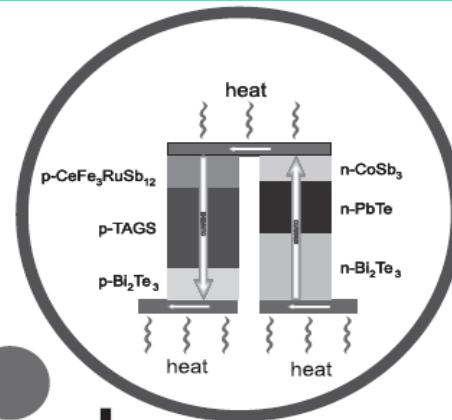


Thermoelectric Activities of European Community within Framework Programme 7 and additional activities in Germany



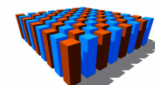
H. Böttner

Fraunhofer Institute for Physical
Measurement Techniques IPM
Dept. Thermoelectrics Systems
Freiburg, Germany



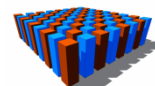
**3rd Thermoelectric
Applications
Workshop**

MARCH 20-22, 2012
BALTIMORE, MARYLAND



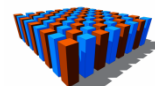
Content

- Thermoelectric within 7th Framework Programme of European Community
- DFG (German Research Foundation) priority programm „Nanothermoelectric“
- Public funded applied research in Germany
- Position of Fraunhofer IPM



Content

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EC Framework Programme 7 (FP7) NMP



Nanosciences, nanotechnologies, **m**aterials & new
production technologies

NMP.2010.1.2-3

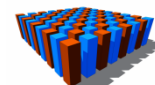
2011-2014

Thermoelectric energy (TE) converters based on nanotechnology aspects of the manufactured nanoparticles as well as the composites

Expected impact : through improved TE materials $ZT \geq 3$ wanted

■ NANOHIGHTECH	11/2014
■ THERMOMAG	10/2014
■ NEAT	03/2014
■ NECTEC	05/2014

http://cordis.europa.eu/fp7/projects_en.html



EC Framework Programme 7 (FP7) NMP



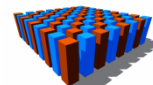
Statistics:

money,
countries

Volume:	21,7 Mio Euros
Funding:	14,7 Mio Euros

Countries:

Germany	10
France	6
UK	6
Sweden	6
Spain	5
Italy	3
Greece	2
Lichtenstein, Austria, Switzerland, Poland, Cyprus, Russia	1

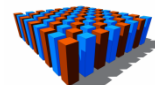


EC Framework Programme 7 (FP7) NMP



Statistics: institutions

■ Universities	14
■ Other R&D (FhG)	9(4)
■ Companies	20
SME	10
large	10
(automotive	6)



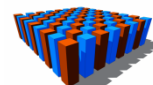
EC Framework Programme 7 (FP7) NMP



Main topics

- NANOHIGHTECH 11/2014
Bi₂Te₃/Si/SiGe/B₄C/B₉C in low cost industrial processes
superlattices for automotive application (???)

- THERMOMAG 10/2014
nanostructured Mg₂Si solid solution/bulk materials, no ZT target
high temp. waste energy harvesting



EC Framework Programme 7 (FP7) NMP



Main topics

■ NEAT

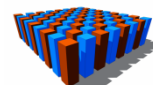
03/2014

Mg₂Si nanoparticles in n-Mg₂(SiSn) alloy matrix
capable for ZT >3 (???)
kW-range converters for industrial and
automotive applications

■ NEXTEC

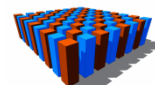
05/2014

nanoscale material will be selected as part of
first workpackage, **no ZT target**, bulk nanoscale
material and nanoscale thick film (>> 50µm),
waste heat power generation and cooling



Content

- Thermoelectric within 7th Framework Programme of European Community
- **DFG (German Research Foundation) Priority Program „Nanothermoelectric“**
- Public funded applied research in Germany
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DFG priority program „Nanothermoelectric“



DFG-SCHWERPUNKTPROGRAMM SPP 1386

Nanostrukturierte Thermoelektrika:

Theorie, Modellsysteme und kontrollierte Synthese.

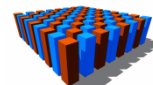
Deutsche
Forschungsgemeinschaft

DFG

Nanostructured thermoelectrics: theory, modelsystems and controlled synthesis

Coordinator: Kornelius Nielsch University Hamburg

2009-2015



DFG priority programm „Nanothermoelectric“



Structure:

3 competence areas

Materials

synthesis of nanoscale thermoelectric materials with defined geometry and composition

Characterization

structural and thermoelectric characterization

Theory

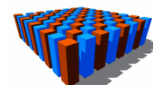
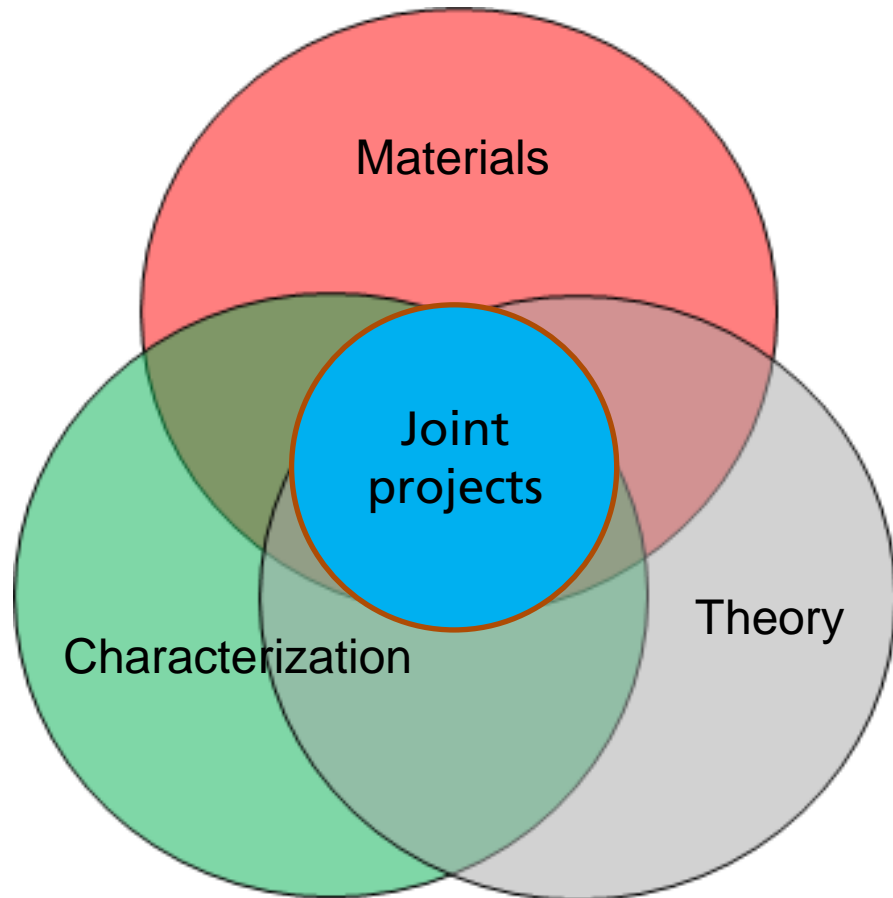
modeling and theory

Grau, teure Freunde, ist alle Theorie

All theory is gray, my friends

J. W.v. Goethe, Faust I, 2038 f.

/ Mephistopheles



DFG priority programm „Nanothermoelectric“



Education

TE Winter School	14.-19.02.2010	97
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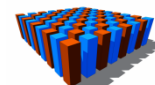
TE Spring School	28.03. – 01.04.2011	63
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TE PhD Summer School	09. – 12.08.2011	27
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TEM Training	07/2010 and 02/2011	6
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DFG priority programm „Nanothermoelectric“



Education

Thermal conductivity in
reduced dimensions:
3-Omega-method and beyond

27./28.05.2010

45



Transport theory

27./28.01.2011

42



Spark Plasma Sintering
of nanoparticles

21./22.03.2011

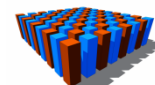
28



Measurements of nanostructured
thermoelectric materials

18.-20.03. 2012

XX



DFG priority program „Nanothermoelectric“



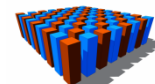
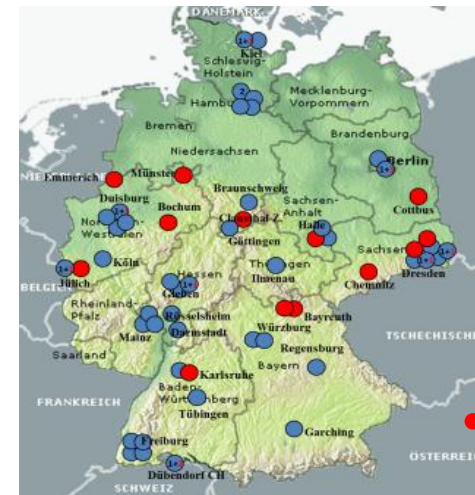
groups

1st funding period 2009-2012

103 publications until Jan 2012

proposals for the

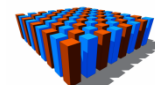
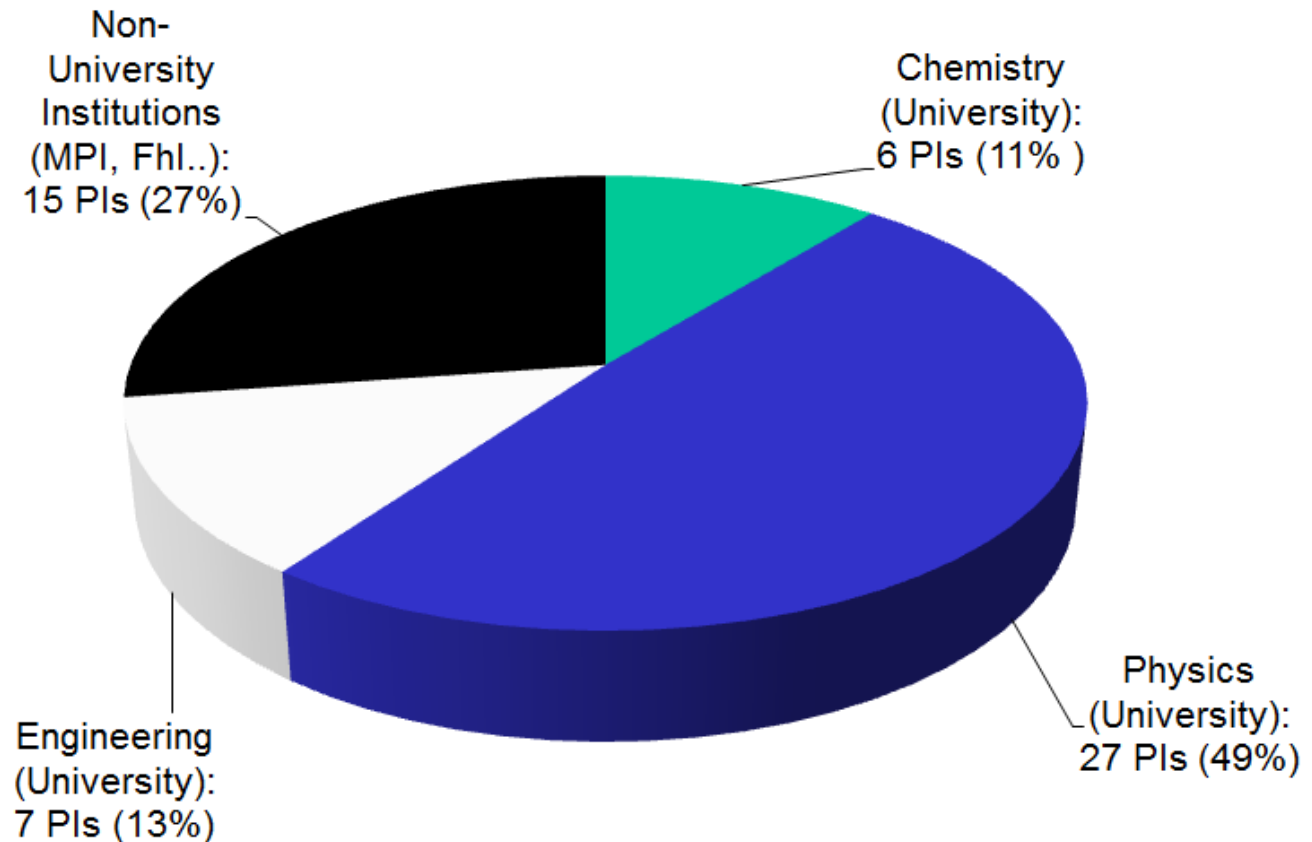
2nd funding period 2012-2015



DFG priority programm „Nanothermoelectric“



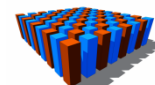
PI
distribution:
on
institutions



DFG priority programm „Nanothermoelectric“



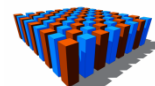
PI		1 st	2 nd
distribution:	Bi ₂ Te ₃ based Nanostructures	4	+2
	IV-VI related Materials (e.g. PbTe)	1	+2
on topics	Antimonides (e.g. Zn ₄ Sb ₃ , CoSb ₃)	3	
	Heusler, Silicides and Clathrates	4	
	Thermoelectric Oxides	3	+3
	Silicon based Nanostructures	4	
	Model Systems (z.B. GaAs)	2	
	Thermoelectric Measurements	5	+7
	Theory and Modeling	8	+6



Content

topics

- Thermoelectric within 7th Framework Programme of European Community
- DFG (German Research Foundation) priority programm „Nanothermoelectric“
- **Public funded applied research in Germany**
- Position of Fraunhofer IPM



New funding situation in Germany

Energy Technology Perspectives: Scenarios and Strategies to 2050

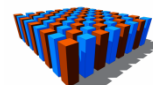
energietechnologien
2050

“... Guidelines for a clean, reliable and affordable energy supply by the year 2050 are to be outlined in an energy concept. The aim of the energy concept is to provide a road map towards the era of renewable energies. In future, Germany aims to rank amongst the world's most energy-efficient and environmentally friendly national economies, offering competitive energy prices and a high level of prosperity. ...”

Joint press release 2010-8-30

R. Brüderle, Federal Minister of Economics and Technology

N. Röttgen, Federal Minister for the Environment, Nature Conservation and Nuclear Safety



Public funded applied research in Germany



energietechnologien
2050

Scenarios and Strategies
towards 2050: Energy efficiency in Industry

Technologies for energy harvesting:

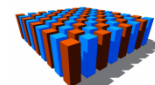
- Thermoelectricity
- Organic Rankine Cycle (ORC)
- Kalina Cycle
- Heat exchanger
- Industrial heat pumps

Result:
public R&D is
important

Recommendations for public R&D funding:

- Evaluation of usable waste heat source
- New thermoelectric materials
- Industrial production technologies for thermoelectric generators
- Improvement of heat exchanger
- New concepts for ORC
- New refrigeration substances for heat cycle

H. Bradke, Berlin, 05/2009



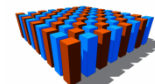
Public funded applied research in Germany



2008-2015



	Funding (M€)	Project volume
DFG (German Research Society)	8.7	8.7
BMBF Scientific Fed. Min. of Education and Research	5.5	5.5
BMBF Applied Fed. Min. of Education and Research	25	40
BMWi Applied Fed. Min. of Economics and Technology	11	19
	=====	=====
total	50.2	73.2



Public funded applied research in Germany



Companies

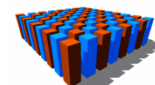


Thermopower 1
2011-2015



special projects

Company	SMEs	Large companies /big groups
TE- manufacturer/distributor	4	
Electronic manufacture		5
Measurement techniques		1
Automotive companies		2
Automotive supplier	1	10
Chemical industry		3
Ceramic industry	2	2
Automotive engineering		1
Steel and (special) smelter		2

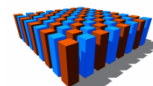


Public funded applied research in Germany



Materials

- Skutterudites 3 times
- Half-Heusler
- Mg-, Mn-Silicides
- Oxides
- Chalcogenides



Public funded applied research in Germany



PUBLIC WORKSHOP PROGRAM THERMOPOWER



Federal Ministry
of Education
and Research

and



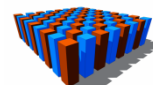
16.-17. 10. 2012 Dechema Building Frankfurt



DECHEMA

Society for Chemical Engineering and
Biotechnology

<http://www.ptj.de/ThermoPower>





3rd IAV-Conference on Thermoelectrics

November 21 – 23, 2012 Ellington Hotel, Berlin

PRESENTATION POSSIBILITIES

Presentations, posters, exhibition,
NEW Poster and Exhibits Slam

LECTURES LANGUAGES AND DURATION

German and English with simultaneous translation. Presentations should last 20 minutes, with a following 10-minute discussion.

IMPORTANT DATES

Submission of abstracts for presentations (max. 3000 characters) and posters (max. 1500 characters) under iav.com/conferences

Closing date for abstracts: **June 18, 2012**

CONTACT

Abstracts, Presentations, Posters

IAV GmbH

Carnotstraße 1

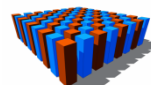
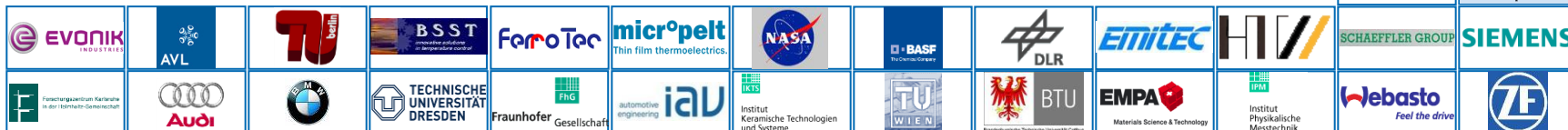
10587 Berlin

Tel: + 49 30-39978-9894

E-Mail: thermoelektrik@iav.de

REGISTRATION AND FURTHER INFORMATION

iav.com/conferences



Public funded applied research in Germany



Call for 2012

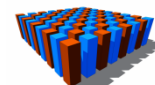


Federal Ministry
of Education
and Research

New program including
thermoelectric harvesting systems

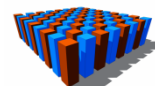
"Energieautarke Mobilität -
Zuverlässige energieautarke Systeme
für den mobilen Menschen"

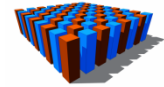
Energy autarkic mobility –
Reliable energy autarkic (self powered)
systems for mobile people



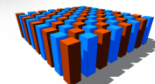
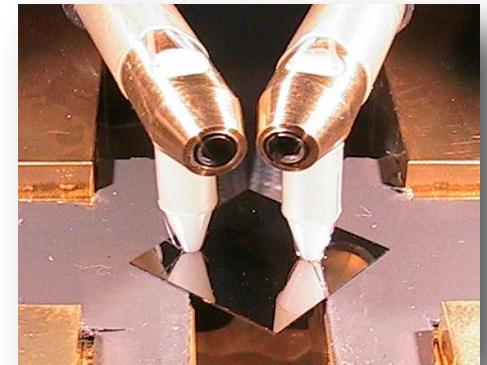
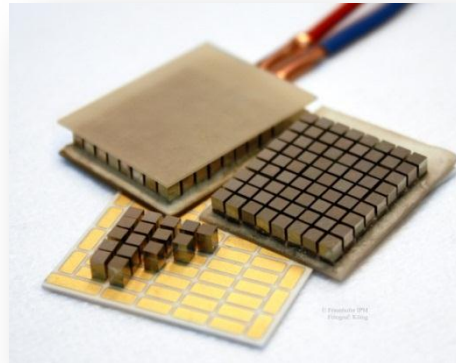
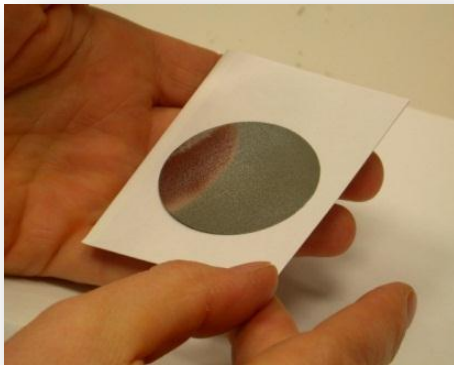
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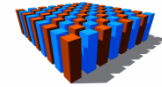




Materials – Modules – Metrology and Systems

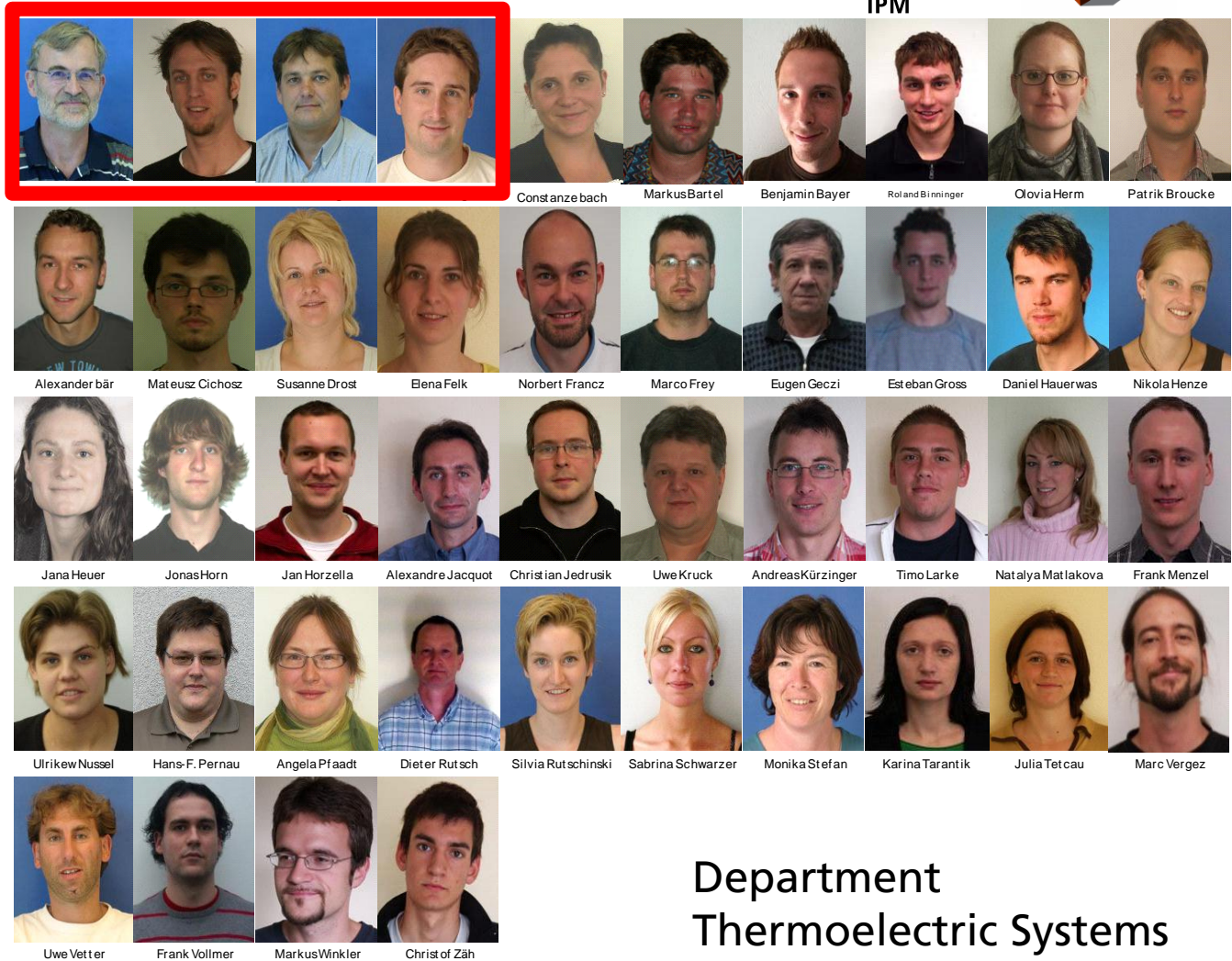


Position of Fraunhofer IPM

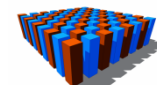


Numbers

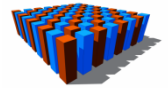
10 scientists
7 engineers
9 technicians
15 students



Department
Thermoelectric Systems



New situation at Fraunhofer IPM



Dr. Kilian Bartholome

Head of dept. TES
01.03.2012



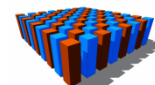
Jan König

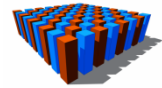
Group leader
Energy converters



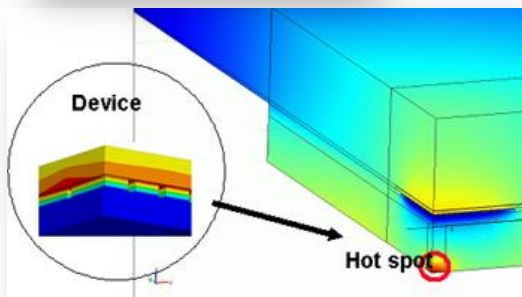
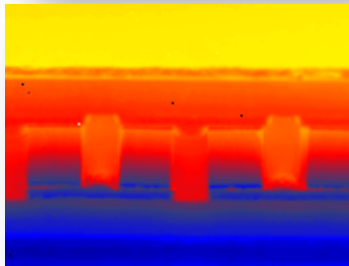
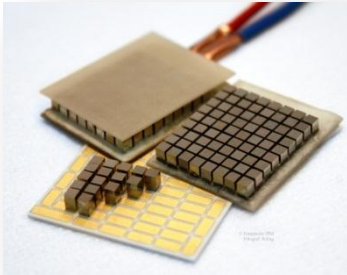
Martin Jaegle

Group leader
Metrology and self
powered systems



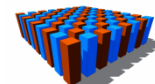


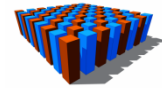
Topics



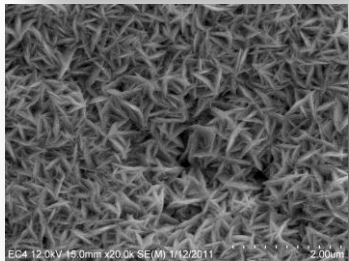
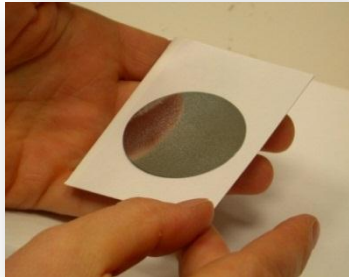
Converters for power generation and cooling

- High-Temperature and Nano materials
- Bulk and thin film system technology
- Development of production processes
- Simulation
- Metrology for materials, modules and integrated systems
- systems development



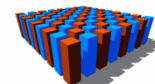


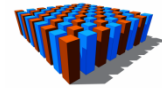
Materials



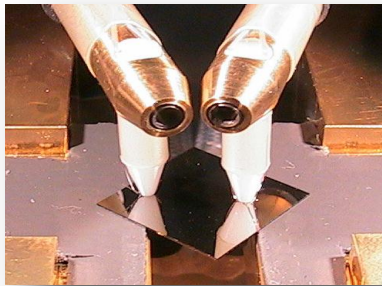
Novel materials and manufacturing methods

- Processing/modules for high temperature and bulk-nanoscale materials: “CoSb₃”, Mn-, Mg-Silicides, HH
- new production methods: SPS, electrochem. deposition, printing
- Seebeck „standard“-materials, in collaboration with german (PTB) and international metrology institutes
- Online measurement of material properties (Fh-IPM ZT-meter)



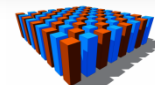
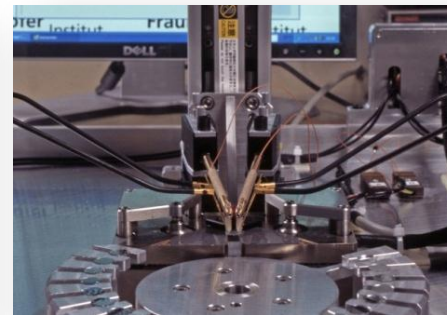
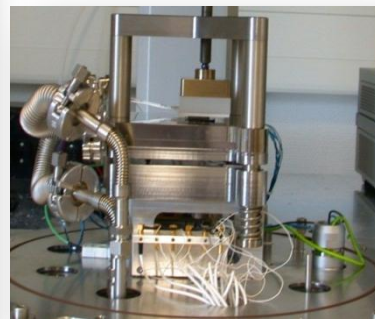


Metrology

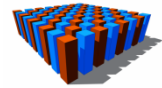


Customized measurement systems for all manufacturing steps

- High throughput screening systems
- Online measurement of ZT-value
- 3- Omega systems
- Module characterization
- On demand lab: customer sample characterisation



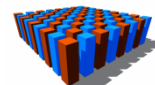
Position of Fraunhofer IPM



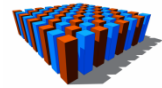
Systems: Harvesters



- Harvesting thermal energy from μW to kW
- Energy autarkic sensors transferring data via wireless communication

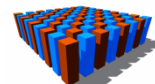
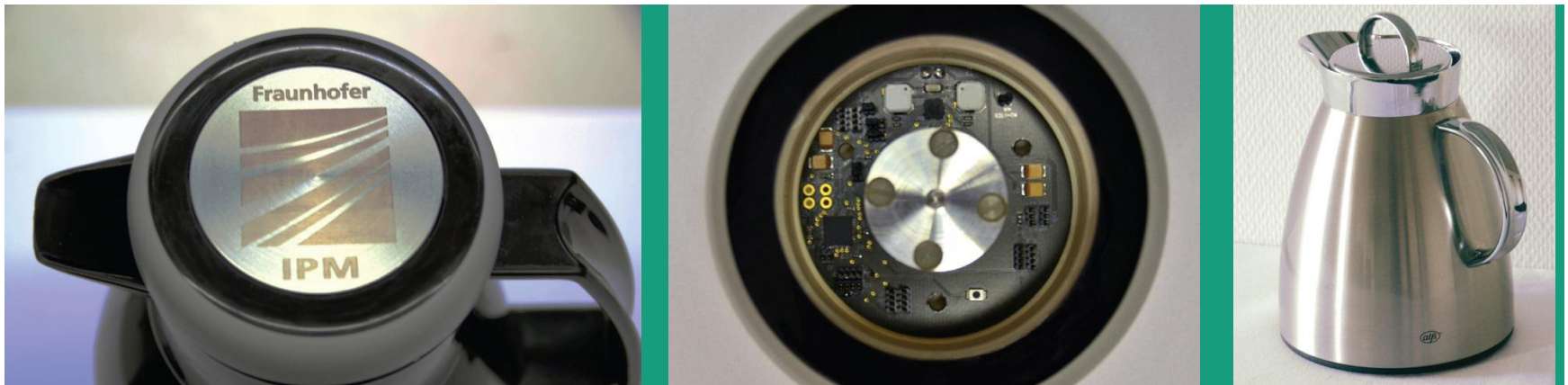


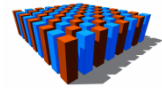
Position of Fraunhofer IPM



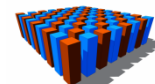
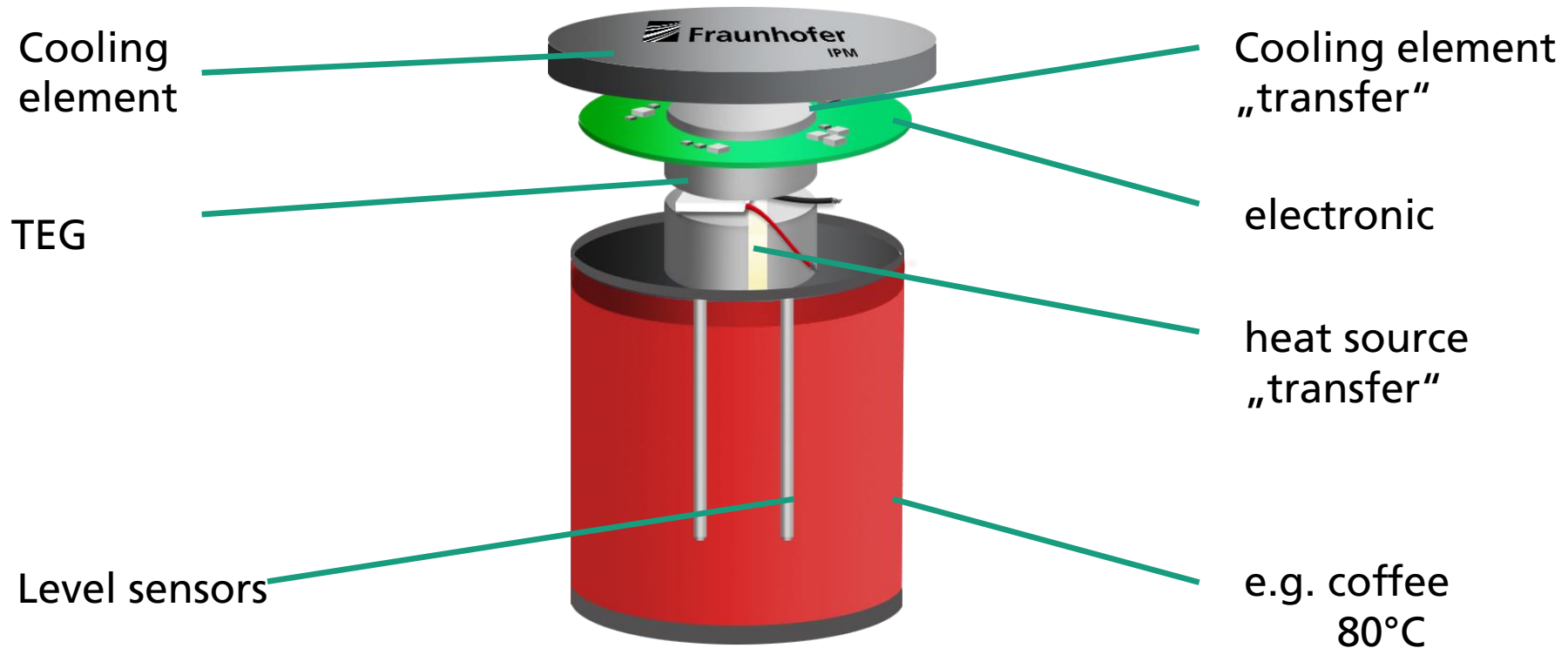
Systems:
Harvesters

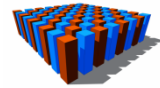
Communicating coffee pot





Communicating coffee pot

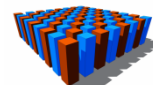
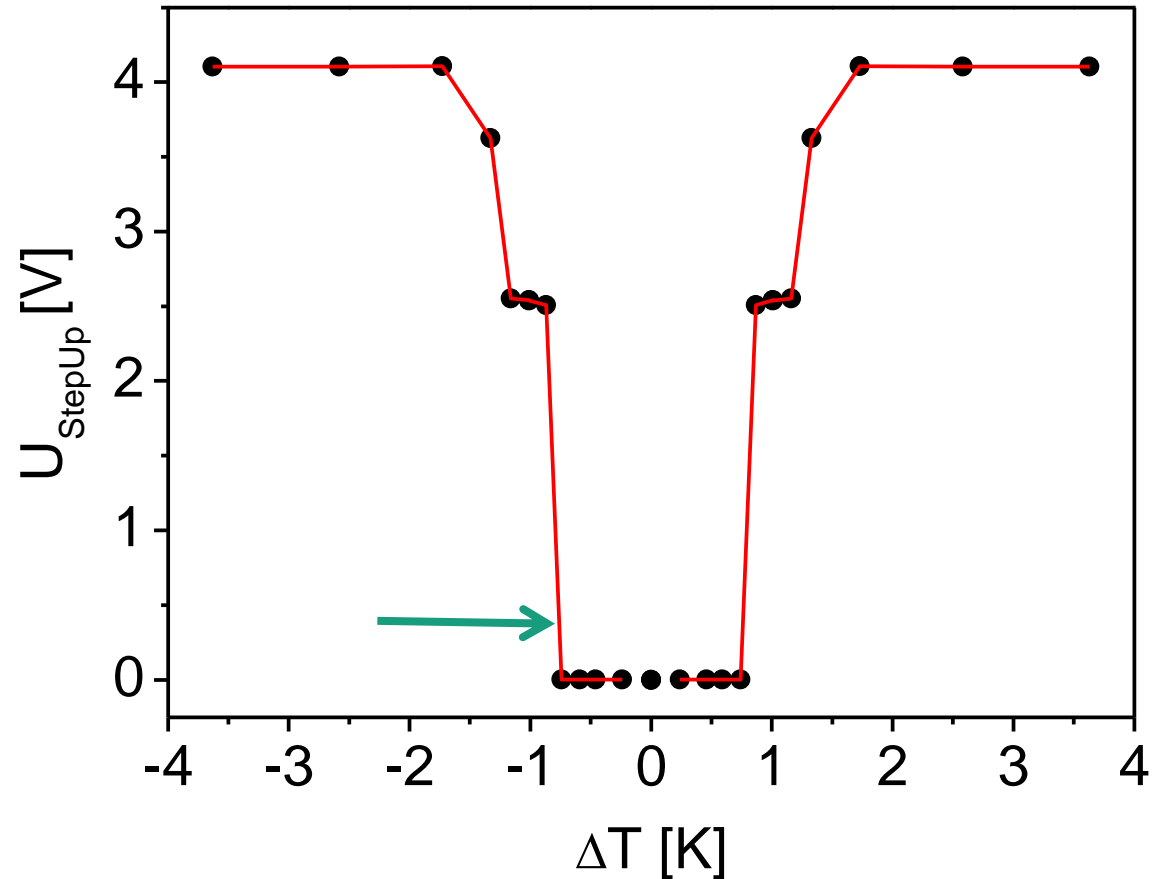


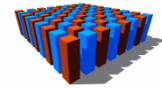


Communicating coffee pot

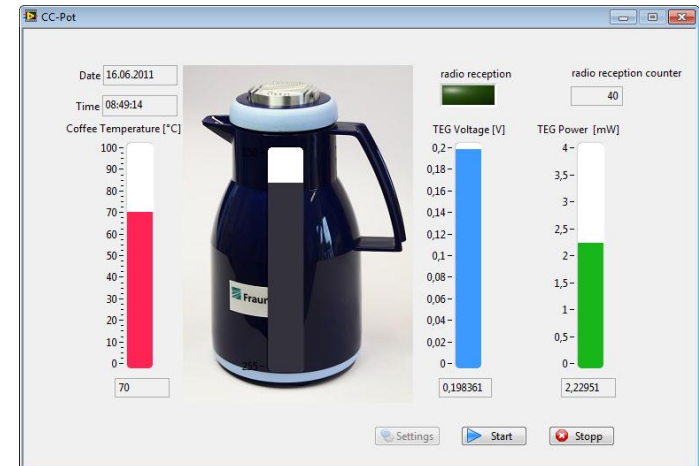
Step-up
converter starts
from

→ $\Delta T = \sim 0,8 \text{ K}$



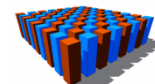


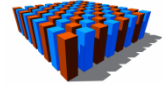
Communicating coffee pot



Data:

■ Max. TEG-voltage:	400 mV
■ Average TEG-voltage:	150 mV
■ Max. power:	85 mW
■ Average power:	12 mW

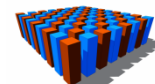




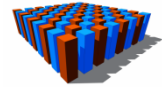
Communicating coffee pot

Information to
secretary:

⊗ empty



Position of Fraunhofer IPM

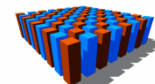


Never again cold coffee



This demonstrator can be ordered
custom designed from
Fraunhofer IPM

Quelle: fotolia.de



Thanks for your attention

and

happy coffee break

