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

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Dept. Thermoelectrics Systems
Freiburg, Germany
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, materials & 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

EC Framework Programme 7 (FP7) NMP

Statistics:
- 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
  Bi$_2$Te$_3$/Si/SiGe/B$_4$C/B$_9$C in low cost industrial processes
  superlattices for automotive application (???)

- **THERMOMAG** 10/2014
  nanostructured Mg$_2$Si solid solution/bulk materials,
  no ZT target
  high temp. waste energy harvesting
EC Framework Programme 7 (FP7) NMP

Main topics

- **NEAT** 03/2014
  Mg$_2$Si nanoparticles in n-Mg$_2$(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
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Nanostructured thermoelectrics: theory, modelsystems and controlled synthesis

Coordinator: Kornelius Nielsch University Hamburg

2009-2015
DFG priority program "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

J. W. v. Goethe, Faust I, 2038 f. / Mephistopheles
### DFG priority programm „Nanothermoelectric“

#### Education

<table>
<thead>
<tr>
<th>Event</th>
<th>Dates</th>
<th>Participants</th>
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</thead>
<tbody>
<tr>
<td>TE Winter School</td>
<td>14.-19.02.2010</td>
<td>97</td>
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<tr>
<td>TE Spring School</td>
<td>28.03. – 01.04.2011</td>
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<td>TE PhD Summer School</td>
<td>09. – 12.08.2011</td>
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<td>TEM Training</td>
<td>07/2010 and 02/2011</td>
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### DFG priority programm „Nanothermoelectric“

**Education**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Date</th>
<th>Pages</th>
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<tbody>
<tr>
<td>Thermal conductivity in reduced dimensions: 3-Omega-method and beyond</td>
<td>27./28.05.2010</td>
<td>45</td>
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<tr>
<td>Transport theory</td>
<td>27./28.01.2011</td>
<td>42</td>
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<tr>
<td>Spark Plasma Sintering of nanoparticles</td>
<td>21./22.03.2011</td>
<td>28</td>
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<tr>
<td>Measurements of nanostructured thermoelectric materials</td>
<td>18.-20.03. 2012</td>
<td>XX</td>
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</tbody>
</table>
DFG priority programm „Nanothermoelectric“

- groups
- 1\textsuperscript{st} funding period 2009-2012
- 103 publications until Jan 2012

proposals for the
2\textsuperscript{nd} funding period 2012-2015
DFG priority programm „Nanothermoelectric“

PI distribution:

- Non-University Institutions (MPI, FhI..): 15 PIs (27%)
- Chemistry (University): 6 PIs (11%)
- Physics (University): 27 PIs (49%)
- Engineering (University): 7 PIs (13%)
## DFG priority programm „Nanothermoelectric“

<table>
<thead>
<tr>
<th>PI distribution:</th>
<th>1st</th>
<th>2nd</th>
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<tbody>
<tr>
<td>on topics</td>
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<tr>
<td>Bi$_2$Te$_3$ based Nanostructures</td>
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<td>+2</td>
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<tr>
<td>IV-VI related Materials (e.g. PbTe)</td>
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<td>+2</td>
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<tr>
<td>Antimonides (e.g. Zn$_4$Sb$_3$, CoSb$_3$)</td>
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<tr>
<td>Heusler, Silicides and Clathrates</td>
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<tr>
<td>Thermoelectric Oxides</td>
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<tr>
<td>Silicon based Nanostructures</td>
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<td>Model Systems (z.B. GaAs)</td>
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<td>Thermoelectric Measurements</td>
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<tr>
<td>Theory and Modeling</td>
<td>8</td>
<td>+6</td>
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</table>
Content

topics

- Thermoelectric within 7th Framework Programme of European Community
- DFG (German Reserach 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

“… 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

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

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

Result: public R&D is important

H. Bradke, Berlin, 05/2009
Public funded applied research in Germany

<table>
<thead>
<tr>
<th></th>
<th>Funding (M€)</th>
<th>Project volume</th>
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<tbody>
<tr>
<td><strong>DFG (German Research Society)</strong></td>
<td>8.7</td>
<td>8.7</td>
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<tr>
<td><strong>BMBF Scientific</strong></td>
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<tr>
<td>Fed. Min. of Education and Research</td>
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<tr>
<td><strong>BMBF Applied</strong></td>
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<td>Fed. Min. of Education and Research</td>
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<tr>
<td><strong>BMWI Applied</strong></td>
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<td>Fed. Min. of Economics and Technology</td>
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<tr>
<td><strong>total</strong></td>
<td>50.2</td>
<td>73.2</td>
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Public funded applied research in Germany

Companies

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<tr>
<th>Company</th>
<th>SMEs</th>
<th>Large companies/big groups</th>
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<tr>
<td>TE-manufacturer/distributor</td>
<td>4</td>
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<tr>
<td>Electronic manufacture</td>
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<tr>
<td>Measurement techniques</td>
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<tr>
<td>Automotive companies</td>
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<tr>
<td>Automotive supplier</td>
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<td>10</td>
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<tr>
<td>Chemical industry</td>
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<tr>
<td>Ceramic industry</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Automotive engineering</td>
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<tr>
<td>Steel and (special) smelter</td>
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<td>2</td>
</tr>
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</table>

Thermopower 1
2011-2015

special projects
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
PROGRM THERMOPOWER

16.-17. 10. 2012 Dechema Building Frankfurt

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

New program including thermelectric 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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Position of Fraunhofer IPM

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
Position of Fraunhofer IPM

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
Position of Fraunhofer IPM

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)
Customized measurement systems for all manufacturing steps

- High throughput screening systems
- Online measurement of ZT-value
- 3-Omega systems
- Module characterization
- On demand lab: costumer 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
Position of Fraunhofer IPM

Communicating coffee pot

- Cooling element
- TEG
- Level sensors
- Cooling element „transfer“
- Electronic
- Heat source „transfer“
- E.g. coffee 80°C
Step-up converter starts from

$\Delta T = \sim 0.8 \text{ K}$
Data:

- Max. TEG-voltage: 400 mV
- Average TEG-voltage: 150 mV
- Max. power: 85 mW
- Average power: 12 mW
Position of Fraunhofer IPM

Communicating coffee pot

Information to secretary:

〇 empty
Never again cold coffee

This demonstrator can be ordered custom designed from Fraunhofer IPM
Thanks for your attention

and

happy coffee break