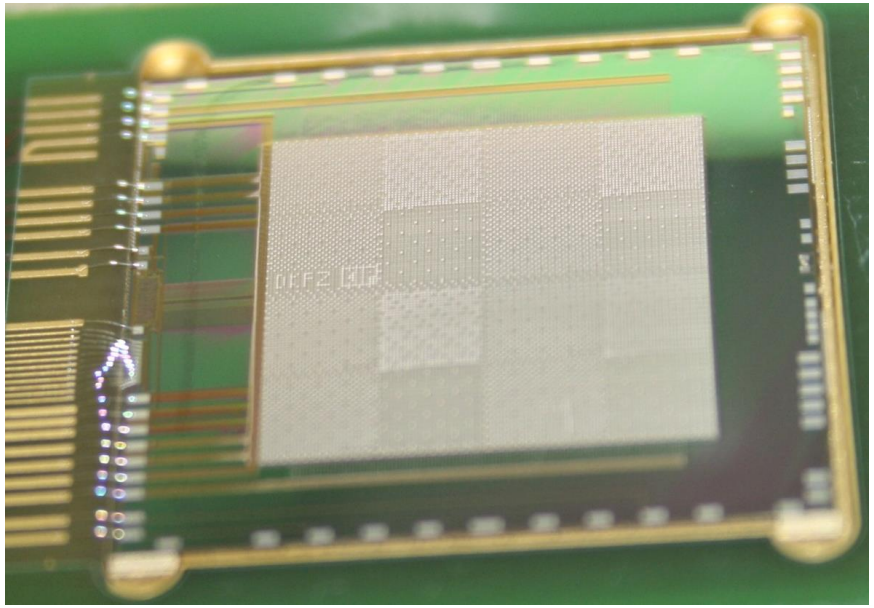
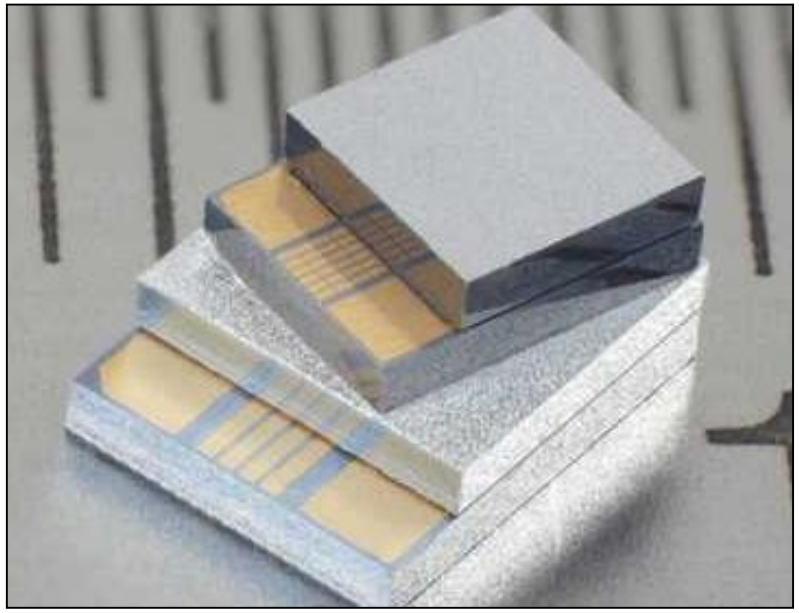




2019-09-18

From Biochips to Industrial Sensors to Electric Vehicles

A Contribution from the Outside World

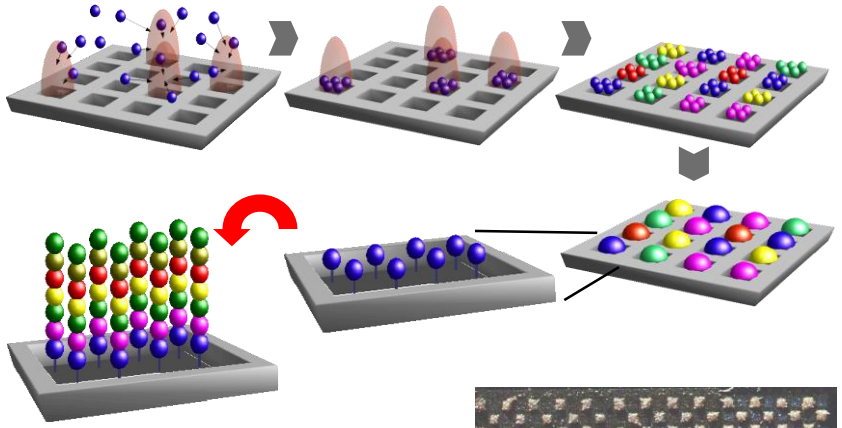
Kai Koenig

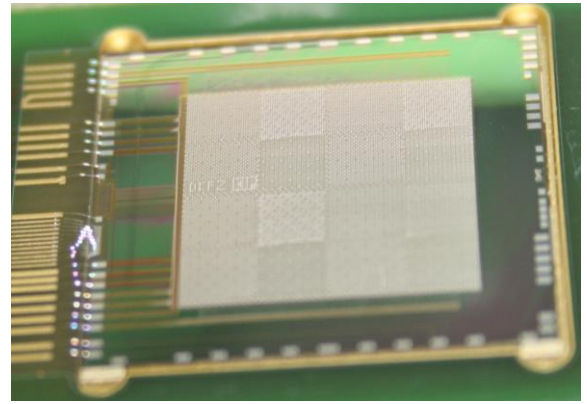
Physics and Peptide Synthesis

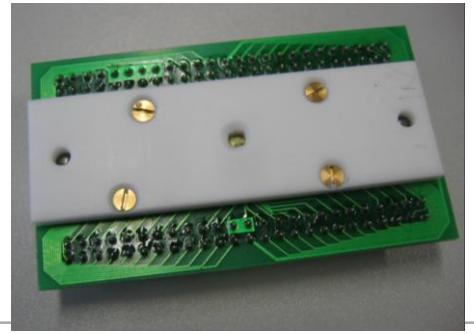
A slightly exotic application of high voltage CMOS integrated circuits

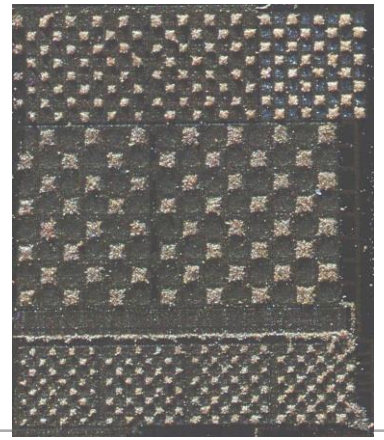
Timeline

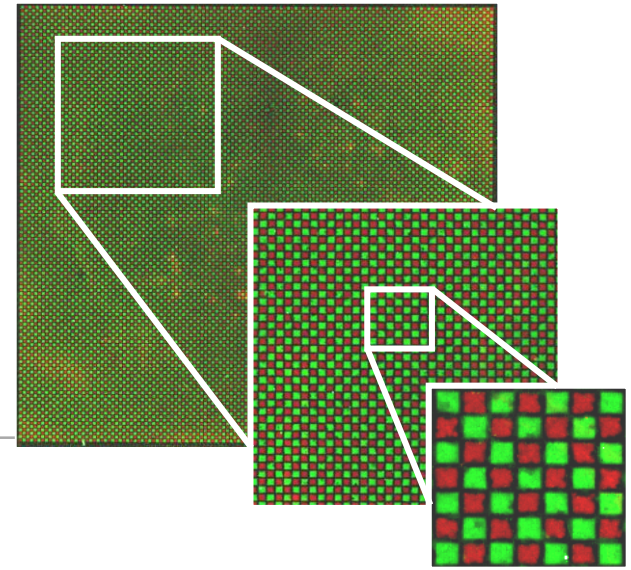
1999	Student, Physics, Uni Heidelberg
2000	Lectures by Prof. Lindenstruth
2001	HiWi @ KIP, DKFZ, ASIC-Labor & other
2005	Dipl. Phys. ASIC in HV tech for peptide synthesis
2010	PhD, Physics with Biology CMOS-Based Peptide Arrays
since 2010	Scientist ABB AG, Corporate Research Center, Ladenburg











confidential

2019-09-18

From Biochips to Industrial Sensors to Electric Vehicles

A Contribution from the Outside World

Kai Koenig, ABB AG, Corporate Research Center Germany, Ladenburg

ABB as a technology leader in focussed businesses

Organization until 2020

>130 years tradition

5 businesses

100 countries

147,000 employees

Electrification (#2) [1]

Industrial Automation (#2)

Motion (#1)

Robotics & Discrete Automation (#2)

Power Grids (*)

[1] Global market position in brackets

*At the end of 2019 ABB sold its Power Grids (PG) division to Hitachi. PG will remain part of ABB until 2020. Together with Hitachi, PG is the global #1 for a powerful, smart, green grid.

ABB in Germany

Germany as a development and competence center with strong local presence

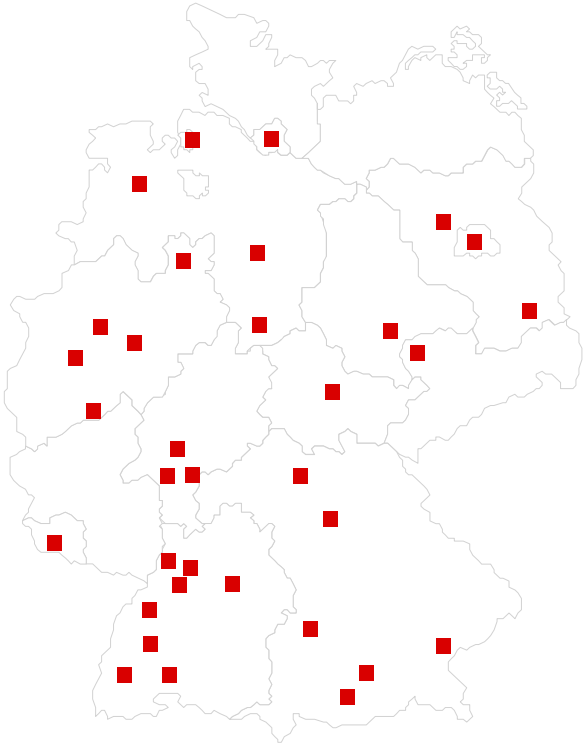
ABB Germany at a glance

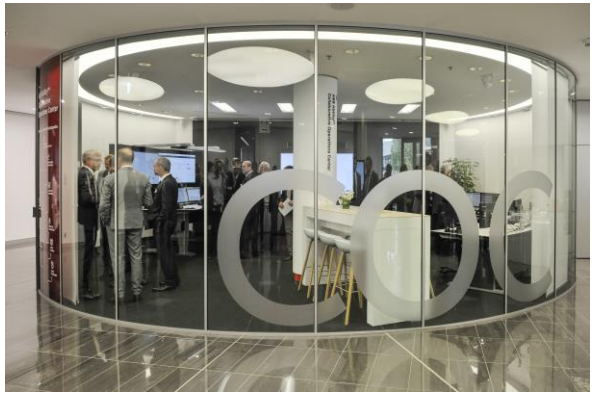
~10,500 employees

2.78 bn euros revenues in 2018*

17 sales and service locations

18 production sites





* Revenues without PG

Corporate Research Center Ladenburg (one of seven global CRCs)

Applied research for next-next generation products

Digital Industry	New technologies for future automation systems, advanced analytics and novel HMC paradigms as basis for digital end-to-end solutions
Building Automation	Turn ABB into a sustainable solution provider based on integration and open standards
Future Power Grids	Innovate grid infrastructure and automation to allow smooth energy transition & optimal use of equipment

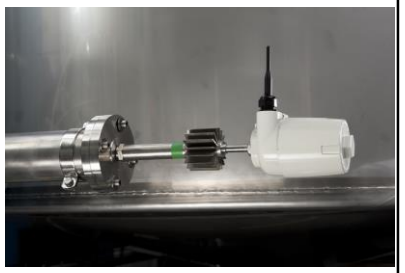
70	30	120	~100	~80	20 MUSD
Inventions/year	Cooperations with universities	Scientific publications/year	Employees	Students/year	Project volume/year

Energy autonomous wireless field instruments

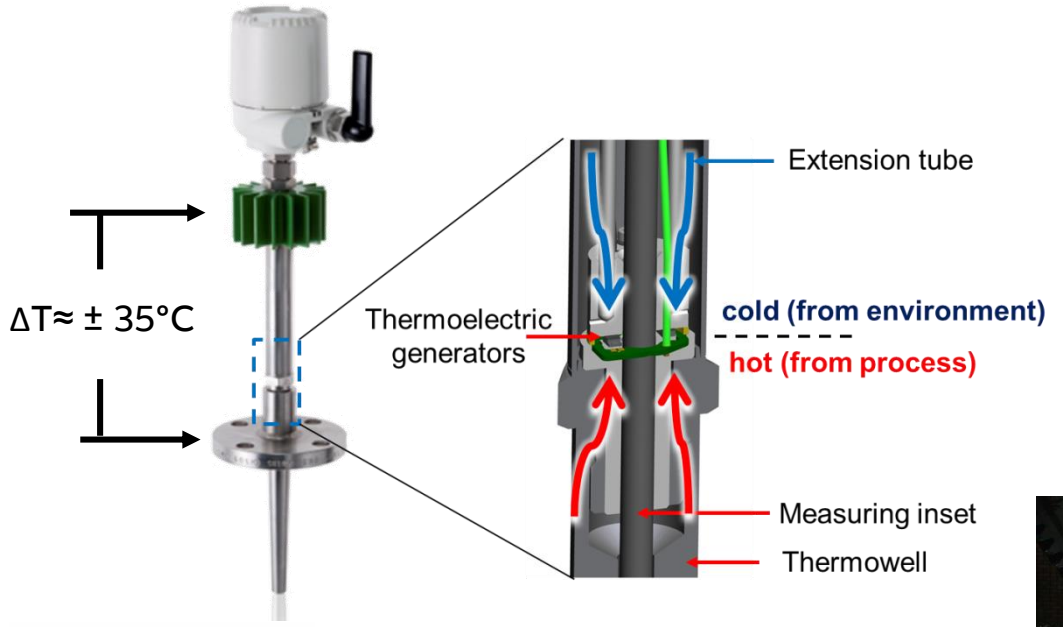
Thermoelectrically powered sensors require neither cables nor battery exchanges

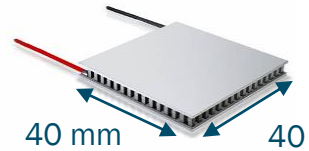
From an idea to a product

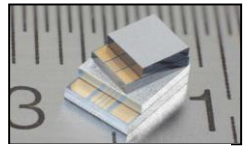
- Investigate technology options and components for suitability
- Examine requirements of existing product
- Develop and test a demonstrator



- Develop and test a better demonstrator
- Handover to business
- Support product development

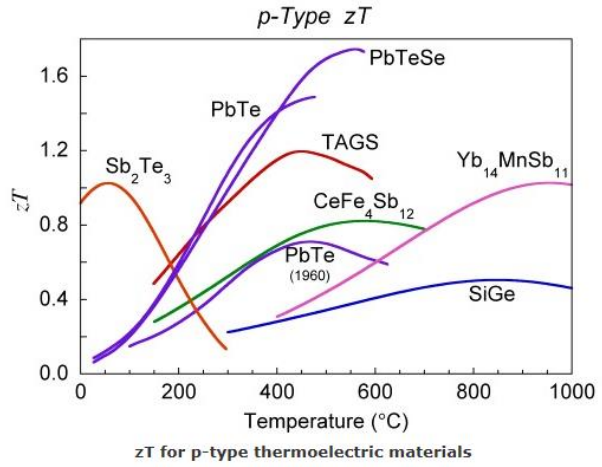




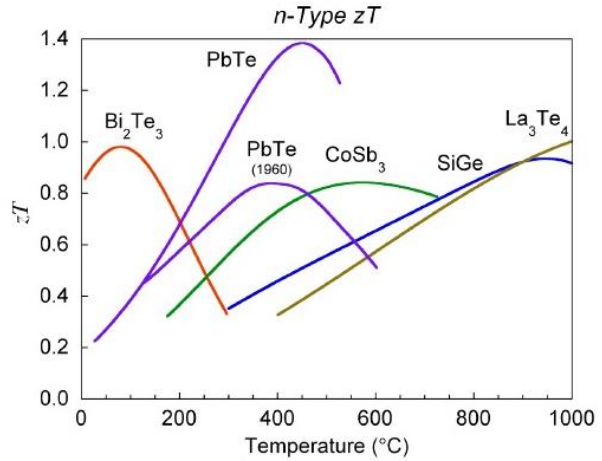


Silicon-integrated thermoelectrics 1

Using silicon wafers to produce very compact thermoelectric generators

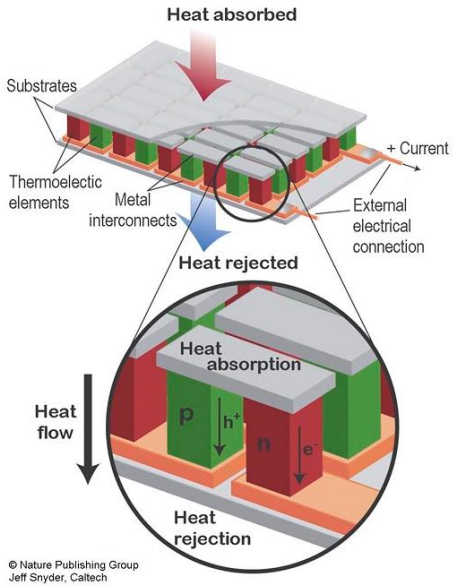


zT for p-type thermoelectric materials



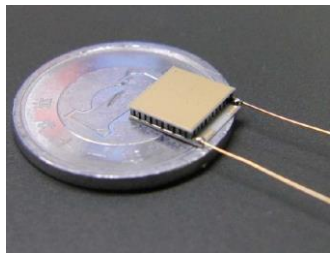
zT for n-type thermoelectric materials

G. Jeffrey Snyder and Eric S. Toberer "Complex Thermoelectric Materials" Nature

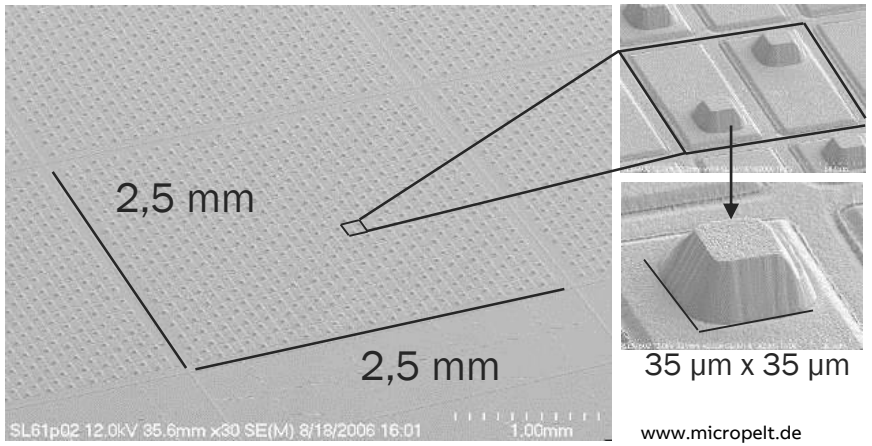


Silicon wafers as substrate for thermoelectrics

Going beyond "playing with small bricks" by using semiconductor fabrication technology



Miniaturized conventional TEG
(Source: KELK / Komatsu)



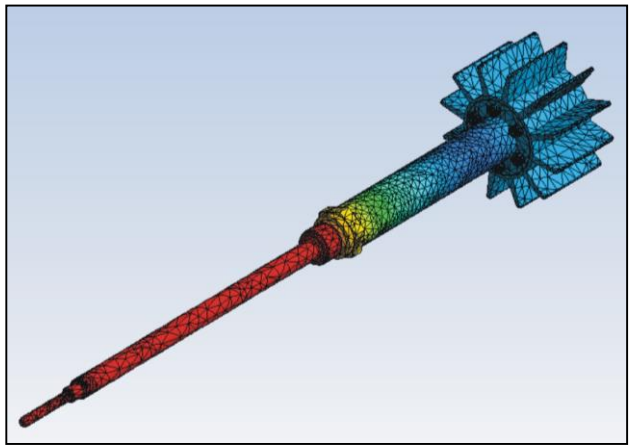
www.micropelt.de

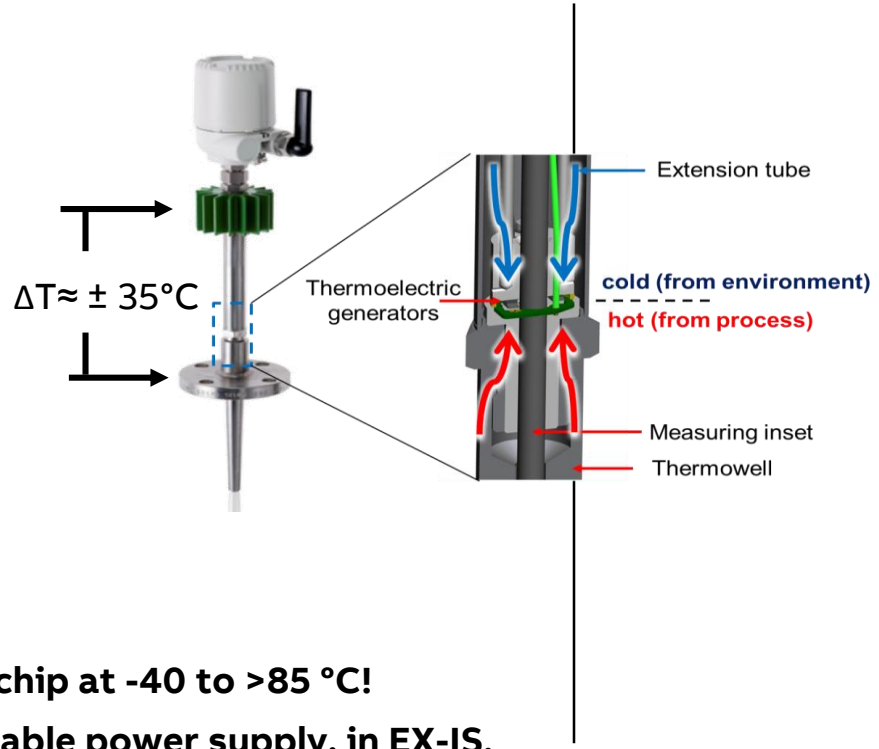
Silicon technology significantly increases voltage level and power density

Silicon-integrated thermoelectrics 2

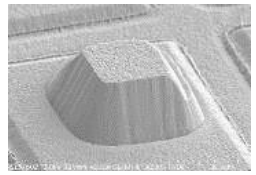
Advanced packaging and thermal management

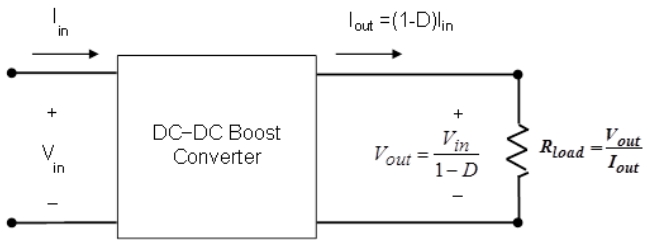
Focussing a thermal gradient really well…





35 µm x 35 µm





… and not crushing (or shearing) a chip at -40 to >85 °C!

And converting low voltages to a stable power supply, in EX-IS.

Silicon-integrated thermoelectrics 3 - technology outlook

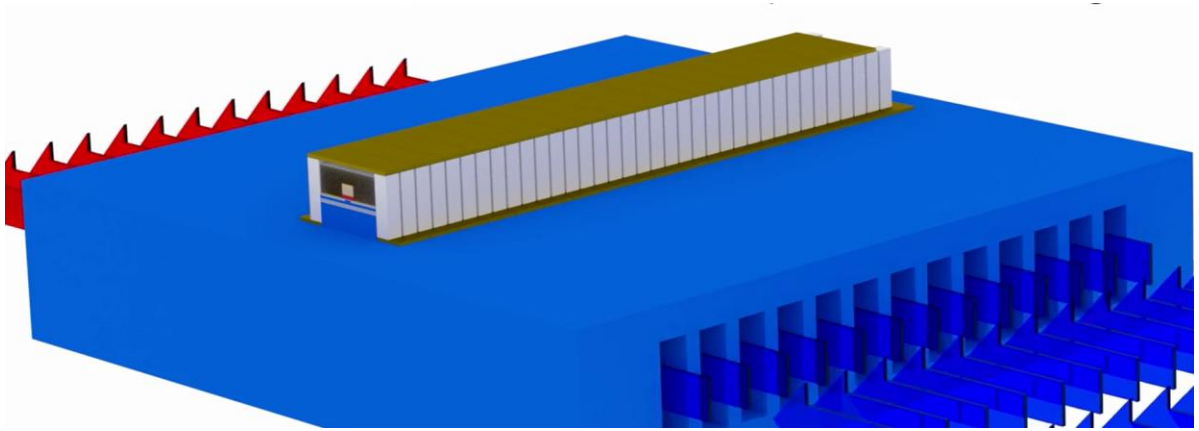
Integrating deposition of thermoelectrics for local fine-tuned temperature control of silicon technology

Conceiveable future applications

- Waste heat recovery, e.g. in large motors
- Heat removal for high-performance computing
- Fine-tuning semiconductor communication lasers (TIPS2020 project, www.tips2020.eu)
- Ultra compact thermocyclers for biochemical applications
- High performance thermally stabilized infrared cameras
- …

State of the technology

- Micropelt: went through bankrupcy, technology not available
- TIPS2020 consortium: Productization ongoing, design kit available for opto integration, academic research
- Other semiconductor companies may investigate for harvesting chips or CMOS / MEMS / Opto integration

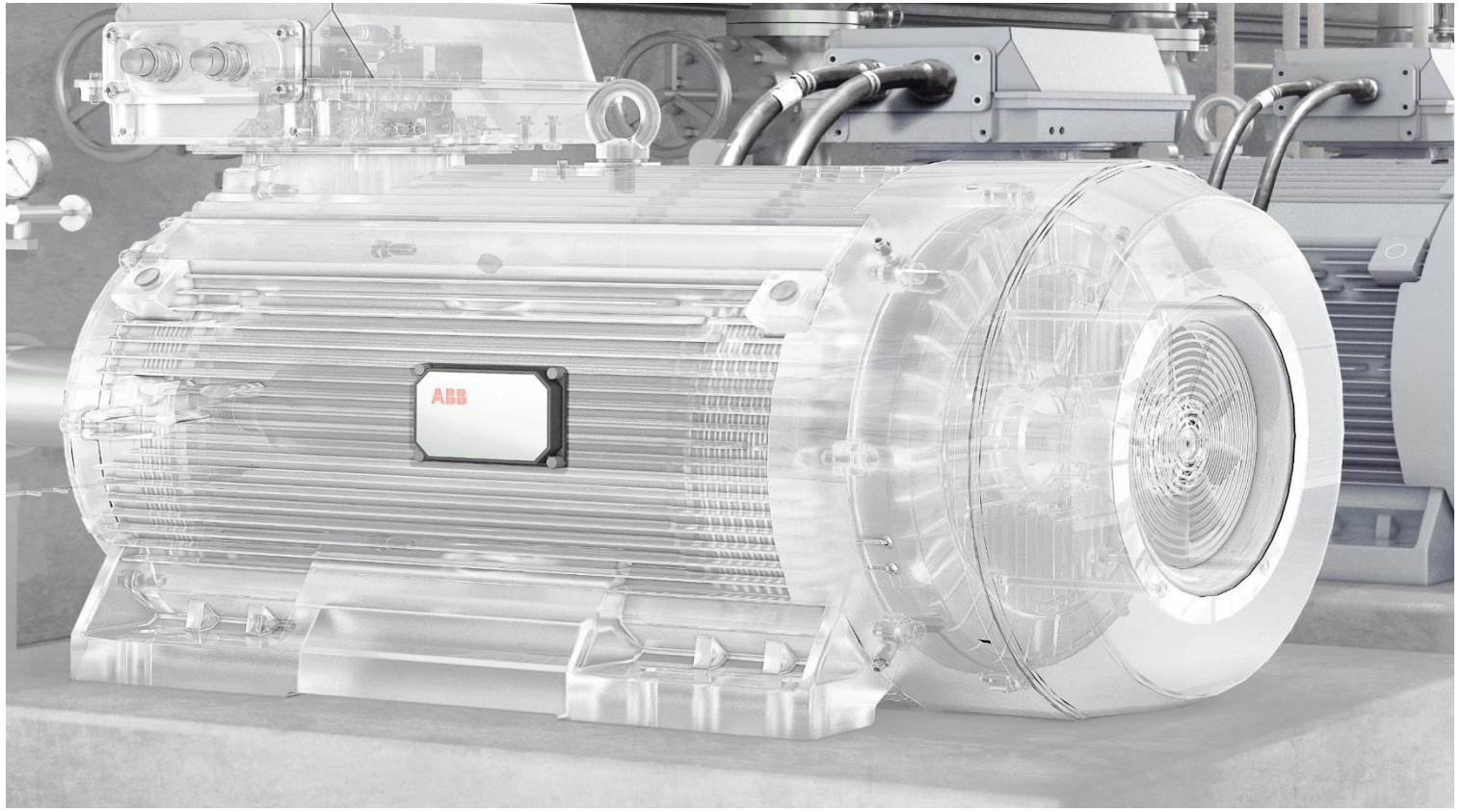


Intelligent motors for the digitalization

ABB Ability™ Smart Sensor

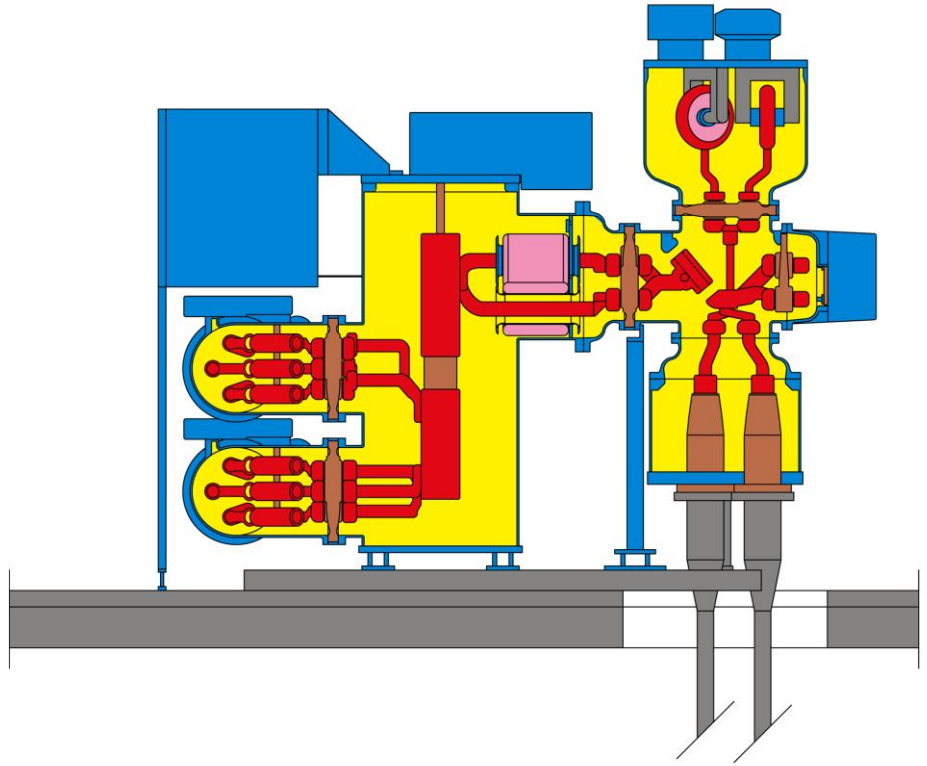
Remote Condition Monitoring

- Easy to deploy as smart sensor is a small wireless package and simple to use
- Reduces motor downtime by up to **70%**
- Extends motor lifetime by as much as **30%**
- Reduces power consumption by up to **10%**



High voltage equipment with the smallest possible footprint

Gas Insulated Circuit Breakers – Compact and safe switching of HV currents



Charging platform for next generation electric vehicles

Market leader of charging infrastructure

Electromobility

Cloud based platform: Combination of leading ABB technologies for fast charging and modern Microsoft cloud services

ABB has sold around 10,500 DC fast chargers in over 70 countries, more than any other manufacturer.

World‘s fastest charging station (Terra HP) recharges a car with 350 kW in just eight minutes charging time for a distance of 200 km

Fleet and site management and optimization for busses and other EV

Depot for up to 240 electric busses, Hamburg.

Charger and pantograph for recharging electric busses enroute and in the depot.

Electric car at an ABB site.

Electric truck used for inter-site logistics & Formula e racecar.

Working at ABB

Focus on Corporate Research Ladenburg

Employment conditions

Adequate salary

Good training opportunities

Flexible working hours, no unpaid overtime

- Flexible organization of working hours
- Home office/homeday
- Sabbatical
- ABB holiday home for children

Interesting and highly varied topics

Opportunities to move to business units

For graduates

Intense hiring just starts after phase of low external hiring

Opportunities for physicists:

- Sales engineers
- **Researchers in CR**
  - 2 open positions for physicists in sensors
  - 4 open positions in optimization, embedded systems or software
- Researchers in the businesses

For students

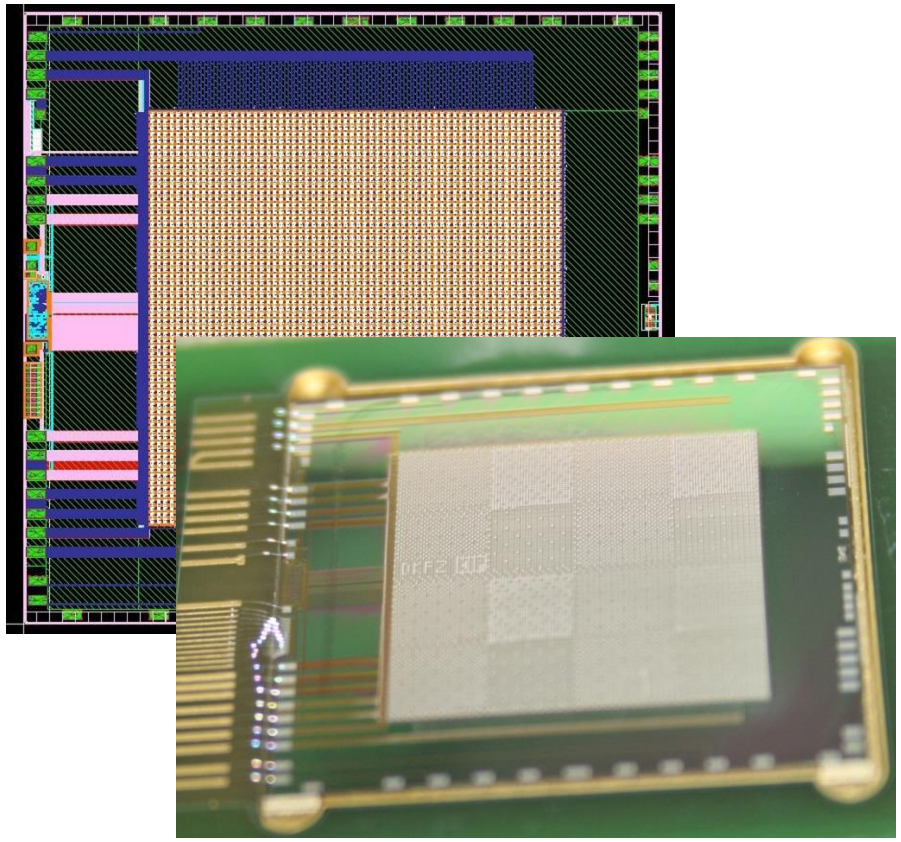
Paid internships for 3-6 months – mandatory and voluntarily – are always available

Topics for Physicists in Ladenburg include:

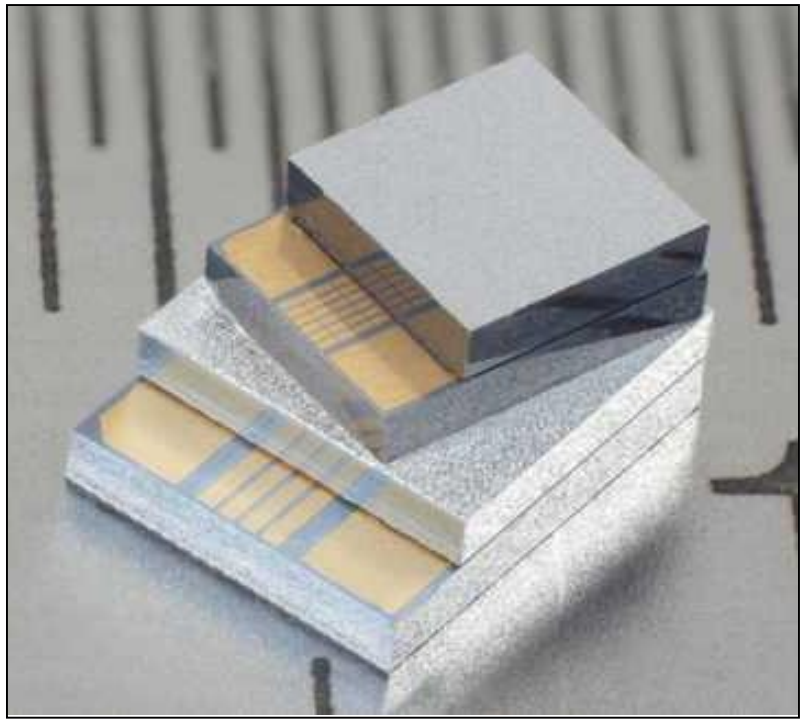
- Sensors
- Data processing
- Breaker mechanics
- Robotics
- Optimization
- Software, Embedded, Security, IoT, …

Contact me for more info

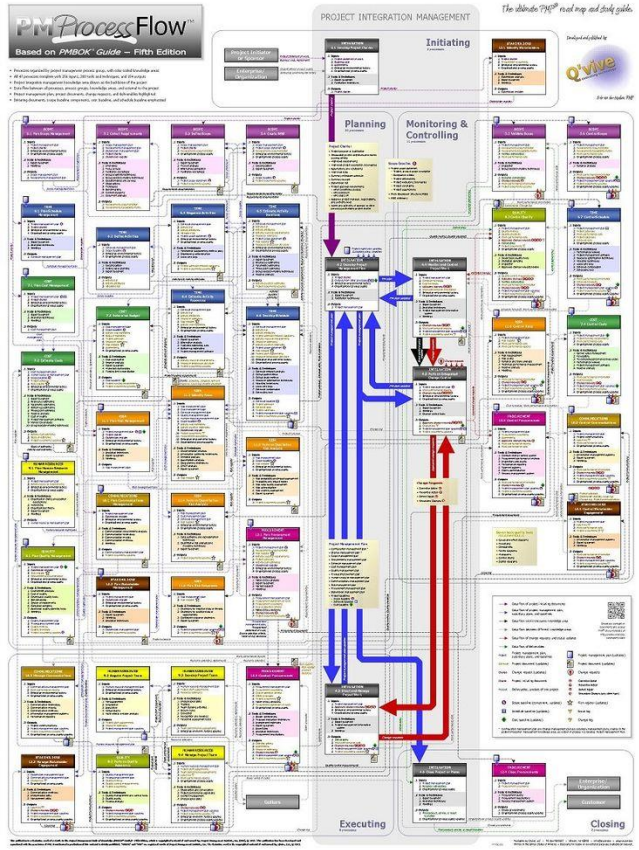
What processes did I use?



AMIS 0.7 V High Voltage (30 V / 100 V) mixed signal – not used as intended



Custom integrated thermoelectrics on silicon wafer (Micropelt) - integration only



Project management processes according to PMI – used heavily customized

2019-09-18

From CMOS to Thermoeletrics to Project Management

Kai Koenig

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kai.koenig@de.abb.com