Fraunhofer
IPM

FRAUNHOFER INSTITUTE FOR PHYSICAL MEASUREMENT TECHNIQUES IPM

1

2

1 *Thermoelectric waste heat recovery system.*
2 *Planar modules with different aspect ratios.*
3 *Thermoelectric unicouples with heat exchanger fins.*

THERMOELECTRIC COMPONENTS AND MODULES

CUSTOM-TAILORED GEOMETRIES

Converting waste heat energy into electricity, this is what Fraunhofer IPM achieves with the aid of thermoelectric generators (TEG): In future, thermoelectric energy harvesting will play a key role in making more efficient use of energy in power plants, industrial processes or automobiles. Fraunhofer IPM produces thermoelectric bulk parts as well as complete modules and generators. These are based on:

- Skutterudites
- Half-Heusler compounds
- Bismuth tellurides or
- Silicides

Modules and generators are adapted to the individual application with the help of full thermoelectric simulations. The requirements for thermally and electrically well matched modules are realized in modules up to a surface area of 3.2 x 3.2 cm².

Usually, thermoelectric modules are connected by application of mechanical pressure o the heat exchanger. Fraunhofer IPM offers expertise in inte-grating thermoelectric modules into the custom-tailored system. This enables a better coupling and transport of heat fluxes.

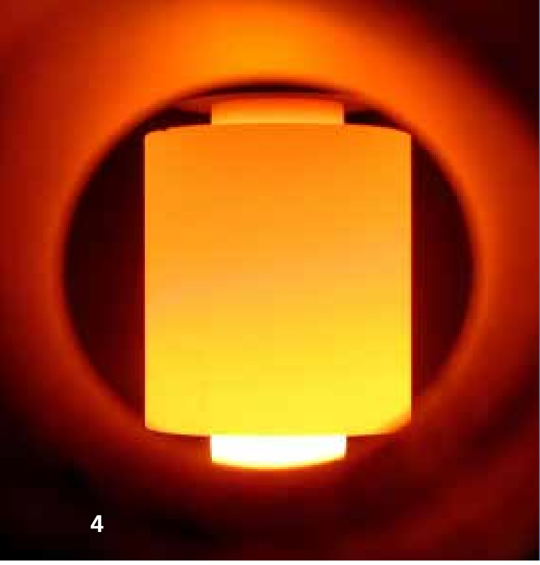
The development of electrical contacts with low ohmic resistance as well as thermal coupling suitable for high temperatures represents a key competence of Fraunhofer IPM.

3

Fraunhofer Institute for Physical Measurement Techniques IPM
Georges-Köhler-Allee 301
D-79110 Freiburg, Germany

Contact
Dr Jan König
Thermoelectrics
Phone +49 761 8857- 329
jan.koenig@ipm.fraunhofer.de

www.ipm.fraunhofer.de/en



4 Sintering tool for bulk materials.

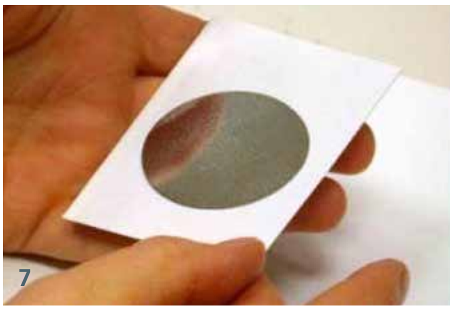
5 Sputtering system for diffusion barriers.

We specialize in the production of thermoelectric legs in custom-tailored geometries such as cubes or rings in a variety of aspect ratios and edge lengths.

Our expertise comprises a wide range of material processing methods for bulk material and thin-films:

- SPS
- Sawing
- Polishing
- Annealing
- Physical Vapor deposition

Fraunhofer IPM is experienced in several different processing techniques for bulk and thin-film material.



6 TE legs (variety of shapes and sizes).

7 200 µm bulk TE material.

Bulk materials: processing techniques

Pulse electric current sintering (PECS, also SPS)

- Diameter sinter body 10 – 20 mm
- Mechanical force up to 2 – 50 kN
- Variety of inert gases and vacuum
- Sinter temperature up to 2,200°C

Polishing

- Minimum material thickness down to 200 µm depending on material class

Separation

- Wire saw, cutting wheel
- Aspect ratios 1:3 possible with edge length down to 1 mm

Physical vapor deposition (e.g. sputtering)

- Typical diffusion barrier materials such as Ni, Ti, Au
- Homogenity of layer thickness of +/- 2 % possible for diameters of up to 145 mm

Electroplating

- Deposition of metal layers and even thermoelectric layers such as bismuth telluride and bismuth antimon telluride are possible

Application of diffusion barriers

Diffusion barriers are applied in order to prevent electrical contacts and the thermoelectric materials from chemical degradation. Fraunhofer IPM utilizes several techniques for the application of diffusion barriers optimized for the specific material classes.

Our offer

- Optimization and processing of functional materials
- Development of diffusion barriers and contact technologies
- Material and module characterization
- Fabrication of custom-tailored thermoelectric components
- Development of prototype systems
- Feasibility studies

Planar modules developed at Fraunhofer IPM (examples)

Material class	Max. operation temp.	Efficiency*	ΔT
Skutterudites	450° C	7%	430 K
Half-Heusler	550° C	5,4 %	530 K
Silicides	500° C	5,0 %	480 K
Bi_2Te_3	200° C	4,2 %	180 K

** for maximum operation temperature and 20°C cold side temperature, estimated by measurements and full thermoelectric simulation.*