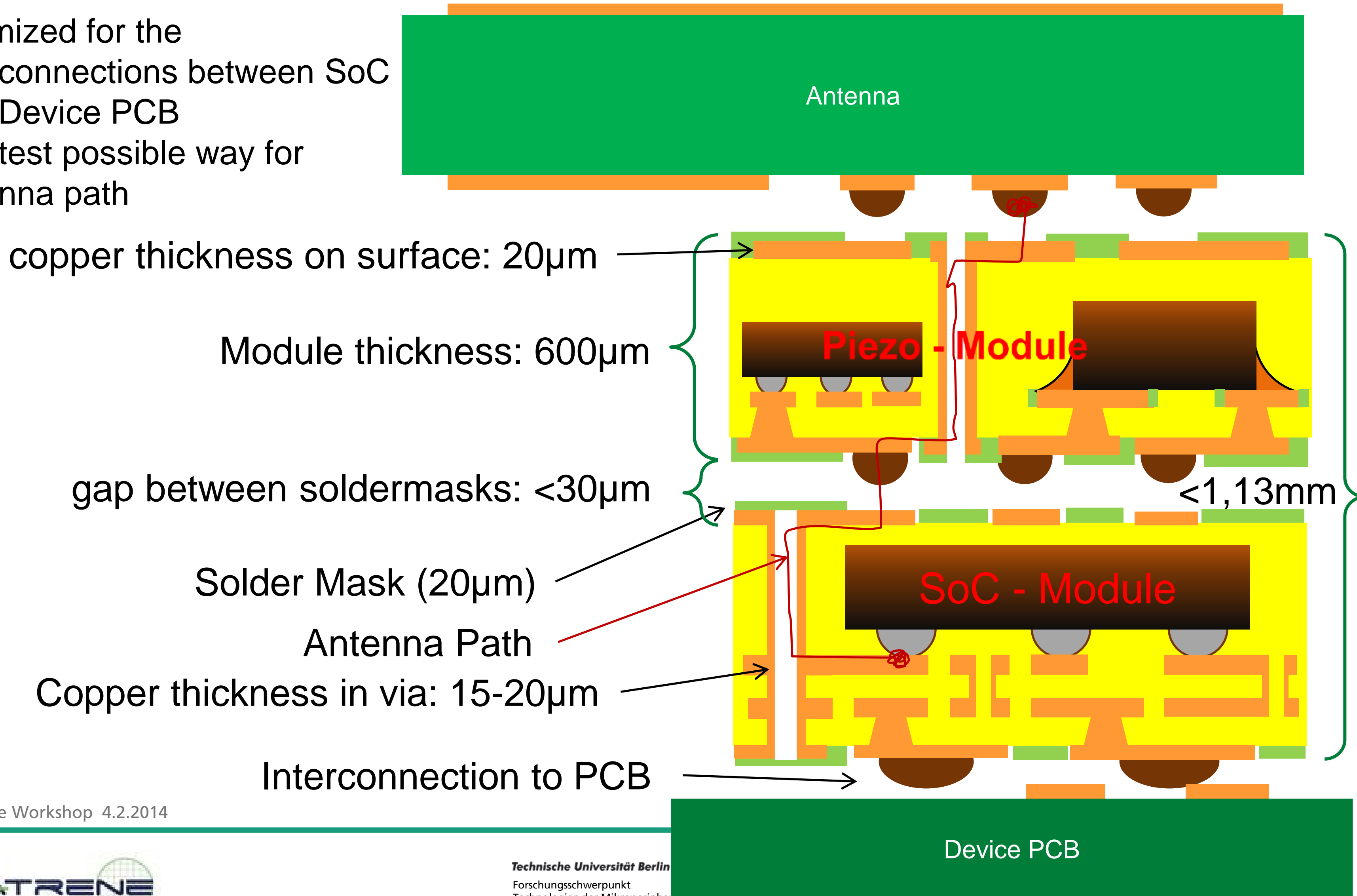
M2 – assembly-layer



M1 – assembly-layer

3D-SiP Stacking Concept

- optimized for the interconnections between SoC and Device PCB
- shortest possible way for antenna path

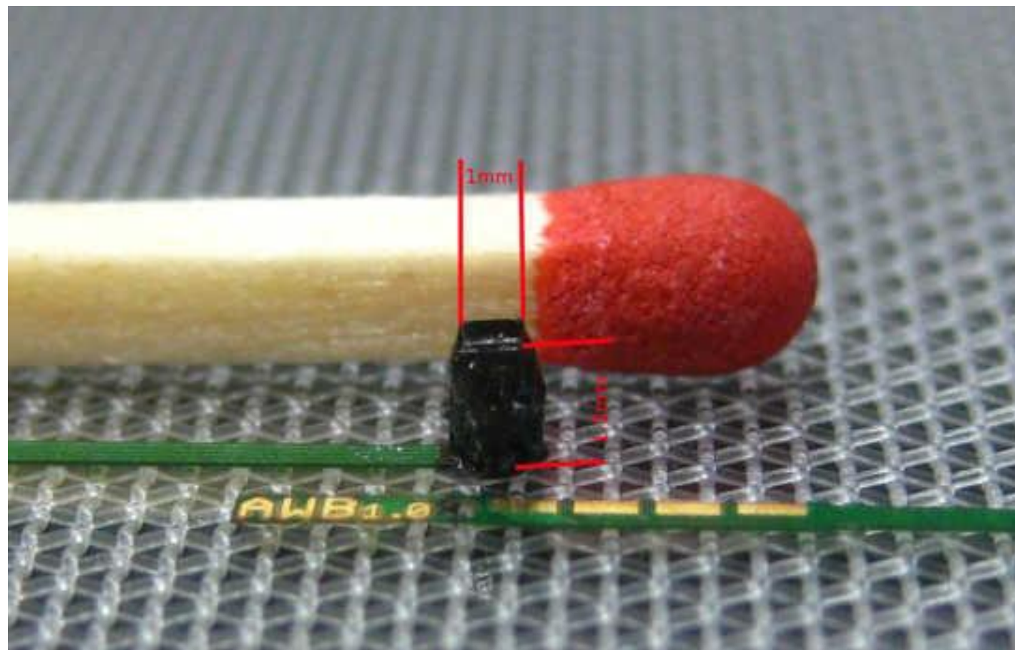


Micro Assembly and Encapsulation

- Heterointegration in 3D
- Ultrasmall form factor assembly
- Mechanical Protective Layer
- Silicone biocompatibility layer

Cooperation with AWAIBA and SUSS resulted in world record in integrated camera system

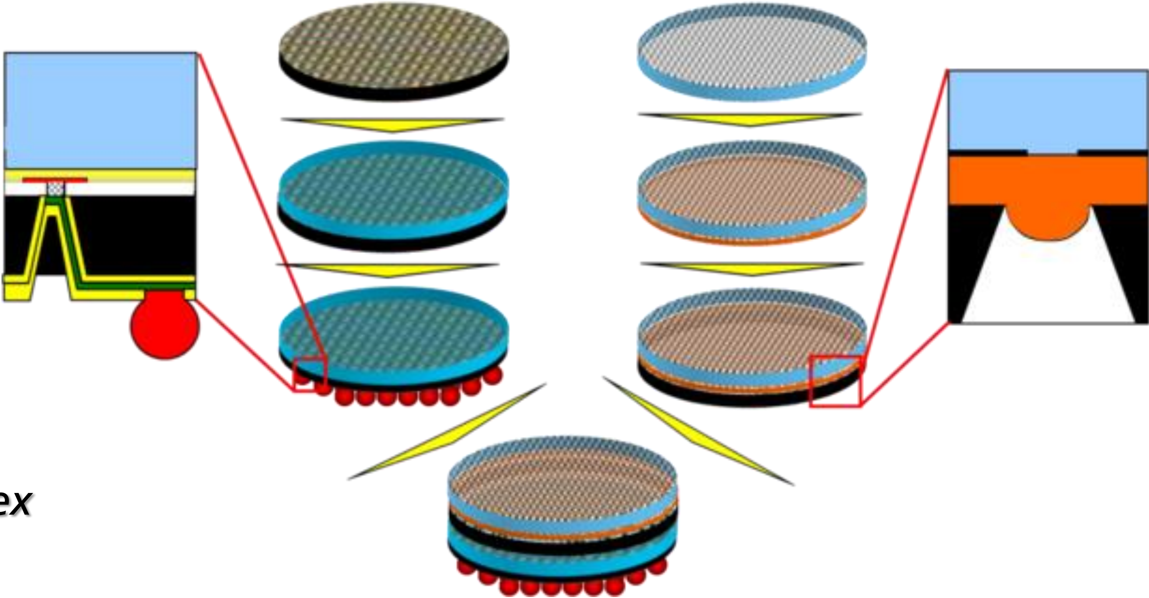
Assembly on 1,5m long miniature flex substrate strip
(roll-roll fabrication)



Novel diagnostic applications using miniature electronic optics and flex integration

Endoscope camera, ultrasmall

- *Combining microelectronic CMOS imaging chip*
- *with microoptical lenses*
- *MEMS bonding technologies*



- *Microbumps for attachment to flex*

Fraunhofer IZM Fraunhofer IOF SUSS MicroTec AWAIBA

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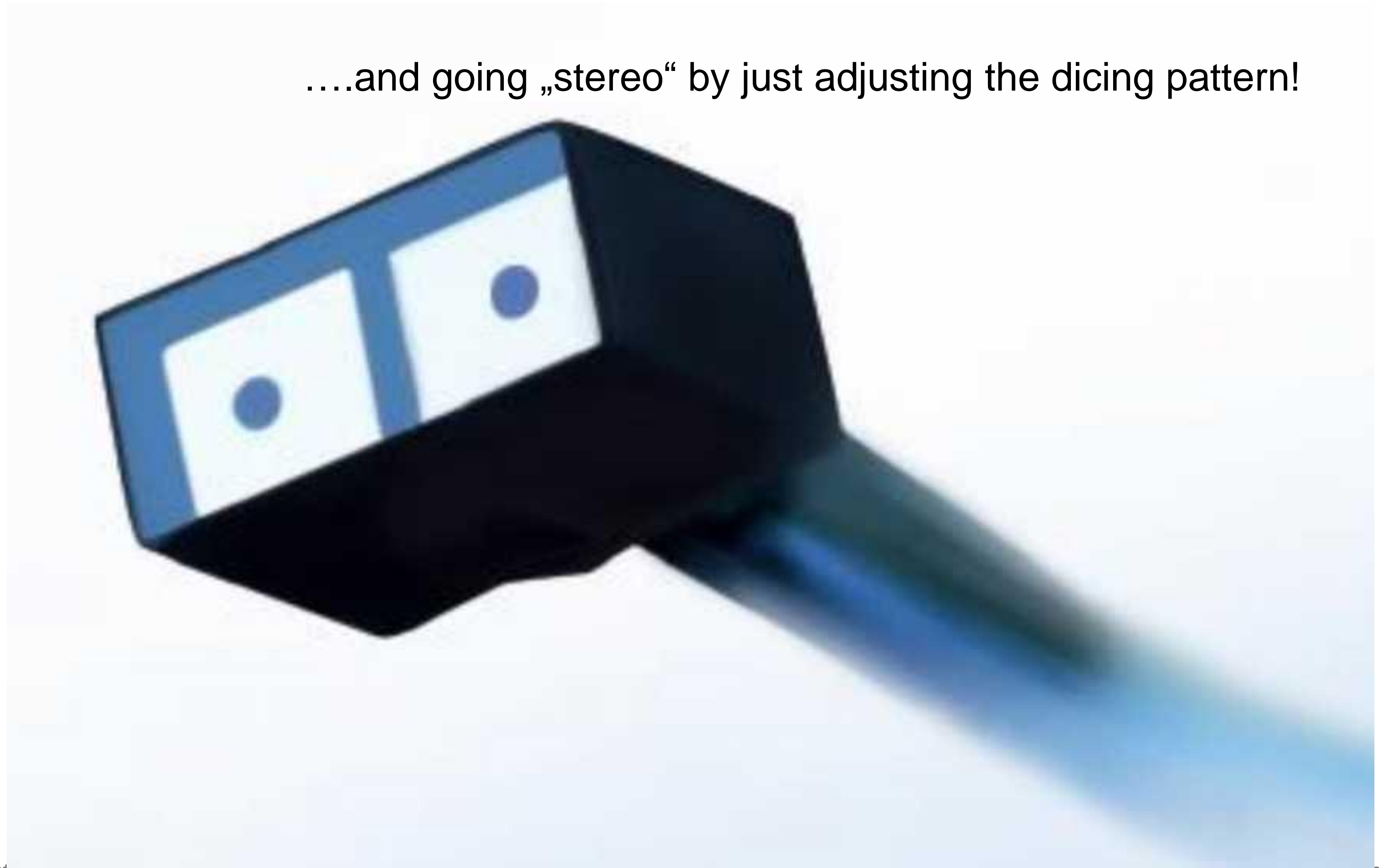
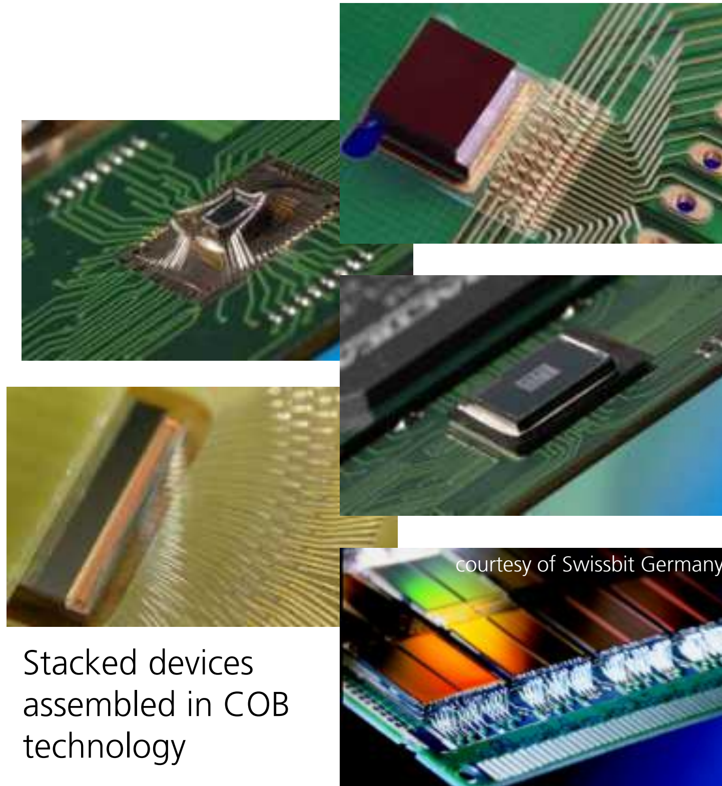
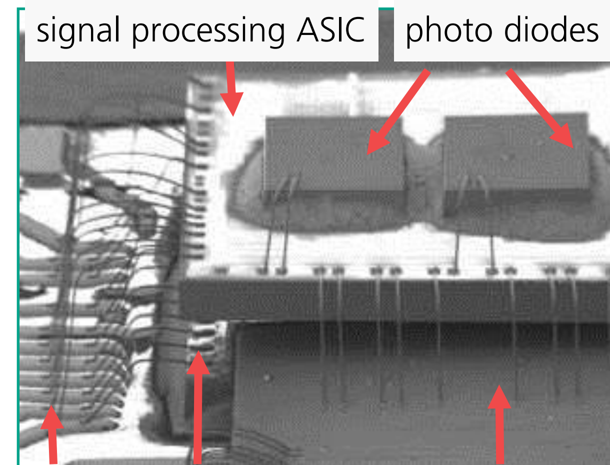


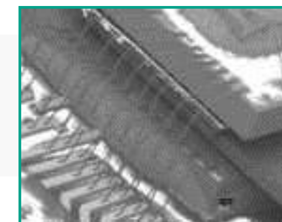
Chip-on-Board Stacking Technology



Stacked devices assembled in COB technology



Wire bonding at different device levels (1mil AlSi1)



S. Schmitz

Flip Chip Technologies

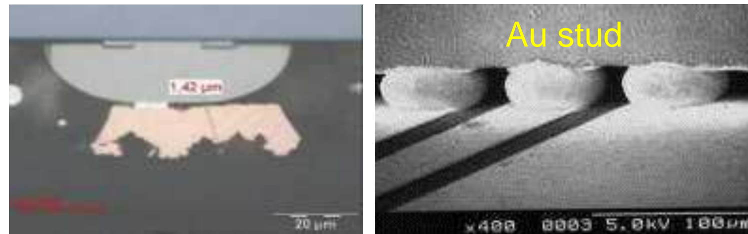
Thermode Bonding

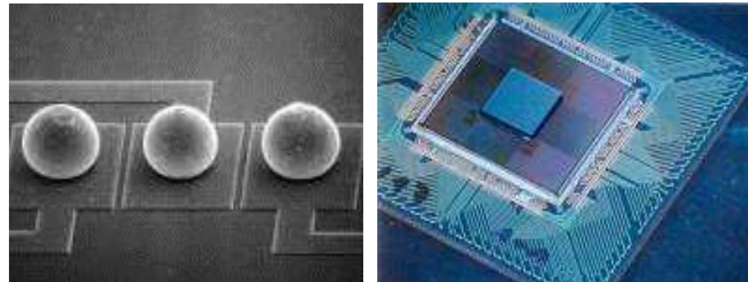
- Thermocompression
- Thermosonic

Reflow soldering

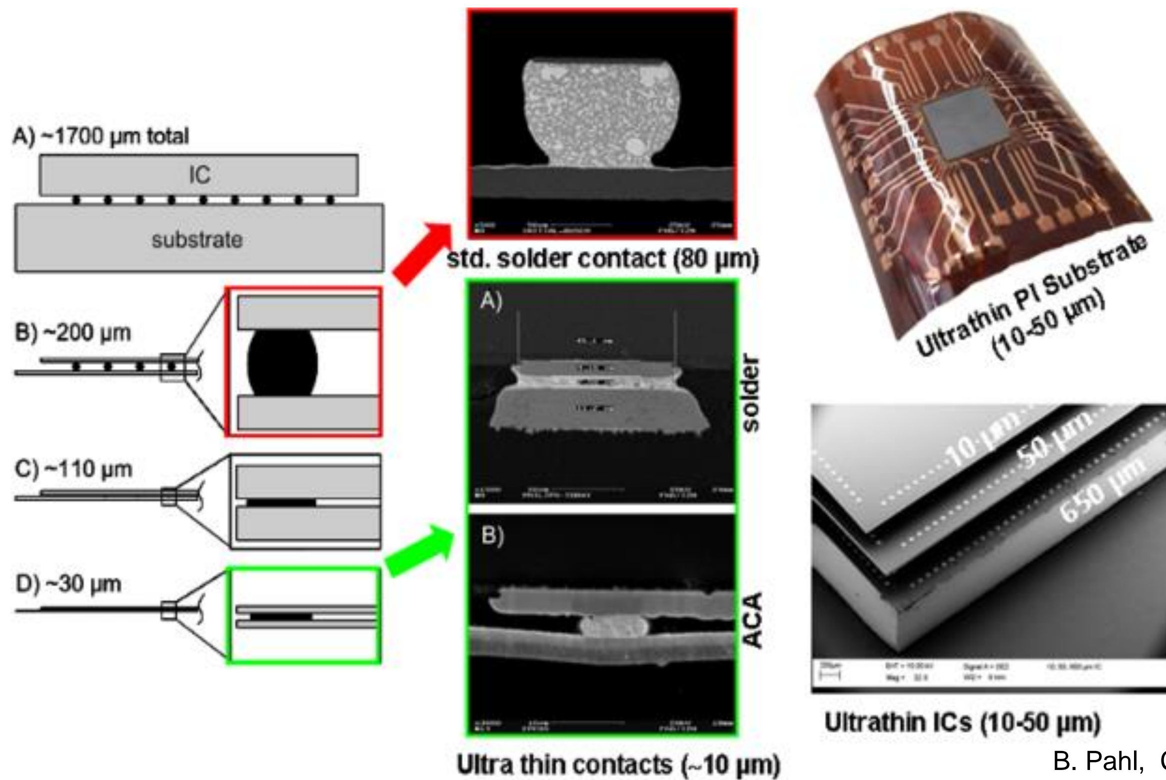
Adhesive Joining

- ICA - Isotropic Conductive Adhesive
- NCA - Non Conductive Adhesive
- ACA - Anisotropic Conductive Adhesive



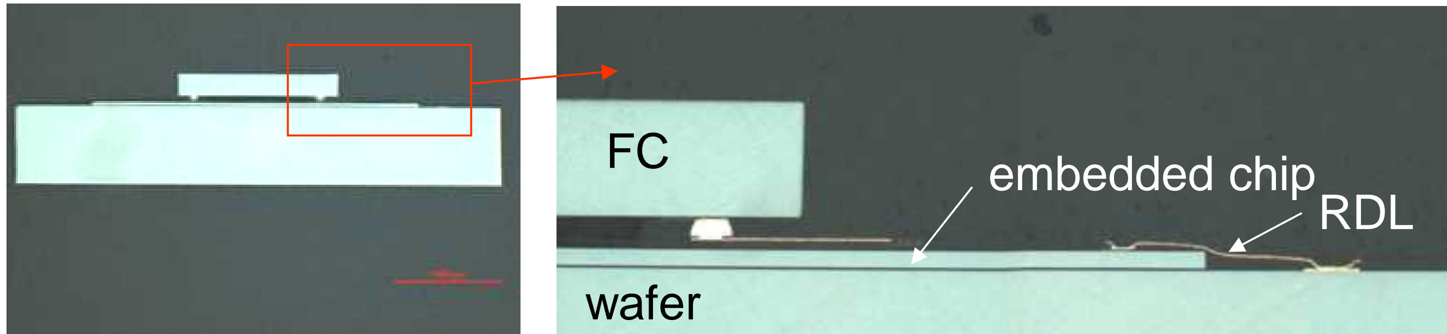


Ultra Thin Flip Chip Interconnects

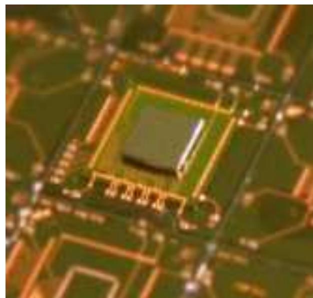


B. Pahl, C. Kallmayer

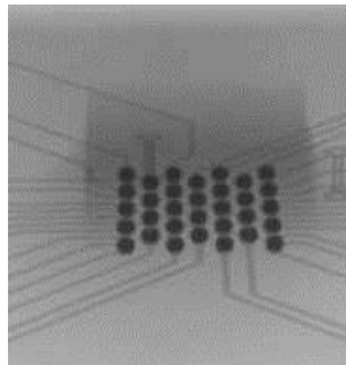
Thin Chip integration: Reliable System Level Integration of Stacked Chips on MEMS



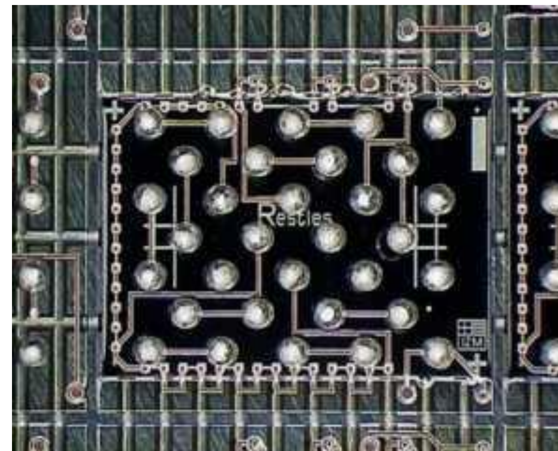
cross section of a three chip stack using chip embedding: thin chip embedded on wafer, formation of a RDL, FC-Bonding



Top view



Bumped TCI on wafer level



Chip scale package integration of different microsystem technologies by thin die stacking, polymer embedding and redistribution/bumping

Combining TSV, µAssembly and thin film routing for next generation medical devices

Medtronic´s vision of chip scale pacemaker

Substrate with thin film wiring and through silicon/glass vias

µAssembly of MEMS and thinned components by die-stacking

Wafer level hermetic sealing

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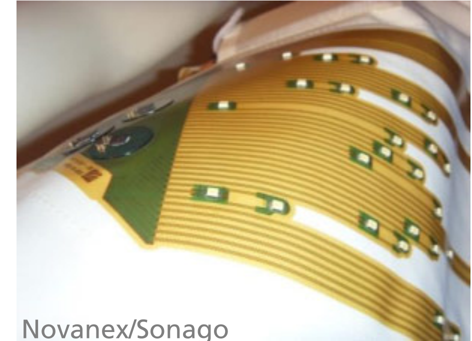
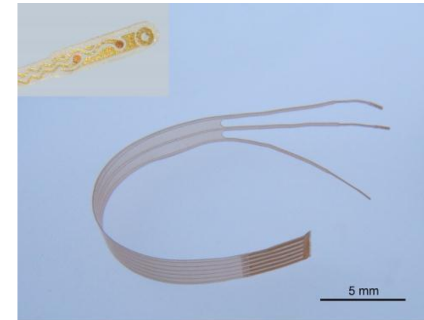
From rigid to flexible systems

MIT


Novanex/Sonago



rigid

flexible

stretchable

Motivation
Enabling potential of thermoplastic substrates

Polycarbonate:

high reliability

flexible

high threshold for plastic deformation

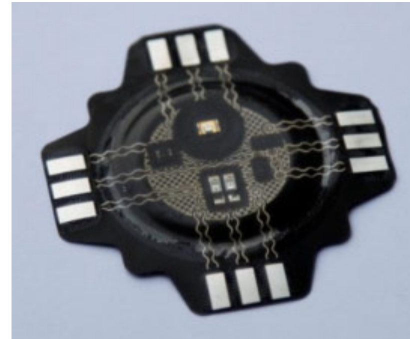
Chemical sensitivity

Polyurethane:

flexible & stretchable

Good adhesion to many surfaces

Low melting temperature

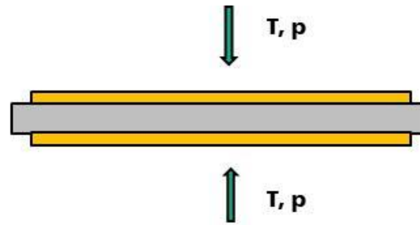


Flexible and Stretchable Substrates

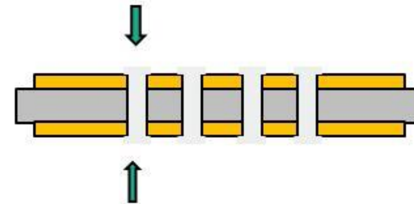
Properties	PI	LCP	PET	PC	TPU
Tensile Strength [MPa]	~100	30	25	70	55
Modulus [MPa]	4500	2300	2000-4000	2300	32
Dielectric constant	2-2.3	3	3.5	3	>3
T_g [°C]	230	T_{melt}: 300-350	80-100	T_{melt}:220-230	T_{mel}: 155-170
CTE [ppm] < T_g	13-20	18	45	40 (with filler) 70 (unfilled)	~200
Moisture uptake [%]	2.5-3.5	<0.1	0.08	0.35	
Breakthrough voltage [kV/mm]	250-300	240	100	60	
Via size [µm]	200 µVia: 75	200 µVia: 75	-	100	100
Min. Line/Space*	25	25	150	25	40
Maturity of technology	standard	low volume	Standard	R&D	R&D, transferred to few manufacturers

Structuring of Thermoplastic Substrates

Cu lamination from both sides

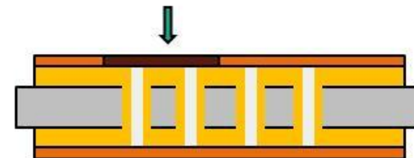


Via drilling

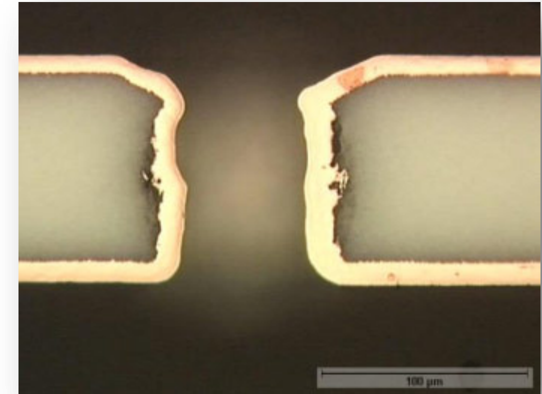


Electroplating

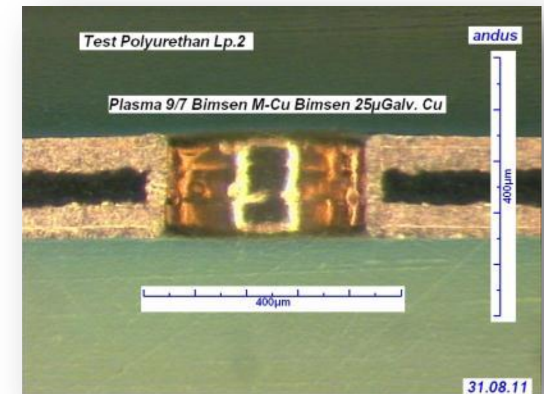
Photolithography



Etching /final metallization (opt.)

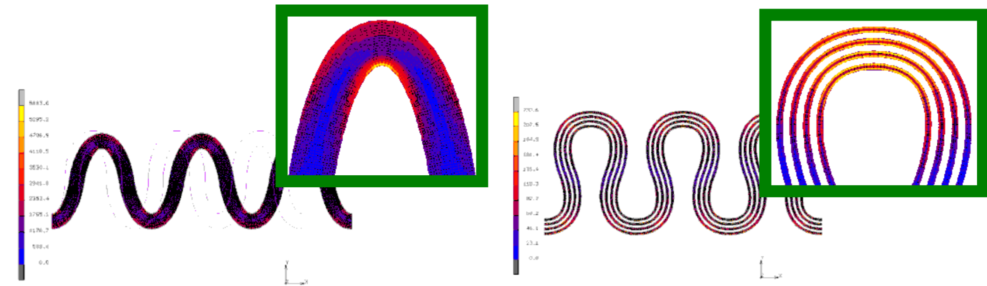


Via in Polycarbonate foil

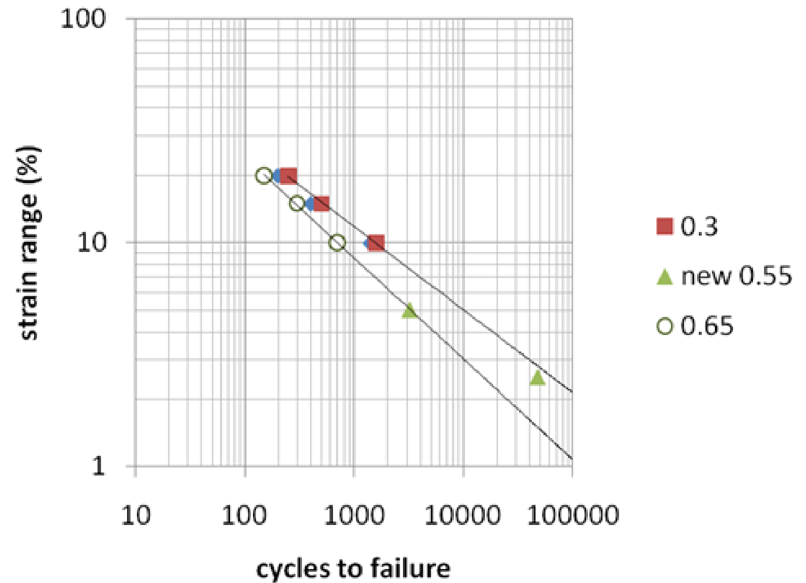


Via in thermoplastic polyurethane foil

Stretchable Circuit Board – Cu track patterning



Cyclic stretching: reliability



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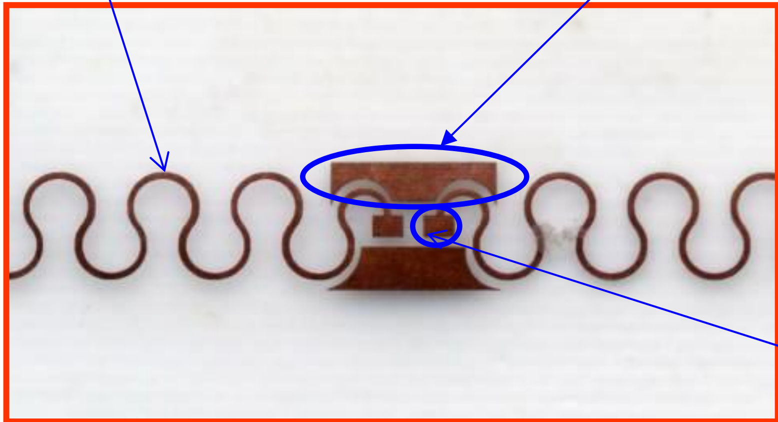
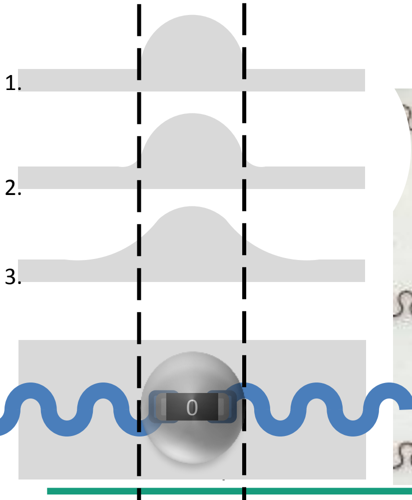
Stretchable Circuit Board – Rigid stretch transition

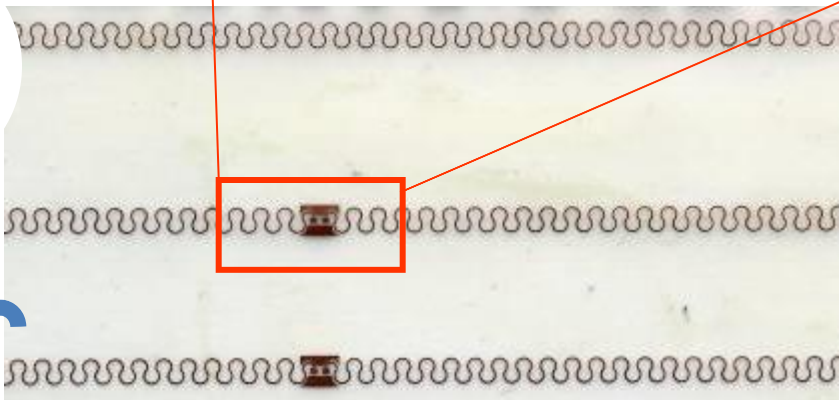
meanders for Stretchablility

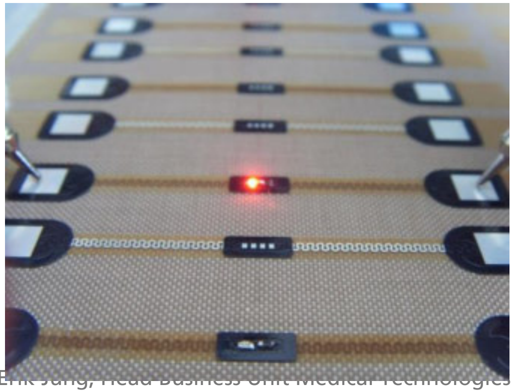
local Cu Stiffeners



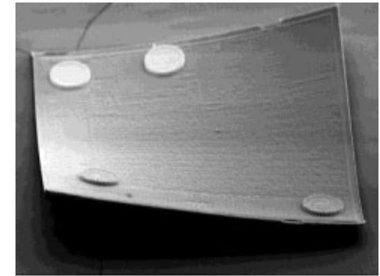
bondpads for components

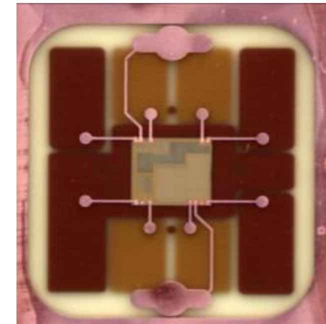


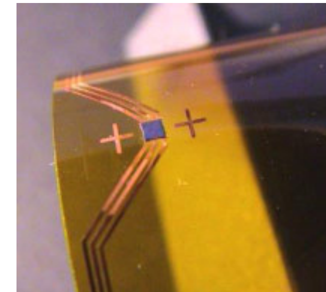




Ultrathin Chips for flexible Electronics







Necessity of ultrathin chips:

- mechanical flexibility
- thin modules
- 3D-integration

Reasons for component integration in substrate:

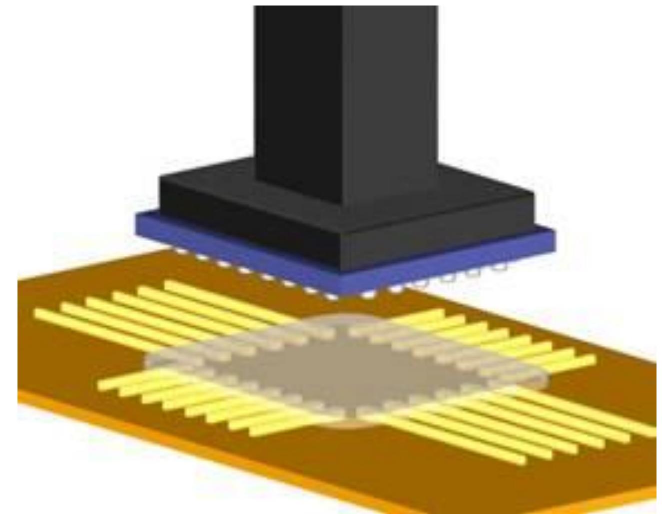
- fine pitch
- high density, short paths
- thin modules with flat surface

Prerequisites:

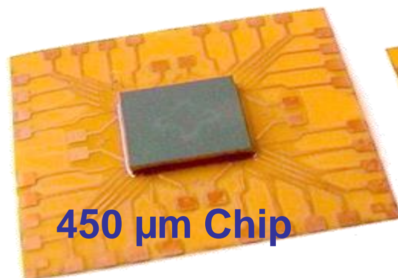
- commercial availability of thin chips
- qualified assembly processes with ultrathin contacs

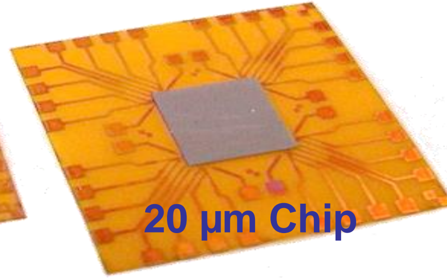
Integration Technologies: Thermode Bonding

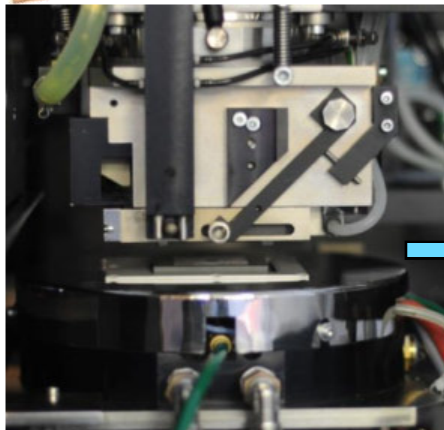
Application of adhesive or noflow underfill

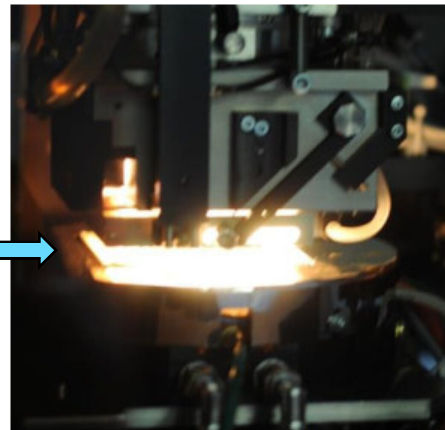


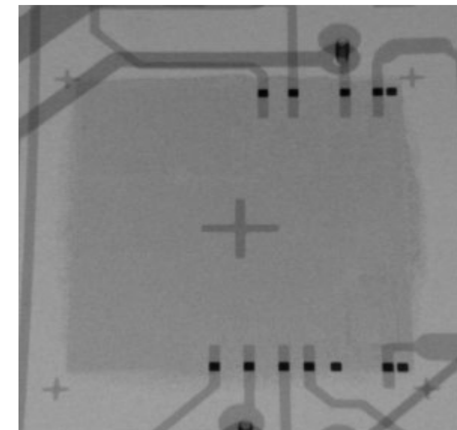
Curing / soldering under temperature and presure









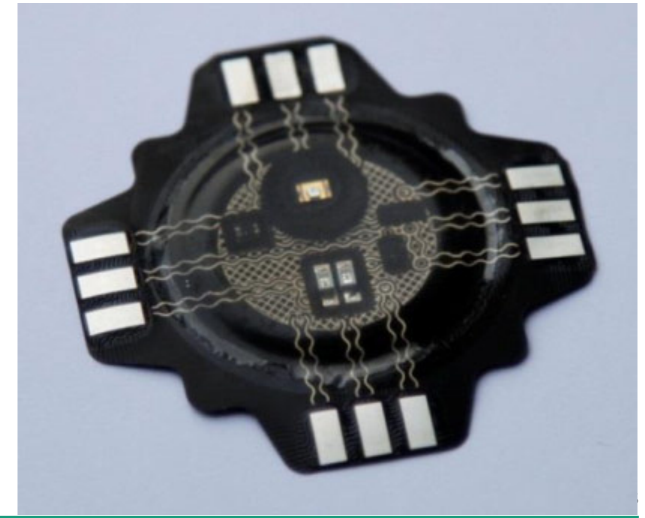


X-Ray of SMX after ACA bonding

Application Example: – Diagnostic Band Aid

Stretchable substrate + encapsulation for the electronic compontes

control
LED
photodetector
read out electronic
Skin tissue
color markers
opt. excitation
flourescence



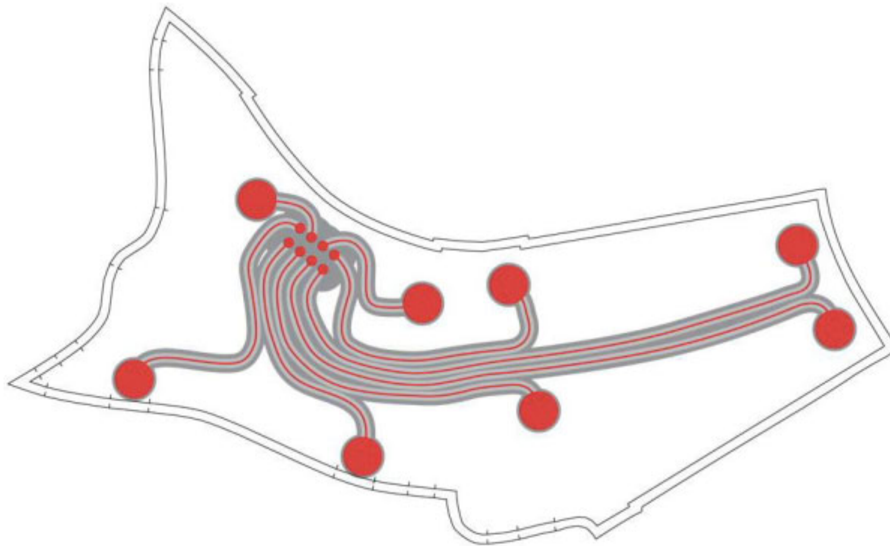
Application Example: T-Shirt for Muscle Stimulation Therapy

System design: Uni Boras*

Functionality: Muscle stimulation therapy for patients with muscle spasticity

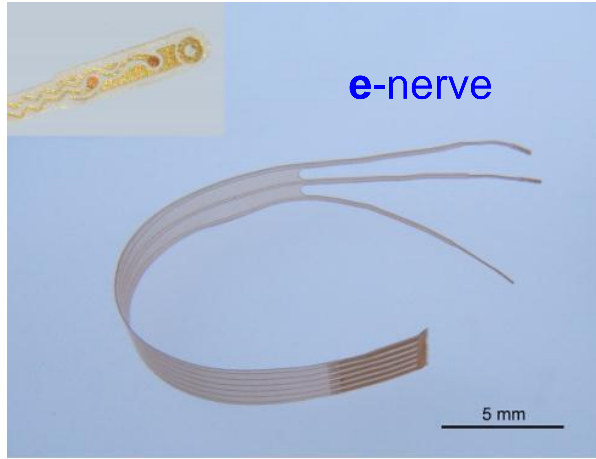
SCB for interconnection between dry electrodes distributed over the shirt

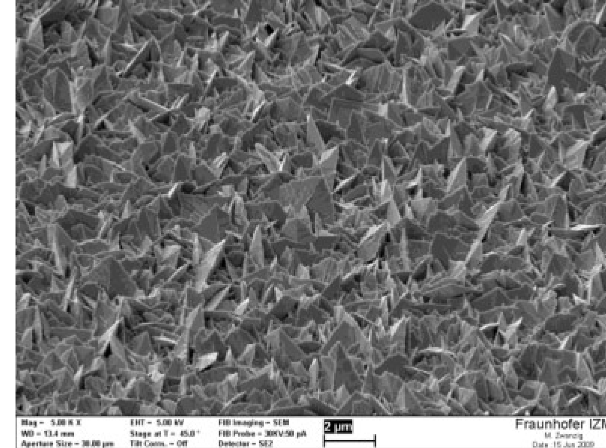
Interconnection to electrodes with push buttons

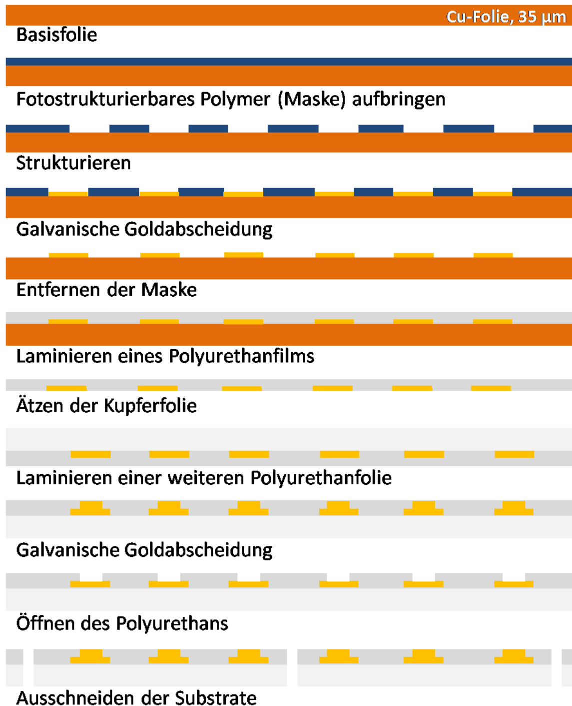


F. Seoane, STRETCHABLE CIRCUIT BOARD TECHNOLOGY ENABLING SEAMLESS TEXTILE-ELECTRONIC INTEGRATION FOR ELECTRICAL MUSCLE STIMULATION THERAPY, Printed Electronics USA, 2012

Application Example: Implantable Electrodes for Neural Interconnection



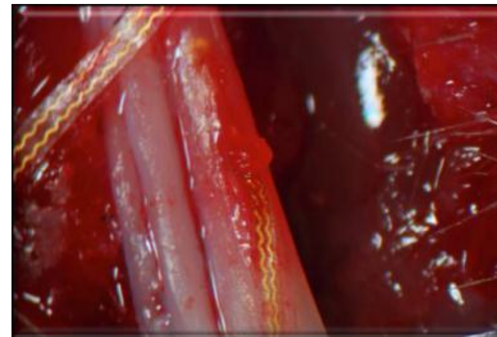




Process flow with Au metallization

Nanostructured Au surface

- Improved cell adhesion
- Increased surface



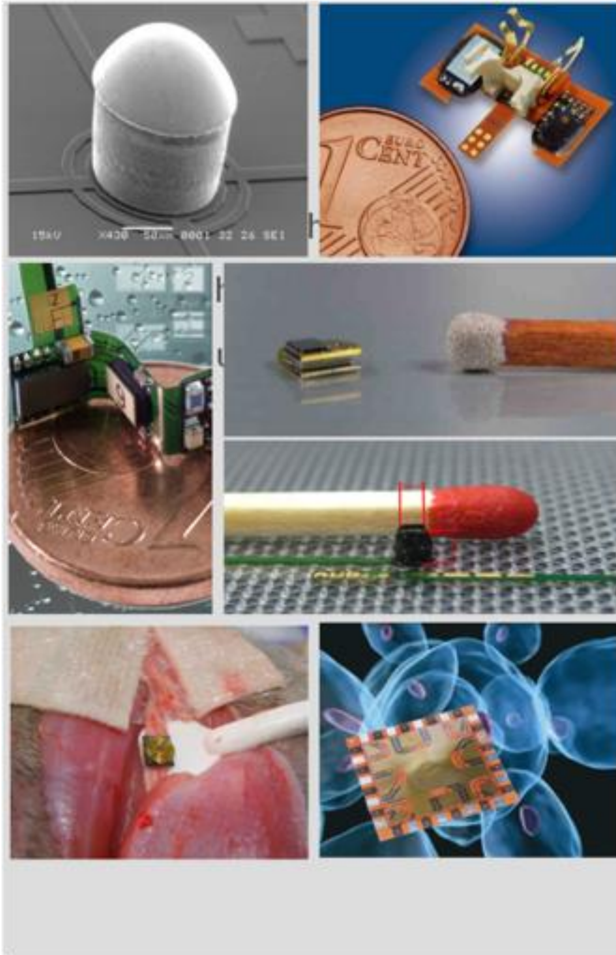
Synopsis

Micro electronics and micro system technology offer new opportunities to use innovative techniques and convert them into novel products.

New and improved diagnostic and therapeutic concepts can be realized by leveraging these technologies

The synergy between the medical sector, micro electronics, microintegration and IT will offer improved quality of life now and in the future at acceptable cost due to the economy of scale and high degrees of autonomy enabled by these advancements

Nano scale sensors will allow to increase functionality of diagnostic methods significantly – micro-packaging will play a strong role here for final integration into a product



Research and Development for Medical Micro Systems

- Engineering support for manufacturing and integration of medical micro systems
- Design for Reliability and Verification of Reliability
- Exhaustive technology portfolio to help our customers to pave the way from concept to product
- Redistribution of chips and wafers
- Hermetization by metal or glassivation
- Polymeric packaging
- Minature system realization
- Ultrafine substrate manufacturing in rigid and flex
- Opto-electrical system design and manufacturing
- System level design and simulation
- Manufacturing processs for prototype and pre-fabrication volumes

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