Fast Capture
Fingerprint/Palm Print Technology

Project Number 2005-IJ-CX-K067, Award Date 09/16/2005

Final Project Report
Phase 1:
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NIJ

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Foil Sensor Development
G. Urban, F. Gemetz, E. Spiller, U. Herberth,

IBB Dr. Büstgens, S. Georges
Foil Sensor Design, Processing, Technical Management

IBA Prof. Aurich (University of Koblenz)
Electronics & sensor simulation model development

PE Productivity Engineering IC Design
ASIC Specification and ASIC development
Stefan Schubert, S. Brenner, R. Malsch, J. Grosse

The Idea – How it started

Wouldn't it be great

to have a very thin foil

that can sense a fingerprint

and be flexible enough

to bend around the finger

for capturing the nail-to-nail impression

in less then 1 second

at 500 ppi resolution and 1.6 x 1.6 Inch ?

The Idea – How it started

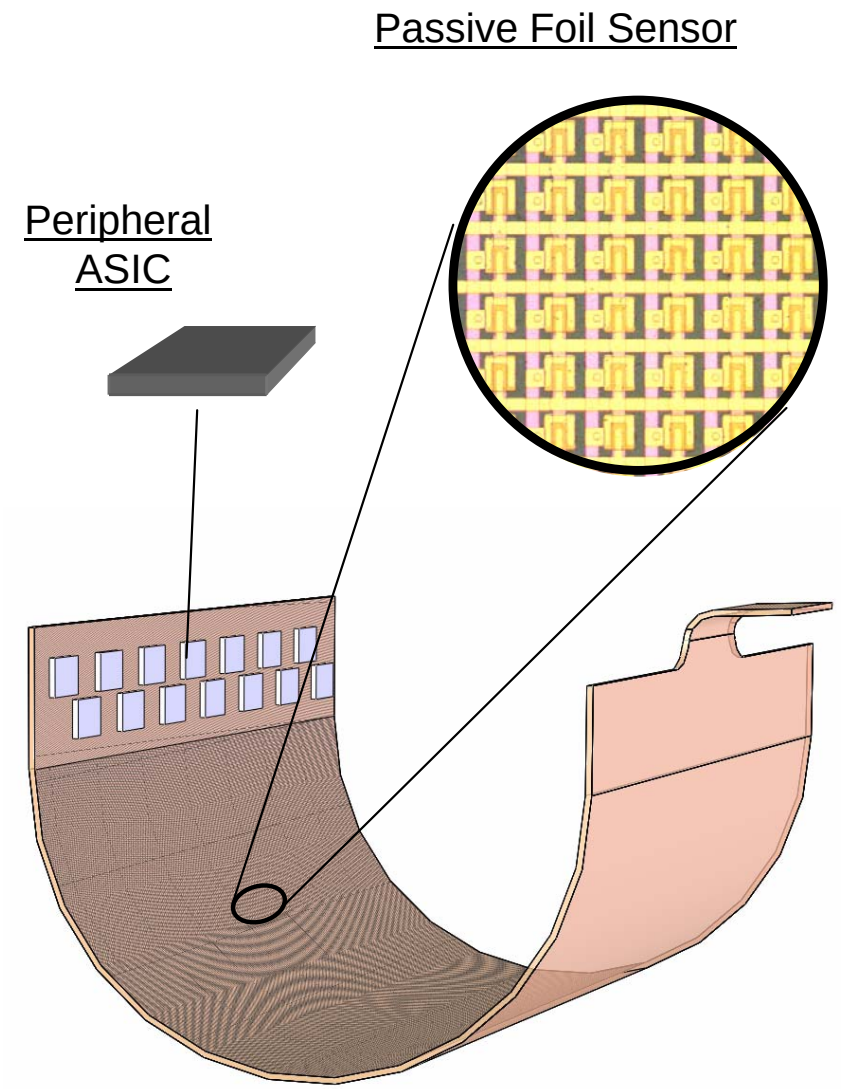
Yes! But:

- **Sensors are not thin**
- **Sensors are not flexible**
- **Sensors cannot bend around a finger**

… unless we find a way to bring existing foil sensor technology and fingerprint sensing principles together.

THIS IS WHAT WE DID.

Basic Technological Approach



Passive Foil Sensor

- Metal or Polymer Foil or Composite
- Thin Film Circuitry
- Sensing Field: Array Layout
- Variable Measurement Principles
- Cheap
- Elastic: adapting to finger
- Best suited for large surface sensors

Peripheral ASIC

- Highly integrated
- Impedance Measurement
- Small
- Cost efficient

Foil Interconnect

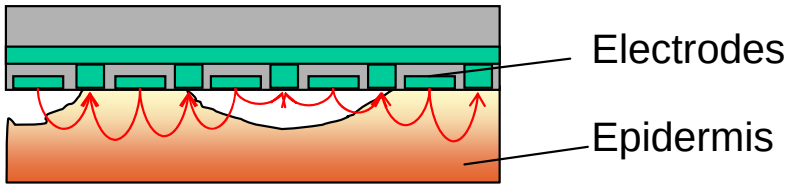
- flexible
- integrated

Measurement Principles

One of the results of the scientific work done before the NIJ project award was for a **novel electronic readout principle** for the fingerprint sensor. It will be applied in special ASICs. The new readout principle enabled us to:

- use the well known base principle of the **capacitive sensor**
- in **flexible sensor geometries**
- that could theoretically be **scaled up** to the size of a palm print.

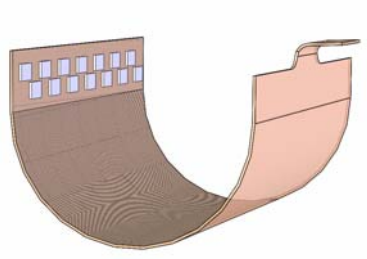
2005
Novel Capacitive Impedance
Principle on IMTEK foil technology



Development Packages in Project Phase 1

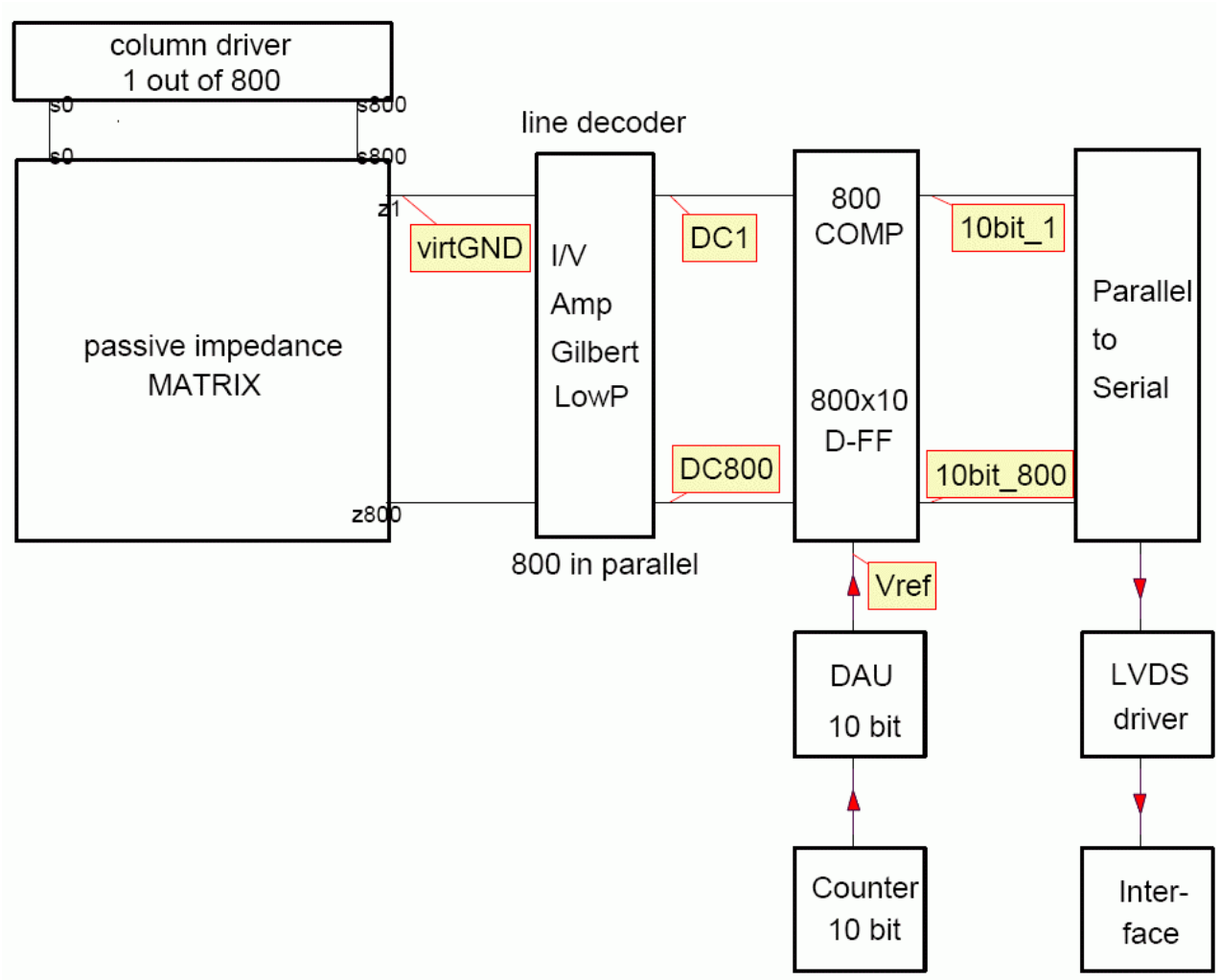
- **Simulation and electronics design (Prof. Urban, Prof. Aurich)**
  - A simulation model of the entire sensor field comprising also the electric model of a finger
  - Impedance test measurements on finger for verification of models

- **Foil sensor development (Dr. Büstgens, Georges)**
  - Fabrication processes, materials definition
  - Mask layout
  - Foil substrate fabrication
  - Tooling for large foil substrate handling
  - Foil Sensor/ASIC assembly process and design definition
  - Flip Chip Setup and Tooling

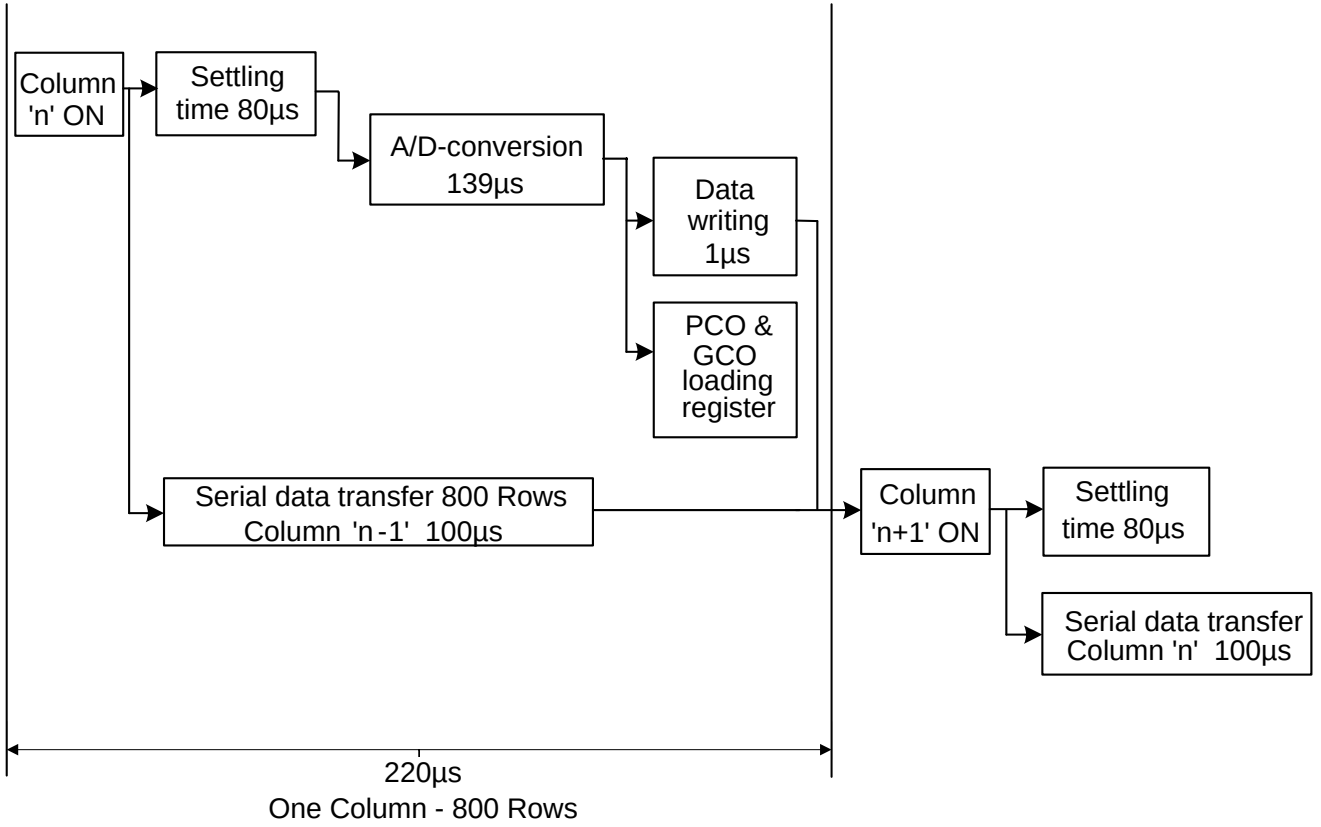


- **ASIC development (Prof. Aurich, PE Productivity Engineering)**
  - Specification and circuit design
  - ASIC Layout development
  - Fab processing of ASIC
  - ASIC testing

Schematic Block Diagram



Schematic Timing Diagram



800 x 800 Matrix = (Cycle time of 1 Column) x (number of columns) = 220µs x 800 = **176ms**

This means that we can acquire more than **5 complete fingerprint images** with 800 x 800 pixels at 500ppi per second with the Foil Sensor in its current design.

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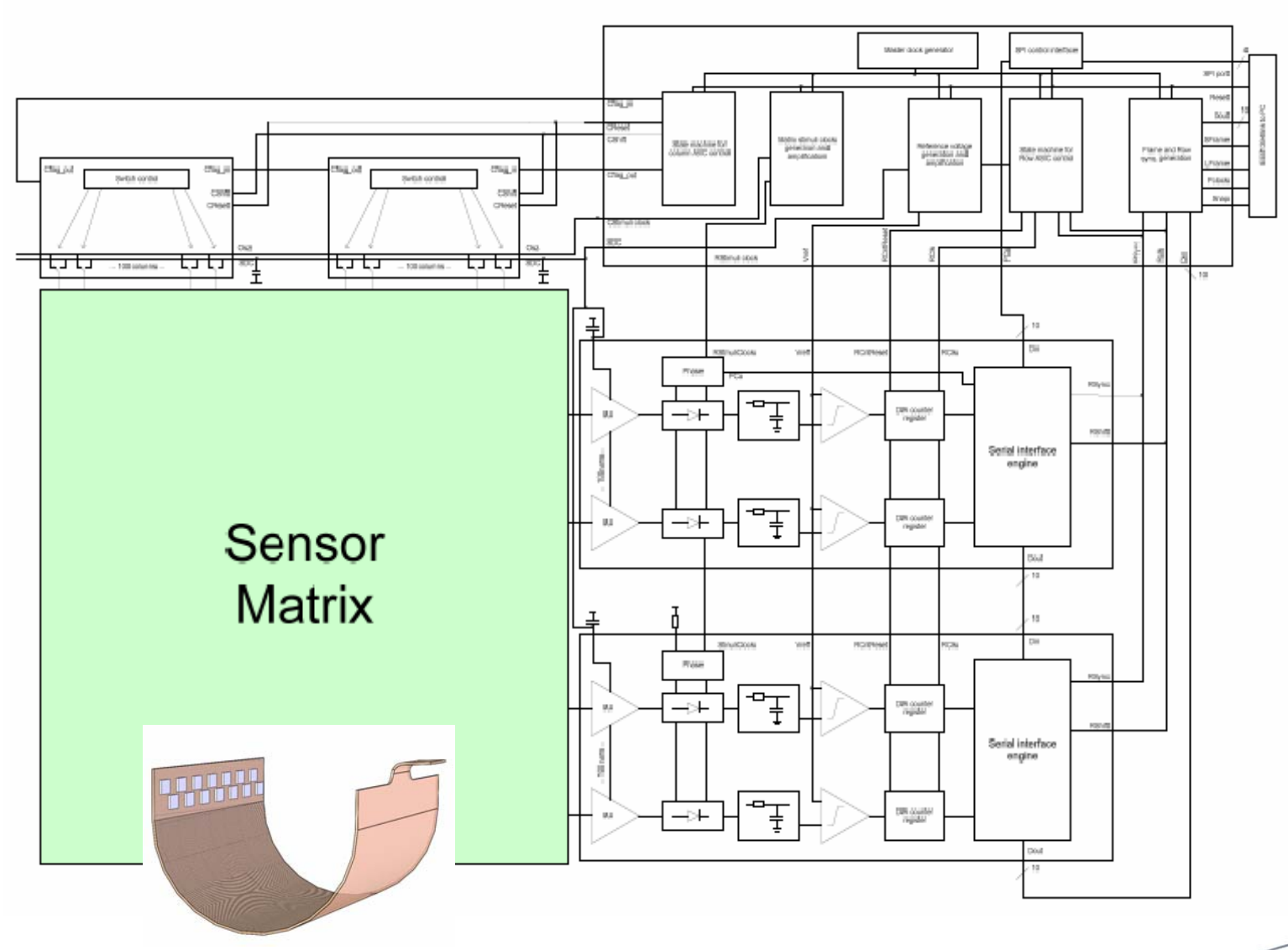
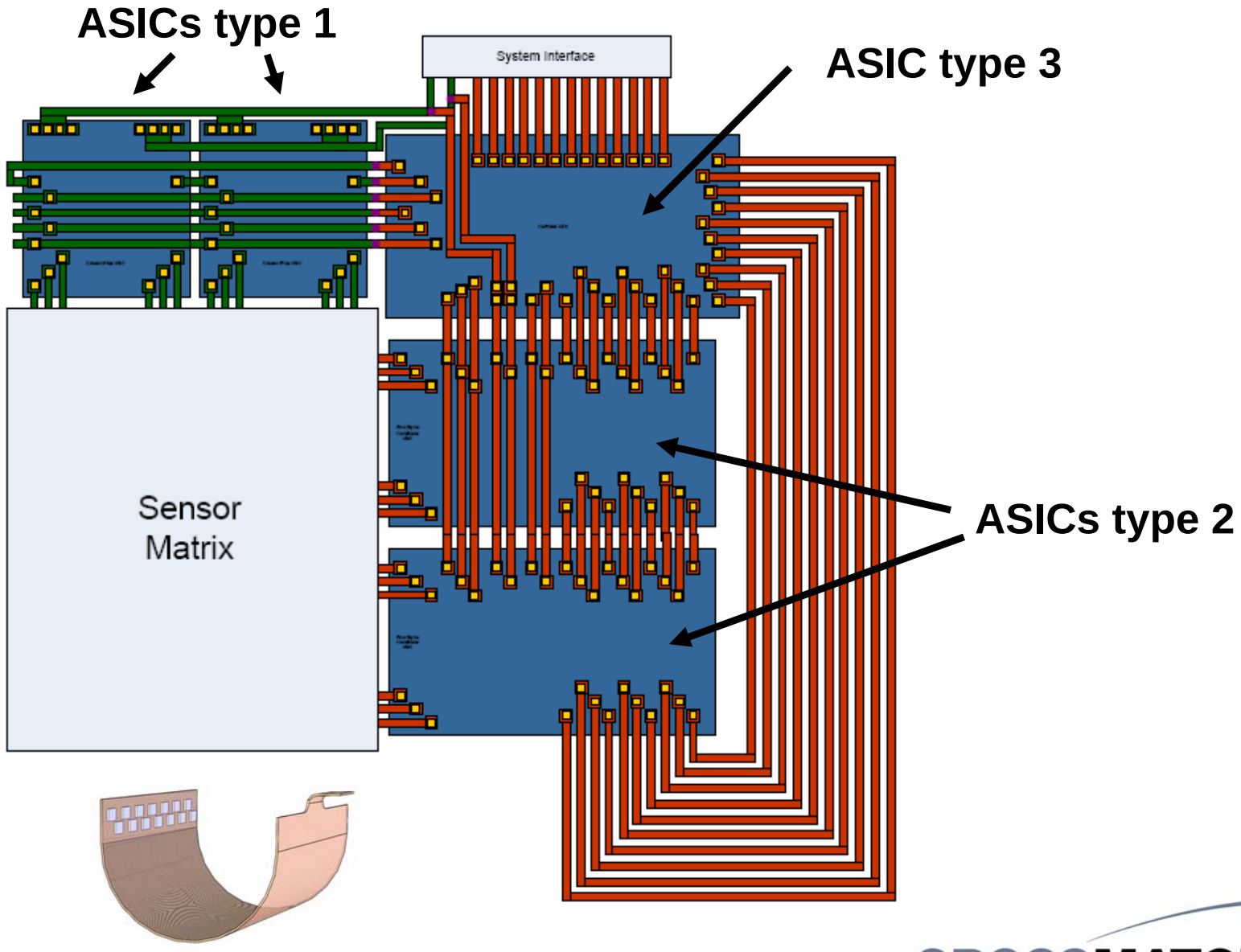
Schematic Block Diagram



Electrical Layout



The Electronics on the Foil Sensor

This is ASIC1

It carries 100 signal drivers and has 100 flip-chip bonding pads for 100 wires going to the section of the sensor matrix field.

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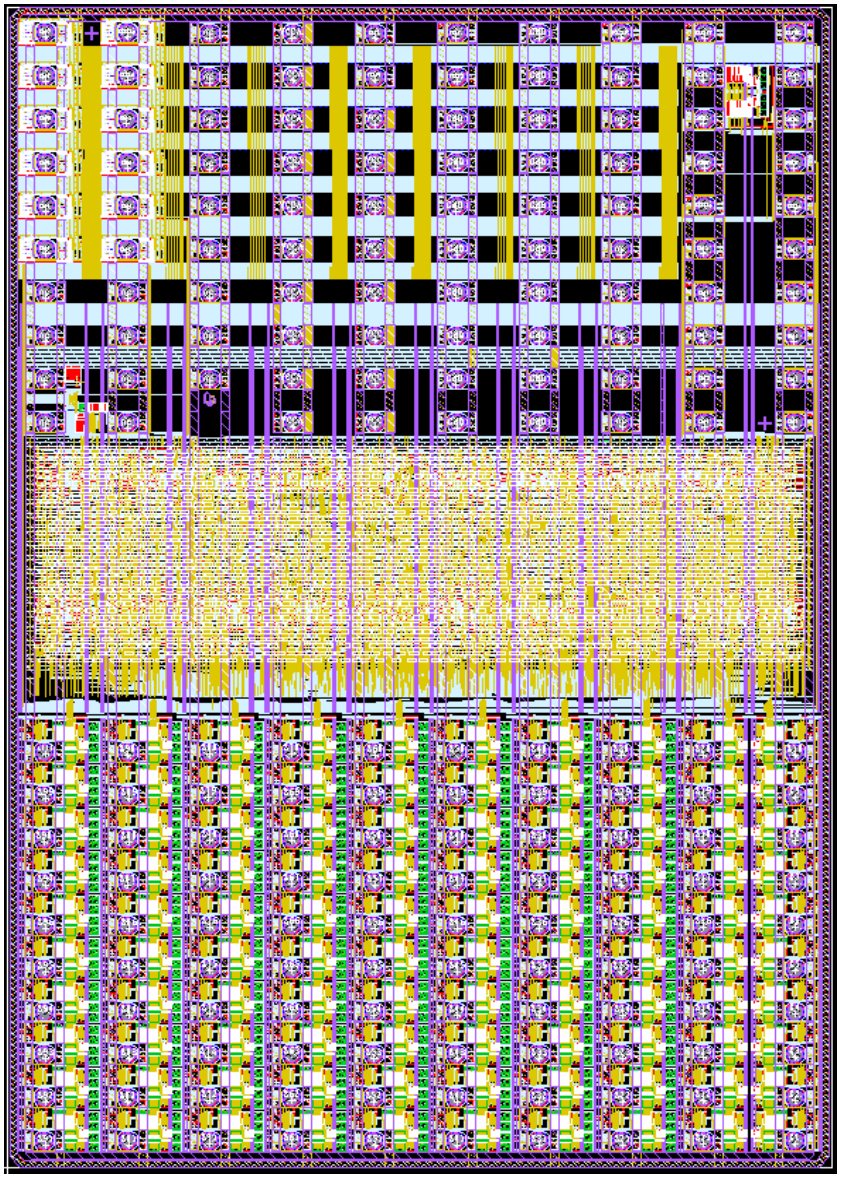
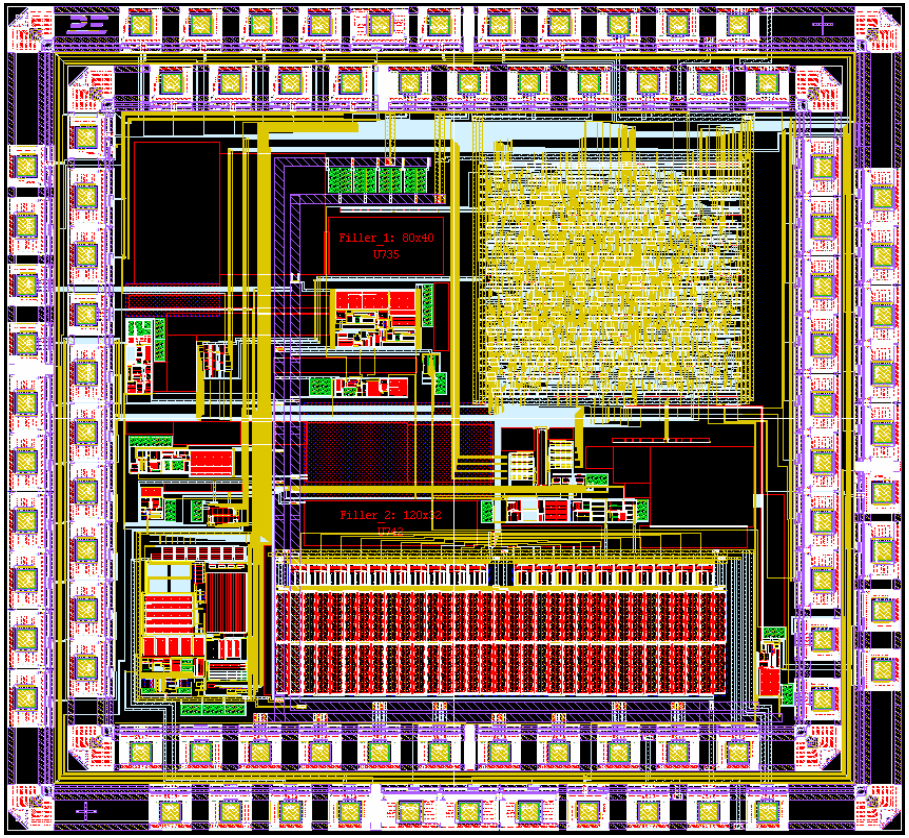
The Electronics on the Foil Sensor



This is ASIC2

It carries 100 signal receivers, filters, Analog-to-Digital Converters and has 100 flip-chip bonding pads for 100 wires coming from the section of the sensor matrix field.

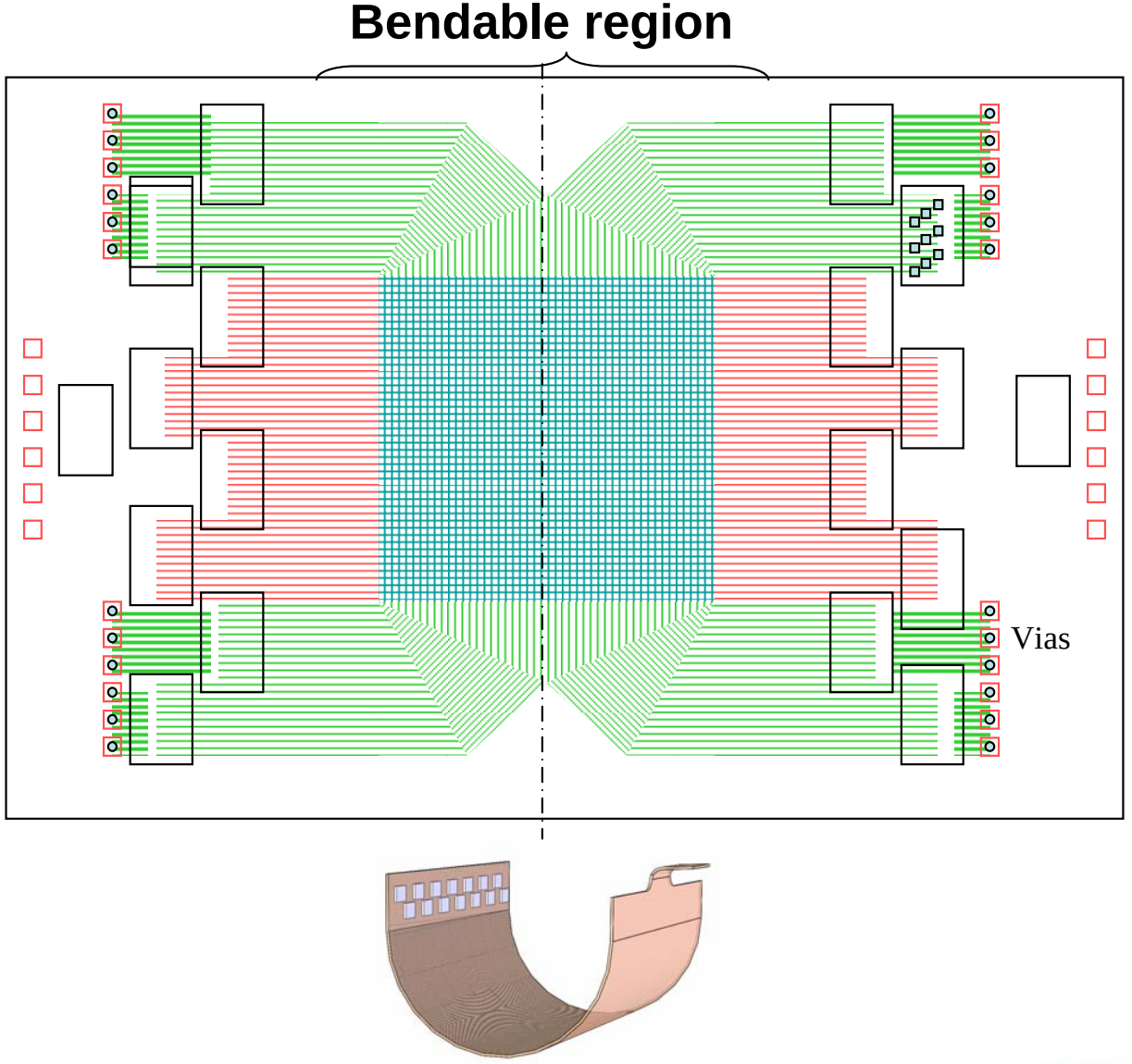
The Electronics on the Foil Sensor



This is ASIC3

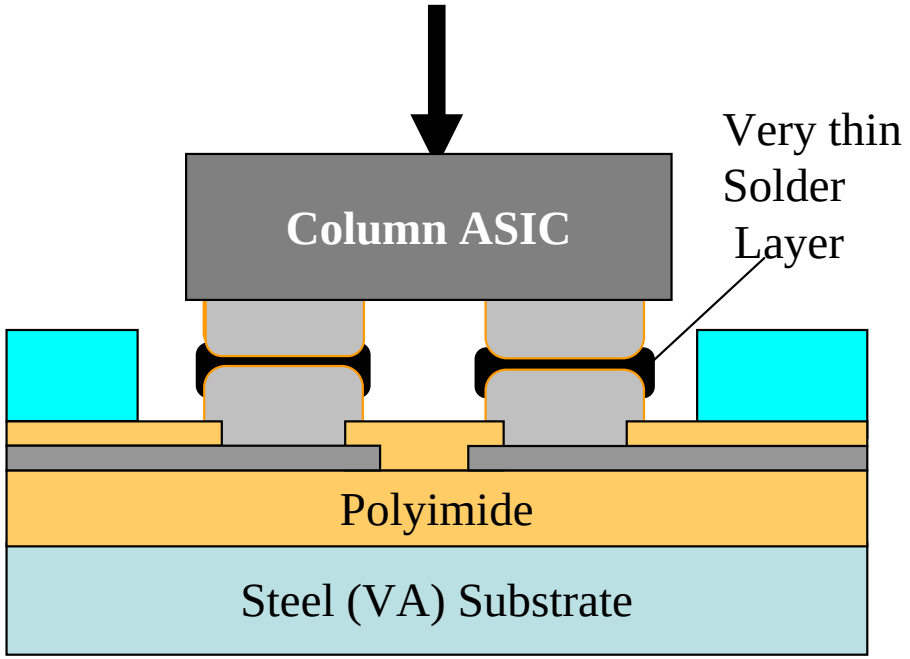
It connects all ASICs type 1 and 2 in a cascade and also provides the controlling logic and the interface to a computer.

Placement of ASICs on Foil

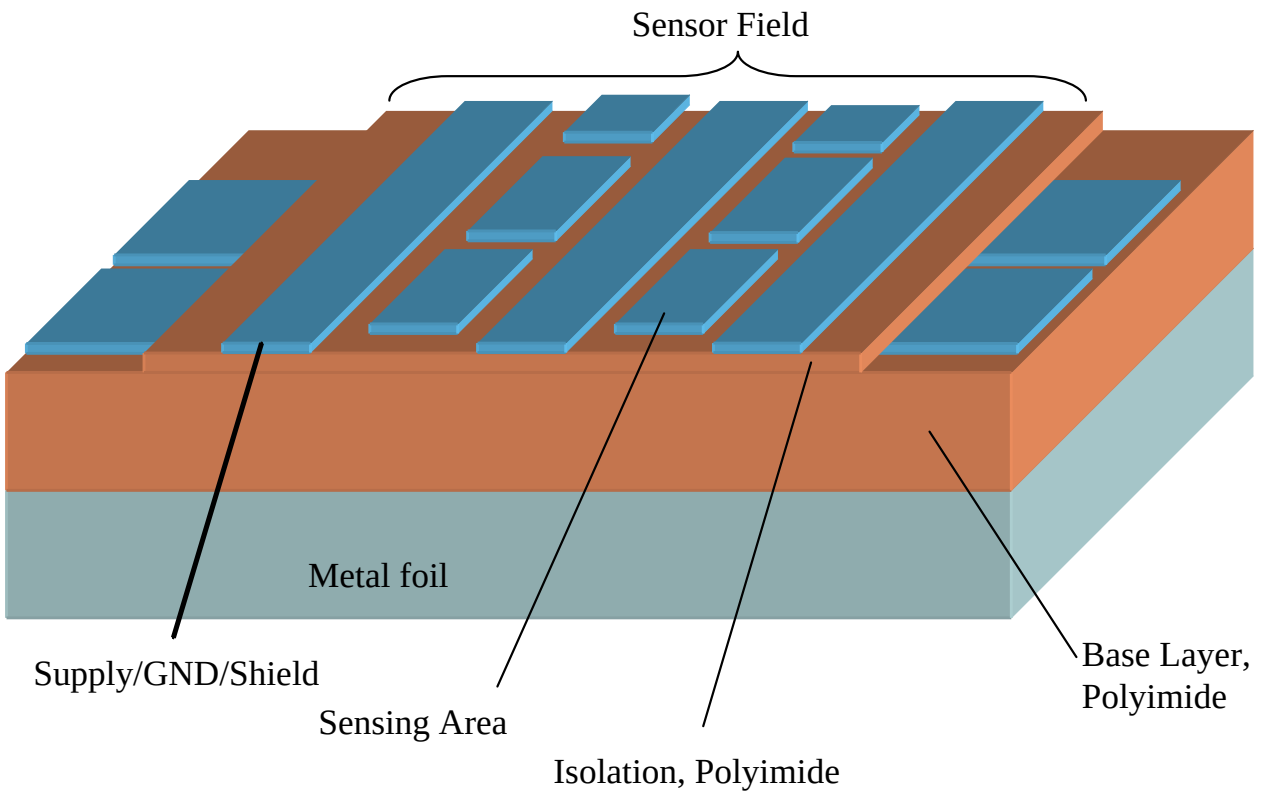


Flip-Chip Bonding of ASICs on Foil

1. A very thin solder alloy is processed on the foil contact pads, Ni-Au are processed on the ASIC pads.
2. Foil and chip are aligned and pressed together with a defined force.
3. After a programmed melting cycle the force is released.



Sensing Pixel Cells on Foil

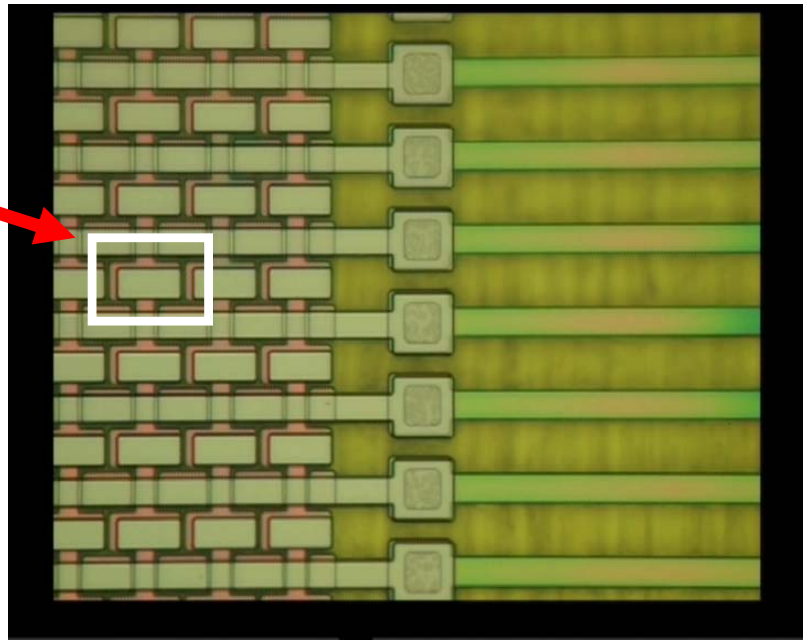


The schematic shows the principle of the sensing cells:

Lines of the rows (vertical) and columns (horizontal), each crossing point is 1 pixel.

Sensing Pixel Cells on Foil

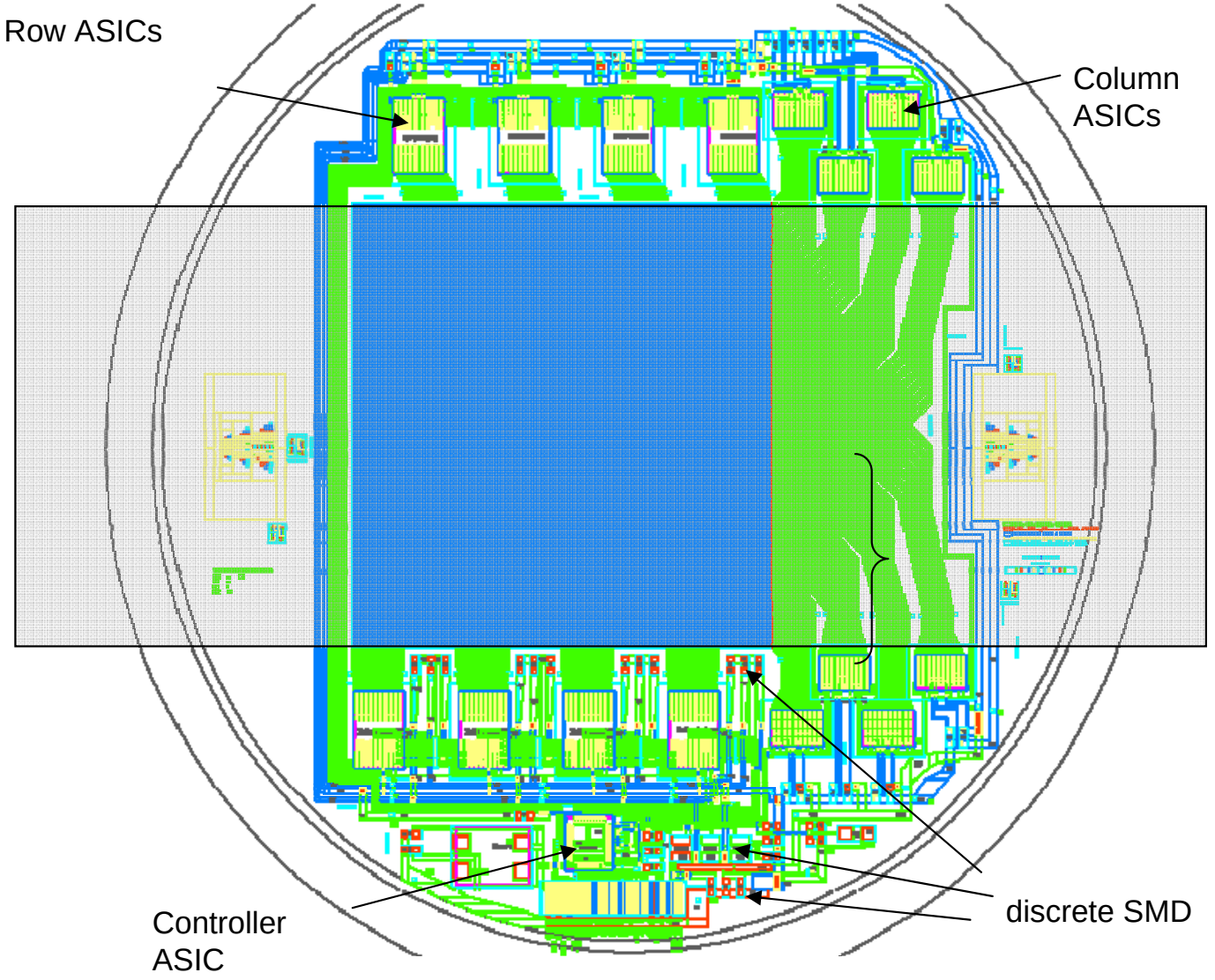
1 Pixel



Same area but shown here as a photographic image taken at the edge of the sensing matrix:

Lines of the rows (vertical) and columns (horizontal), each crossing point is 1 pixel.

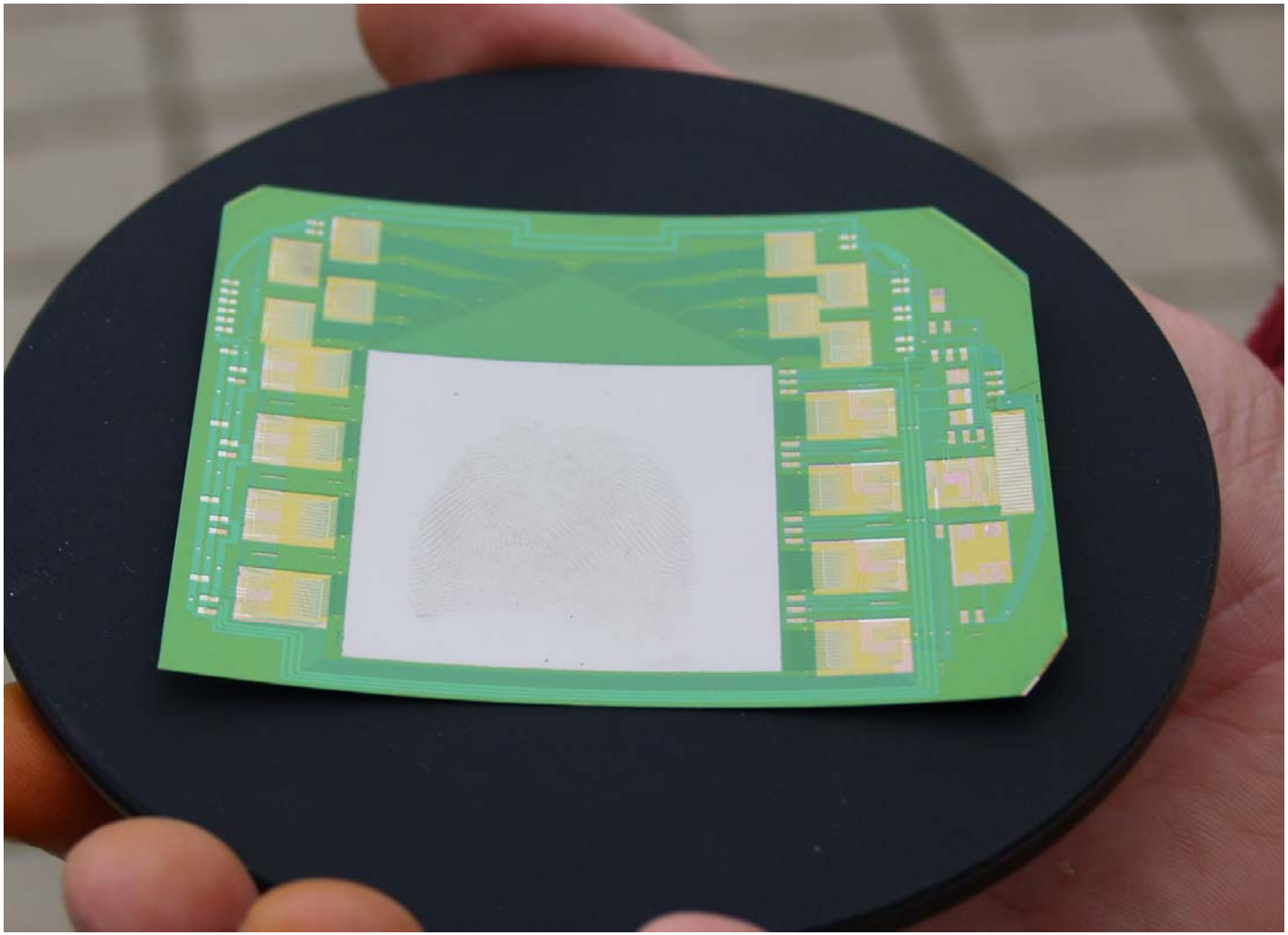
Layout of the complete Foil on 4” Carrier



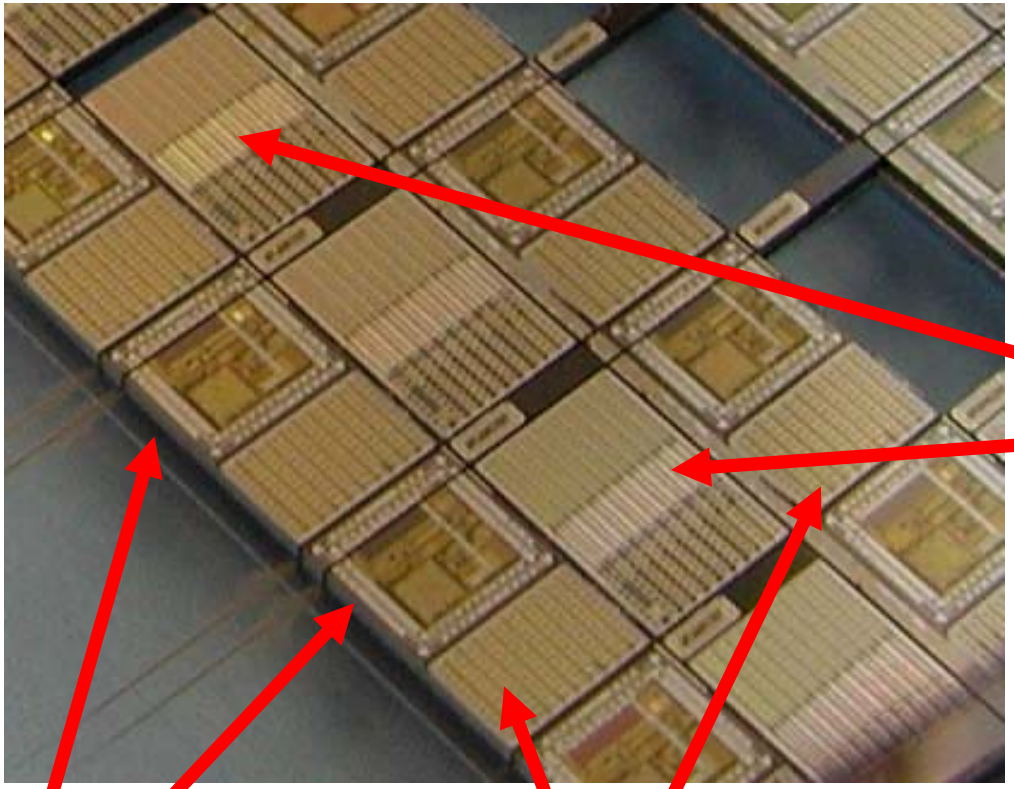
The 4” Carrier Steel Foil gets processed

The following steps were performed in a class 100 clean room environment at the IMTEK in Freiburg. The first layer processed on top of the stainless steel foil is the base isolation layer. The polyimide is polymerized at temperatures > 300°C. Subsequently the 1st metal layer, the first isolation layer, the 2nd metal layer, the electroplating seed layer and finally the solder mask layer are processed. Processing details are common in the field of thin film technology.

Structured Foil prior to ASIC/SMD bonding



ASICs on Multi-Purpose Wafer prior to cutting

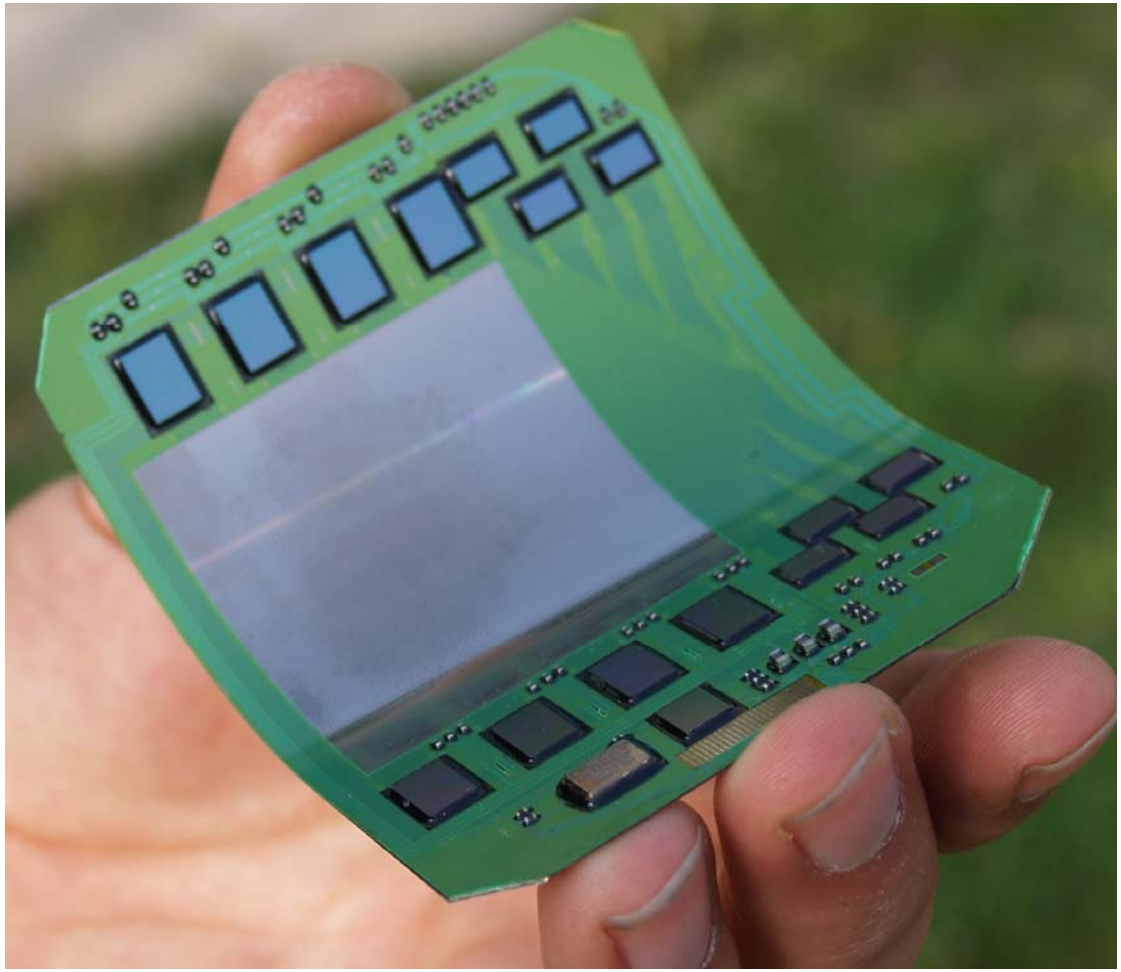


ASIC2 Row Receiver + ADC

ASIC3 Controller + Interface

ASIC1 Column Driver

Sensor Sample complete with ASICs and SMD



The active dimension of the sensor field is 1.6 x 1.6 inch with pixel cells in a 500 ppi equivalent matrix.

This is a mechanical sample containing the structured foil and real ASICs. However it is not operational.

Sensor Technology Sample

The sensor is made on a flexible foil that can bend around the finger

The base is a stainless steel foil of 70-90 microns.

Phase 2 (2-nd Year) development plan:

Rolled equivalent Fingerprint Sensor

- Flip Chip Assembly, System Setup, PC Interface, Software
- Full Phase 1 Sensor characterization
- Optimizations where necessary
- Prepare the Demonstrator for third party functional testing

Outlook: future expansion

Palm print sensor 8“ size

- Simulation model optimization based on the measurements
- Foil sensor development
  - 12“ design phase, Design optimization
  - 12“ processing line setup and tooling
  - processing

Acknowledgements:

The team wants to thank the NIJ and all sponsoring agencies for their strong support and also their patience during the project phase. There have been numerous challenges in this very complex technology development. With your help we achieved a major breakthrough in the development of the flexible foil fingerprint sensor.

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