Paris Summary

ECT 2008

ECT 2008 Paris Applications papers

Summary

Total of 113 papers presented (44 oral, 69 posters)
12 are categorised as applications.(5 oral, 7 posters)

- **System Applications(3)**
- **Simulated Applications (4)**
- **Demonstrated Applications (5)**

Systems Applications

- **ON-CHIP HOT SPOT COOLING: FORCASTS AND REALITY**
- *V. Semenyuk*
- This is a reviw paper in which a detailed analysis is given concerning the attainable maximum efficiency of the cooling technique under discussion. The method of optimal thermal integrating of a micro TEC into a processor-to-heat sink interface is developed. Different TEC configurations are tried with a typical processor, including bulk micro TECs and film-type micro coolers based on standard bismuth-tellurides and their nanostructured superlattices. The optimal TEC geometry and its operation mode are found providing minimal hot spot temperature. Some important factors which are neglected in other studies are taken into account what makes obtained results more realistic.

- **THIN FILM MATERIALS BASED ON V-VI SEMICONDUCTORS AND BINARY SKUTTERUDITE FOR APPLICATIONS ON THERMOELECTRIC MICROSENSORS**
- *A. Boulouz , A. Giani , J. Shumann M. Boulouz , L. Koutti J. Podlecki , and F. Pascal-Delannoy*
- In this contribution is reported important results of structural, electrical, and thermoelectric properties of n-type Bi2Te3, p-type Sb2Te3, p-type (Bi1-xSbx)2Te3 and binary skutterudite CoSb3 elaborated thin films. Some applications to micro devices are presented. To evaluate the efficiency of some elaborated films, a gas and pressure micro-sensor and a simple micromodule peltie are presented.The temperature in the centre of the active zone in the resistance is measured as a function of an injected current by using three different means: an infrared camera, a discrete thermocouple, and the integrated thermocouple.High thermoelectrics performance are reported, sufficient to achieve 2.6 °C of cooling over 1 mm² area for applying a optimal current of Iopt = 2,5 mA. A good response time of gas and pressure sensor is found about 600 ms with good reproducibility and low electrical energy consummation.

- **SELF-SUPPORTED AND MEMBRANE-SUPPORTED BULK-MICROMACHINED THERMOPILES FOR ENERGY SCAVENGERS**
- *Leonov V., Vullers R. J. M., Goedbloed M., Van Andel Y.*
- There are only two basic designs for a film-based thermopile effective for the energy scavenging on low-temperature sources of heat, namely the thermopile on a polymer tape and the micromachined thermopile on a micromachined pillar. The third ,an in-plane thermopile design is described which is well suited for microelectronic industry The thermopile comprises a set of planar film-based thermal shunts located thermally in series with either membrane-supported thermopiles or self-supported ones. The designs allow decoupling of the parasitic in-TEG thermal conduction and of the thermocouple length. The modeling performed for wearable and implantable TEGs shows that the efficiency of such thermopiles exceeds the efficiency of the ones on a polymer tape. Furthermore, the thermopile has obvious advantages as compared with micromachined thermopiles, e.g., it eliminates the problem of electrical contact resistance

Simulation Application Papers

HIGH EFFICIENCY MAXIMUM POWER POINT TRACKING POWER CONDITIONER FOR TEG SYSTEMS

- *Hiroshi. Nagayoshi1, Kenta Tokumitsu1, Hiroshi Maiwa2, and Takenobu Kajikawa2* **(P)**
- Most heat sources are variable and give rise to mismatch power loss. Consequently a power conditioner is required with maximum power point tracking control. In large TEG systems many TE modules are connected in series. The break down of TE module in the string causes a failure of all other TE module output in the string. To avoid such power loss, we have introduced the bypass diode to each TE modules. The paper describes the string power conditioner system with bypass diode.

- **DESIGN AND THERMAL ANALYSIS OF THE COMPONENTS IN A THERMOELECTRIC FINGER ICE-MAKER INCORPORATED IN A DOMESTIC RFRIGERATOR**
- *Rodríguez A., Vián J.G., Astrain D.***(P)**
- In this paper is studied the behaviour of a thermoelectric finger ice-maker incorporated in a domestic refrigerator. The thermal design allows determining and analyzing the thermal resistances of each thermoelectric ice-maker component; viz. between the cold side Peltier module and the ice cubes, and between the ice cubes and the water. Thermal optimisation allows improving the efficiency of the thermoelectric device..

- **THERMOELECTRICALLY HEATED/COOLED WHEELED STRETCHER**
- *Dr. S. Chatterje***(O)**
- The objective of this work is to design a wheeled stretcher which can prevent soldiers from extreme environmental conditions, i.e. either from cold injury or from heat stress.The thermoelectric system comprises 36 modules powered by 24 v DC. and able to provide or extract 250 W of heat with reference to an ambent of +60 or –20C

- **HIGH-EFFICIENCY THERMOELECTRIC GENERATOR BASED ON HEAT REGENERATION**
- *Mauro Brignone1, Alessandro Ziggiotti1; Luca Belforte***(O)**
- In this paper the thermal management of a thermolectric sytem is investigated in order to design an efficient TE generator Employing heat recirculation obtained an a system efficiency greater than the inrinsic efficiency of the thermoelectric materials Mainly theoretical calculations with preliminary results obtained by integrating a five module generator employing Bi2Te3 with a combustion chamber at 250C are reported

Demonstrated Applications

- **DOMESTIC REFRIGERATOR WITH COLD PRODUCTION BY VAPOUR COMPRESSION AND THERMOELECTRICITY(P)**
- J. G. Vián, D. Astrain, A. Rodríguez

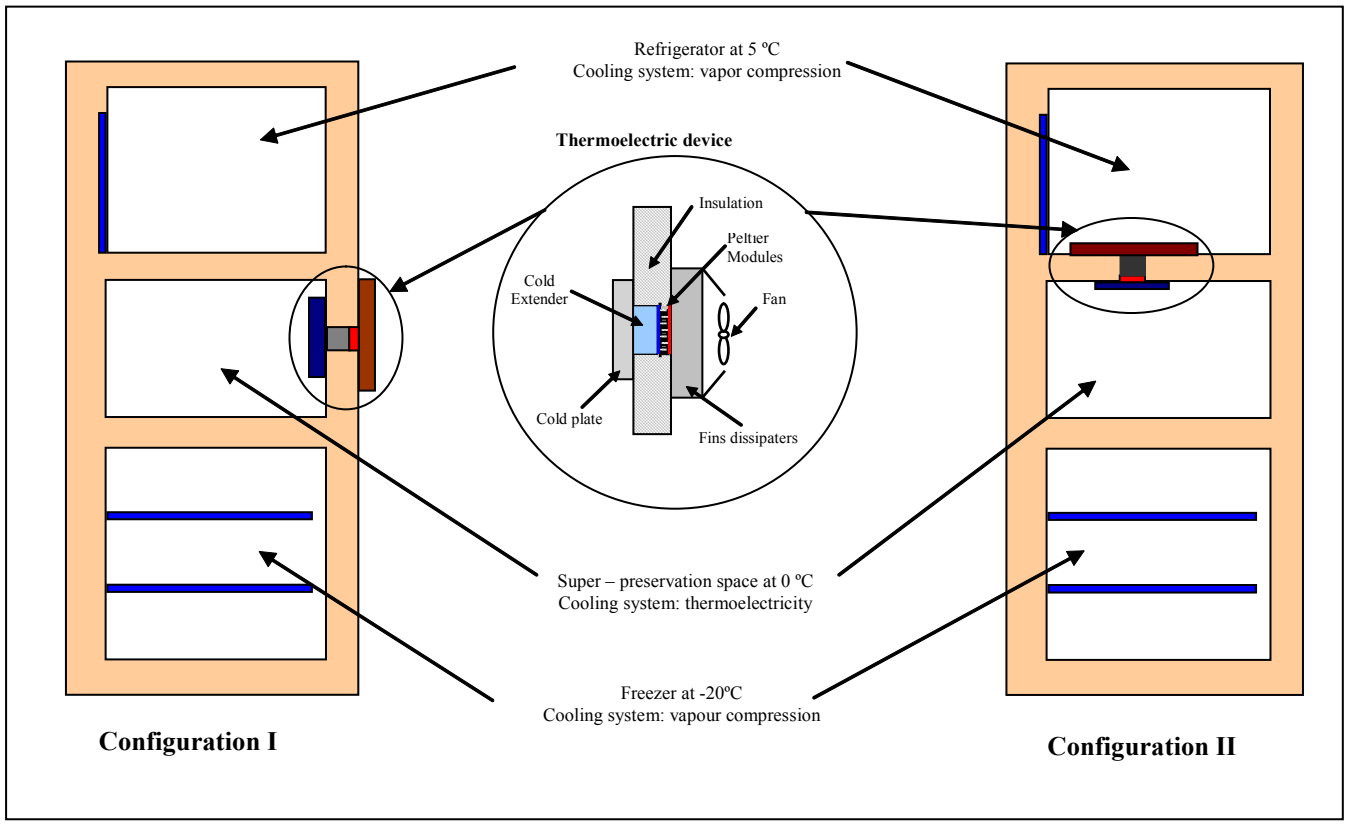
- **FULL-SIZE PROTOTYPE OF ACTIVE THERMAL WINDOWS BASED ON THERMOELECTRICITY(P)**
- Antonio Arenas-Alonso, Rafael Palacios, Ramón Rodríguez-Pecharromán,
- Luis Pagola

- **A 1KW THERMOELECTRIC POWER GENERATION SYSTEM FOR MICRO-COGENERATION (P)**
- K. Qiu, A.C.S. Hayden

- **STUDY OF THERMOELECTRIC POWER GENERATORS**
- **AND APPLICATION IN A SMALL SIZED CAR(P)**
- Hatzikraniotis E1, Zorbas K1,2, Triandafyllis I2 and Paraskevopoulos K.M.1

- **VEHICULAR THERMOELECTRIC APPLICATIONS (O)**
- John W. Fairbanks

DOMESTIC REFRIGERATOR WITH COLD PRODUCTION BY VAPOUR COMPRESSION AND THERMOELECTICITY



Temperature of cold box remains constant 0C when ambient at 30C

The total power consumption is reduced by 20%

1 kW THERMOELECTRIC POWER GENERATION SYSTEM FOR MICRO-COGENERATION

Thermoelectric Module

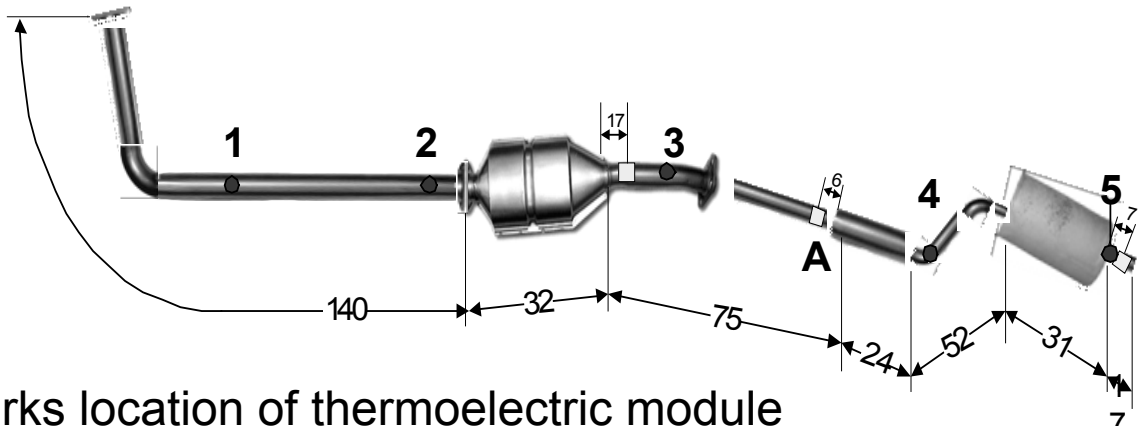
Heat conducting fins on inner surface

FULL SIZE PROTOTYPE OF ACTIVE THERMAL WINDOW BASED ON THERMOELECTRICITY

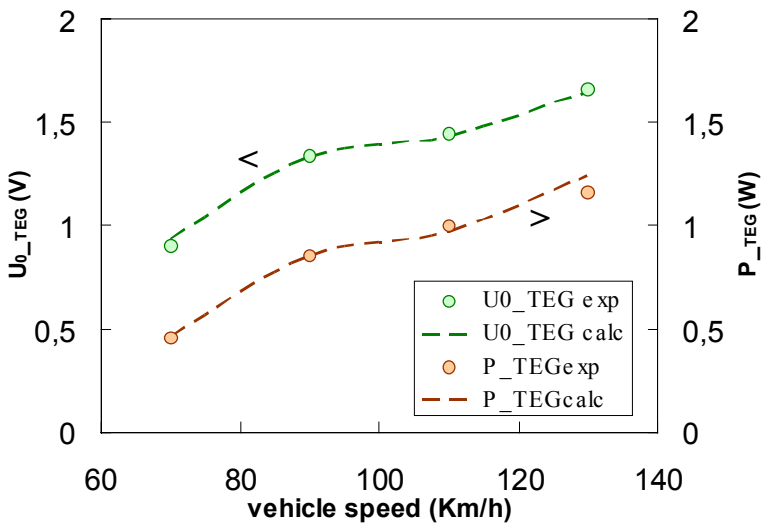
Window with thermoelements embedded in the glass
The system works as a heater or cooler
Black vertical lines are heat exchangers

STUDY OF THERMOELECTRIC GENERATORS AND APPLICATION

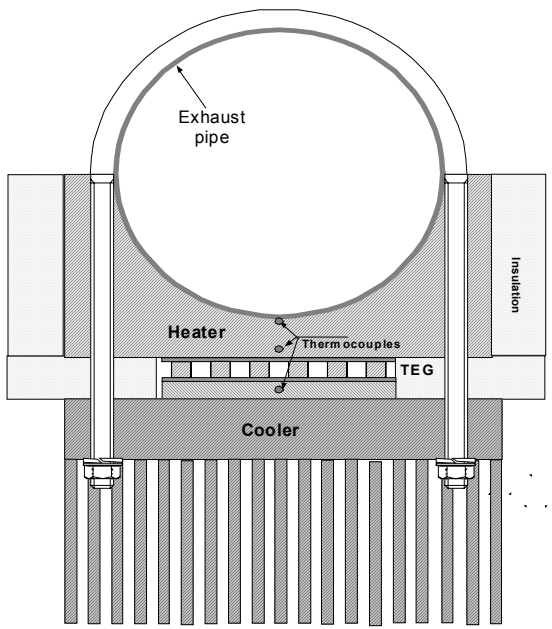
IN SMALL SIZE CAR



A marks location of thermoelectric module



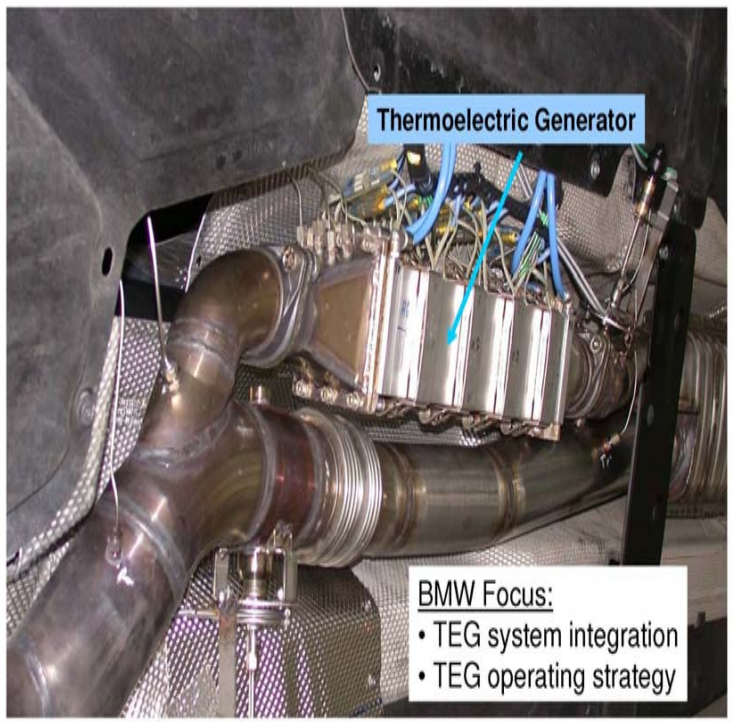
Voltage and power as function of car speed speed



VEHICULAR THERMOELECTRIC APPLICATION

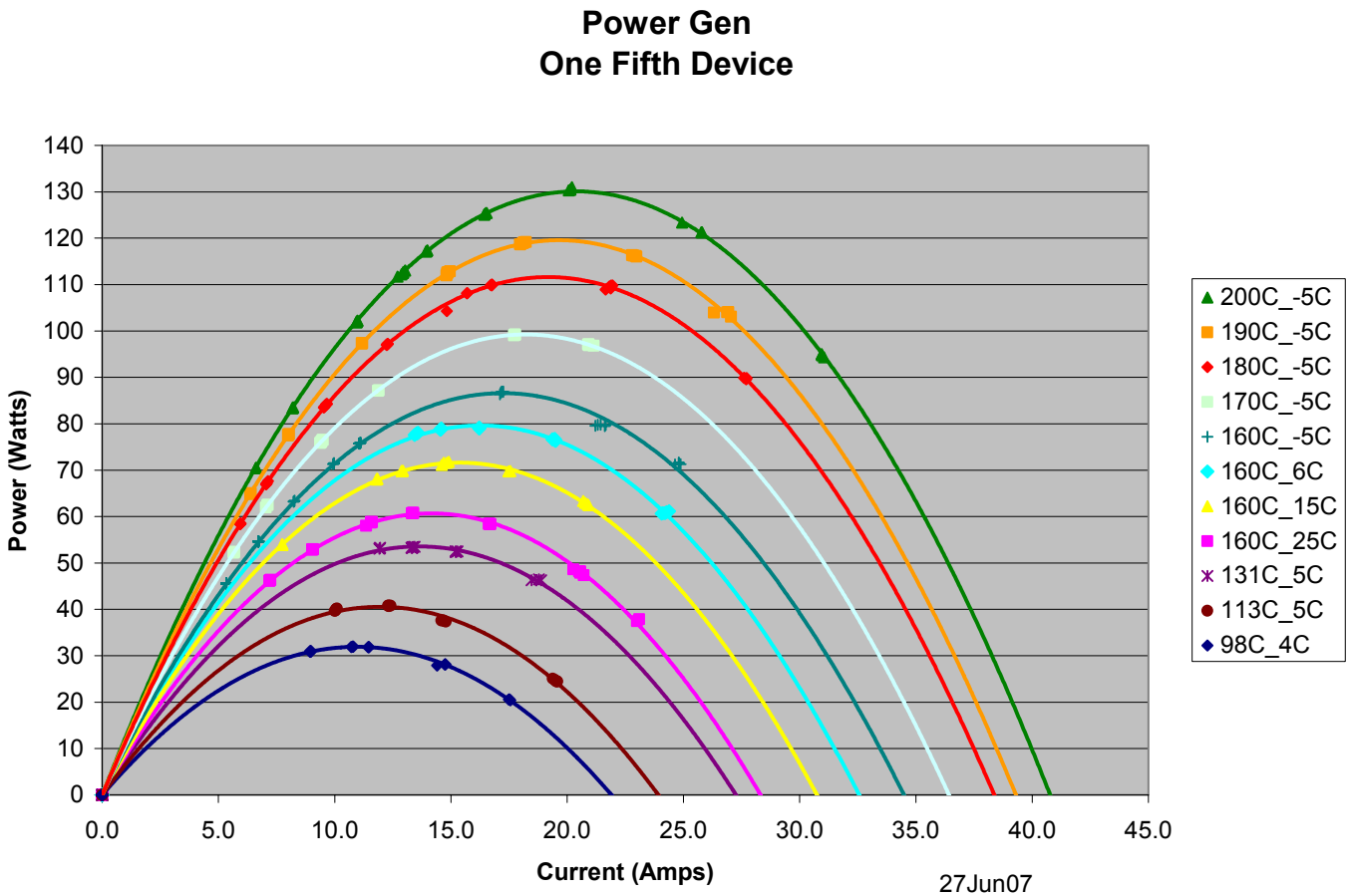
BMW Group
BMW Innovation Day
15.5.2008

BMW EfficientDynamics™ –
BMW's Approach to Reduce CO_2.
TEG Vehicle Implementation.



TEG in position showing generator and by-pass.

TEG section power output as a function of temperature difference



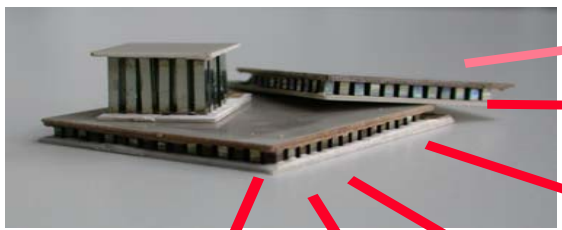
Power output from section of BiTe TEG- max power 130W

Conclusions

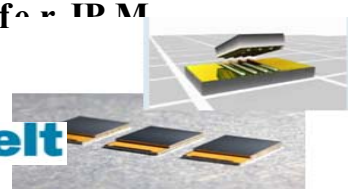
- Thermoelectrics provides an environmentally friendly method of energy conversion
- Applications presented cover both generation and refrigeration
- Current applications tend to be specialised due to low materials performance
- Various stages of development ,but all are novel
- Current major efforts is on applications in combating global warming
- Paradoxically increased fuel costs makes the technology more attractive
- Progress in material improvement is very encouraging
- Achieving material targets will result in explosion in applications
- .

Thermoelectrics at Fraunhofer IPM

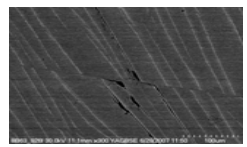
Scopes



R&D for micropelt



Nanoscale materials
Nanocomposites

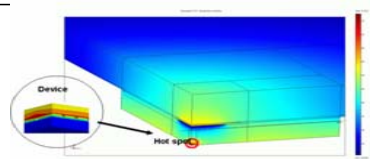


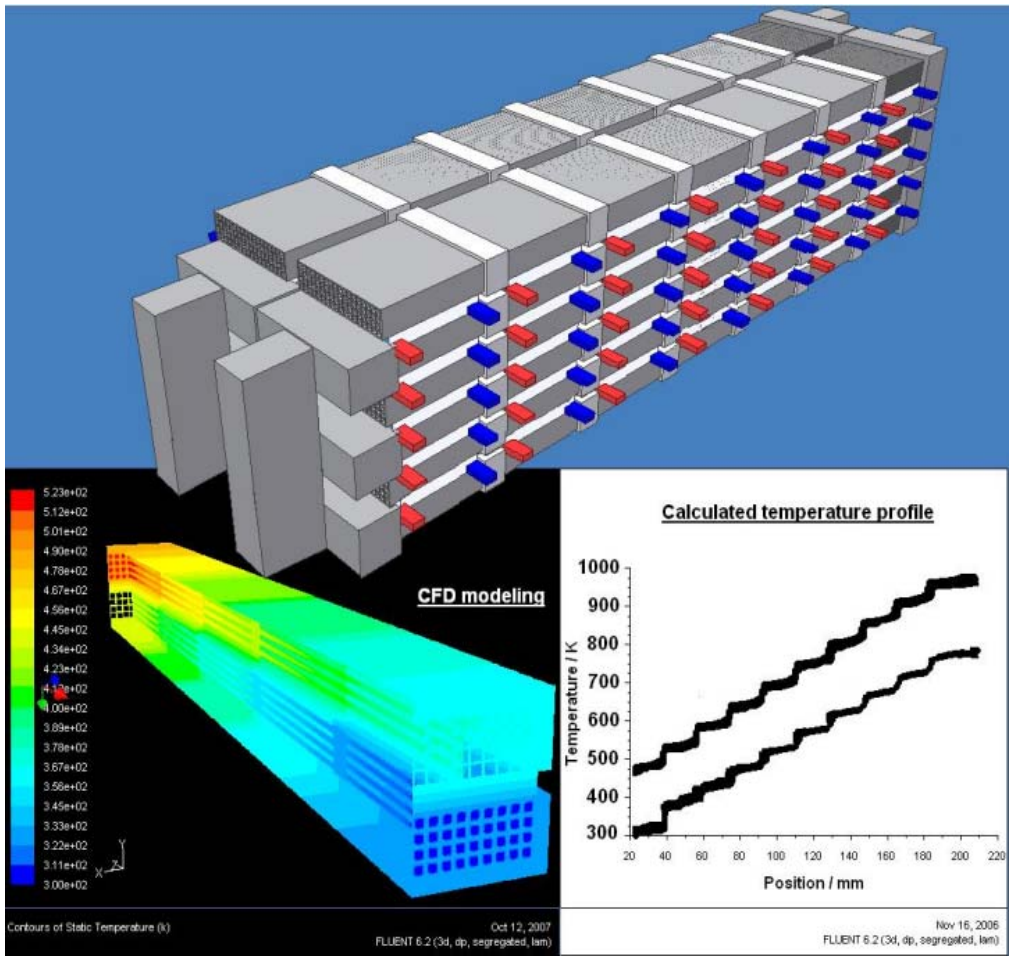
Bulk Materials
Modules
>200 °C; ZT>1

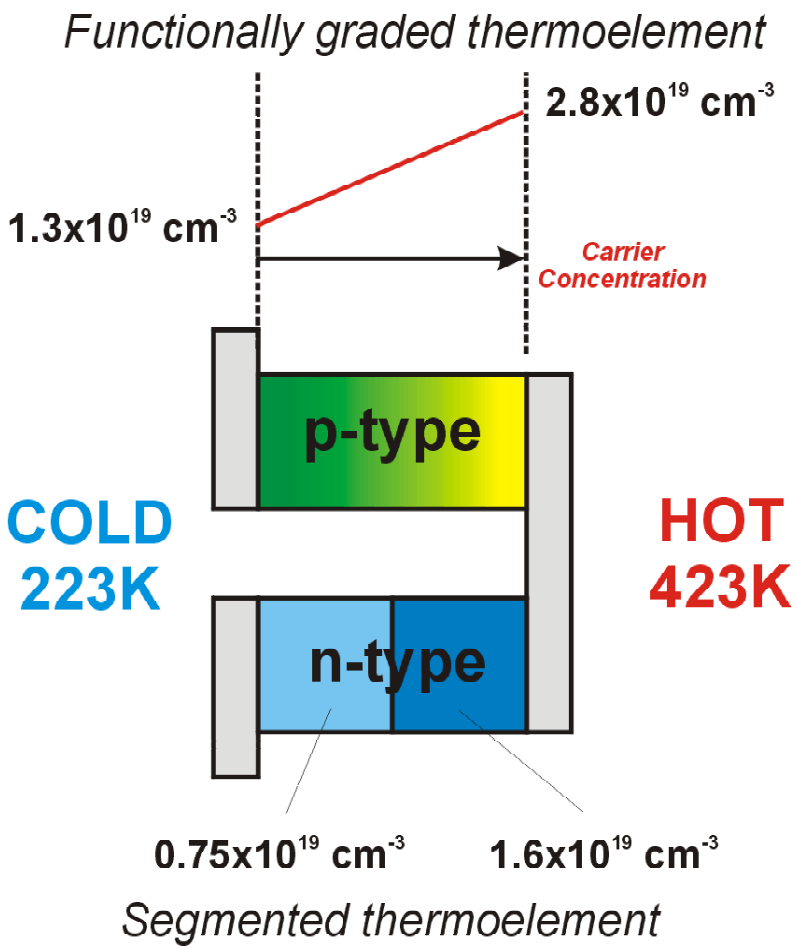
Thermoelectric metrology

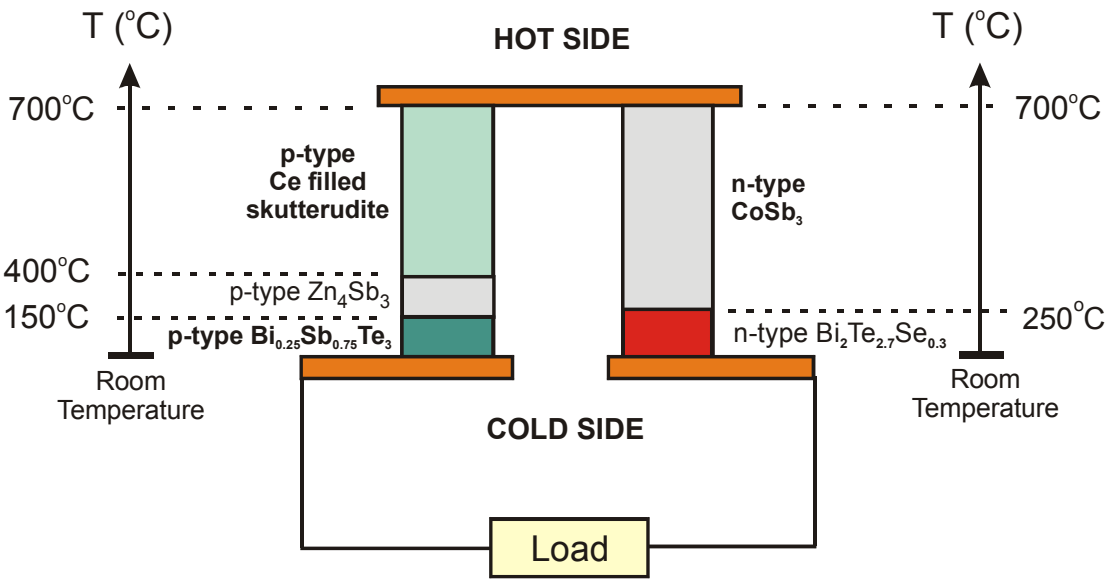
Customer-specific applications

Simulations / calculations




5.23e+02
5.12e+02
5.01e+02
4.90e+02
4.78e+02
4.67e+02
4.56e+02
4.45e+02
4.34e+02
4.23e+02
4.12e+02
4.00e+02
3.89e+02
3.78e+02
3.67e+02
3.56e+02
3.45e+02
3.33e+02
3.22e+02
3.11e+02
3.00e+02
CFD modeling
Contours of Static Temperature (k)
Oct 12, 2007
FLUENT 6.2 (3d, dp, segregated, lam)
Calculated temperature profile
Temperature / K
1000
900
800
700
600
500
400
300
20
40
60
80
100
120
140
160
180
200
220
Position / mm
Nov 16, 2006
FLUENT 6.2 (3d, dp, segregated, lam)

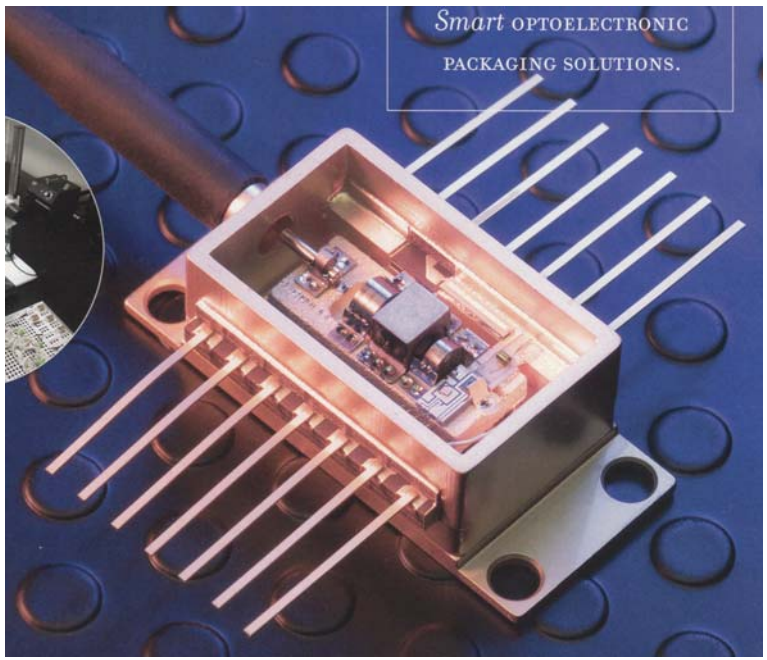

Functionally graded thermoelement
2.8x10^19 cm^-3
1.3x10^19 cm^-3
Carrier Concentration
p-type
COLD 223K
HOT 423K
n-type
0.75x10^19 cm^-3
1.6x10^19 cm^-3
Segmented thermoelement

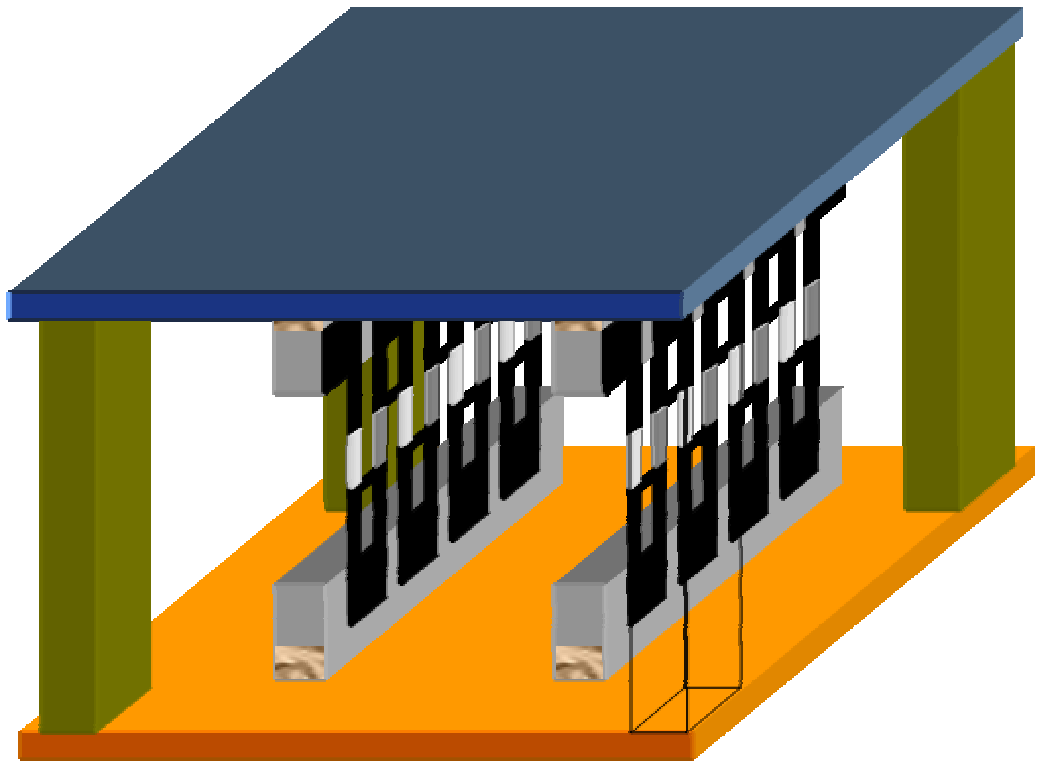

T (°C)
HOT SIDE
T (°C)
700°C
700°C
p-type
Ce filled
skutterudite
n-type
CoSb3
400°C
p-type Zn4Sb3
150°C
p-type Bi0.25Sb0.75Te3
n-type Bi2Te2.7Se0.3
250°C
Room
Temperature
Room
Temperature
COLD SIDE
Load

- Summary
- Introduction
- Materials and modules
-
- Applications and waste heat recovery
- Collaborations with Japan
- Collaboration with Calsonic Kansei
- The EU FP Programmes
- Novel devices

- **Application papers**
- ***Generation***
- **High –efficiency thermoelectric generators based on heat regeneration (Italy)**
- **Thin film materials based on V-V1 semiconductors and binary skutterudite for applications on thermoelectic microsensors.(France,**
- **Germany, Morocco.)**
- **Vehicular Thermoelectric Applications (USA)**
- **Study of thermoelectric power generators and applcation in a small size car) (Greece)**
- **High efficiency maximum power point tracking power conditioner**
- **for TEG systems (Japan)**
- **Self-supported and membrane-supported bulk-micromachined thermopiles for energy scavengers,(Belgium, Netherlands)**
- **A 1kw thermelectric power generation sysem for micro-cogeneration (Canada)**
- **New thermoelectric generators integrating Si/SiGe nanostructures (France)**

- *Refrigeration*
- **Thermoelectrically heated/cooled wheeled stretcher(India)**
- **Design and thermal analysis of the components in a thermoelectric finger ice-maker incoporated in a domestic refrigerator (Spain)**
- **Domestic refrigerator with cold production by vapour compression and thermoelecricity(Spain)**


Smart OPTOELECTRONIC
PACKAGING SOLUTIONS.

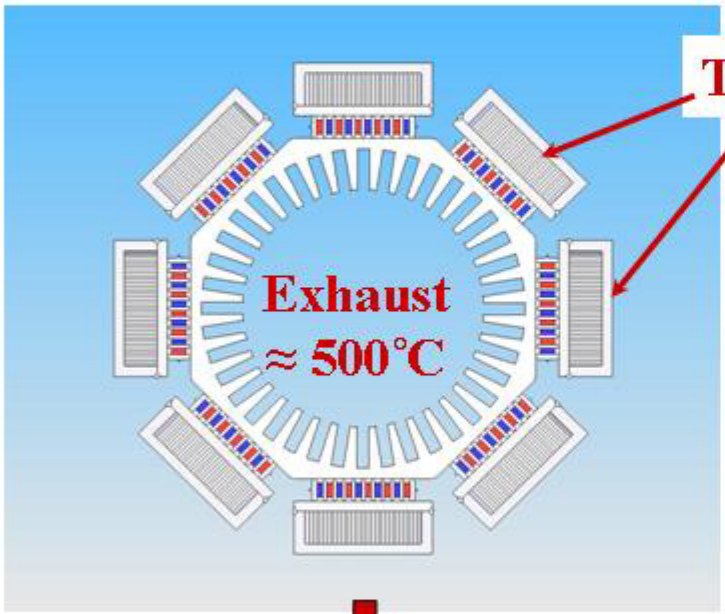


TE Power Generation from Engine Waste Heat

Heat Rejection
Waste Heat > 50%

$T_H \approx 500°C$

$T_C \approx 30°C$



Carnot Efficiency

$$\eta_C = \frac{T_H - T_C}{T_H}$$

TE Efficiency

$$\eta = \left(\frac{T_H - T_C}{T_H}\right)\left(\frac{\sqrt{1+ZT}-1}{\sqrt{1+ZT}+T_C/T_H}\right)$$

Waste Heat Recovery
Goal > 10% Increase in fuel economy

- **Demonstrated Applications**
- **DOMESTIC REFRIGERATOR WITH COLD PRODUCTION BY VAPOUR COMPRESSION AND THERMOELECTRICITY(P)**
- J. G. Vián, D. Astrain, A. Rodríguez
- Mechanical, Energy and Materials Engineering Department
- Public University of Navarra, UPNA. Pamplona SPAIN
- **FULL-SIZE PROTOTYPE OF ACTIVE THERMAL WINDOWS BASED ON THERMOELECTRICITY(P)**
- Antonio Arenas-Alonso, Rafael Palacios, Ramón Rodríguez-Pecharromán,
- Luis Pagola
- Universidad Pontificia Comillas
- Escuela Técnica Superior de Ingeniería ICAI
- Alberto Aguilera 23
- E-28015 Madrid, Spain
- **A 1KW THERMOELECTRIC POWER GENERATION SYSTEM FOR MICRO-COGENERATION (P)**
- K. Qiu, A.C.S. Hayden
- CANMET Energy Technology Centre-Ottawa, Natural Resources Canada,
- 1 Haanel Drive Ottawa, Ontario, Canada K1A 1M1
- **STUDY OF THERMOELECTRIC POWER GENERATORS**
- **AND APPLICATION IN A SMALL SIZED CAR(P)**
- Hatzikraniotis E1, Zorbas K1,2, Triandafyllis I2 and Paraskevopoulos K.M.1
- 1- Physics Department, Solid State Physics Section, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece
- 2- Department of Vehicle Technology, School of Technological Applications, Technological Educational Institute of Thessaloniki, 57400 Greece
- **VEHICULAR THERMOELECTRIC APPLICATIONS (O)**
- John W. Fairbanks
- US Department of Energy - Washington, DC – US

- **Systems applications**
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- SCAVENGERS (O)
- *Leonov V., Vullers R. J. M., Goedbloed M., Van Andel Y.*