INSTITUTE
OF THERMOELECTRICITY
▪UKRAINE ▪

MICROMODULES FOR THERMOELECTRIC GENERATORS

- The micromodules are intended for use in low-power thermoelectric generators of space or terrestrial purpose. Sources of heat can include radioactive isotopes (for example, Pu^{238}), thermal flows in soils, heat released by organisms, including human, thermal flows through the walls of buildings and heat from various heated objects, waste heat from industrial and household devices, microcatalytic sources using flameless combustion of combustible gases or liquids (petrol, kerosene) etc. The micromodules open up the opportunity for wide application of low-power thermoelectric generators for power supply to space equipment. The use of a large number of such generators on space objects radically improves the reliability of electric power sources, provides their convenient location, serves as alternative to solar thermopiles on the orbits distant from the Sun. Terrestrial applications open up new opportunities of using thermoelectricity for power supply to medical equipment (heart pacemakers), heat meters, alarm and guard systems, portable electric devices, etc. Based on the micromodules, compact long-action sources can be created having specific characteristics higher than those of chemical power sources (storage batteries, chemical batteries).

- Besides, the micromodules are high-sensitive sensors for microcalorimetry, heat flow metering, for the determination of energy and power of laser radiation, UHF-fields, integral radiation, etc.

- The operating principle of thermoelectric micromodules is based on the use of thermoelectromotive forces arising in semiconductor thermocouples. A large number of legs in thermopiles (from hundreds to tens of thousands) allows to obtain the necessary electric voltages at relatively small temperatures differences ($\approx$10-100°).

- The diagram and appearance of the micromodule are given in Fig.1.

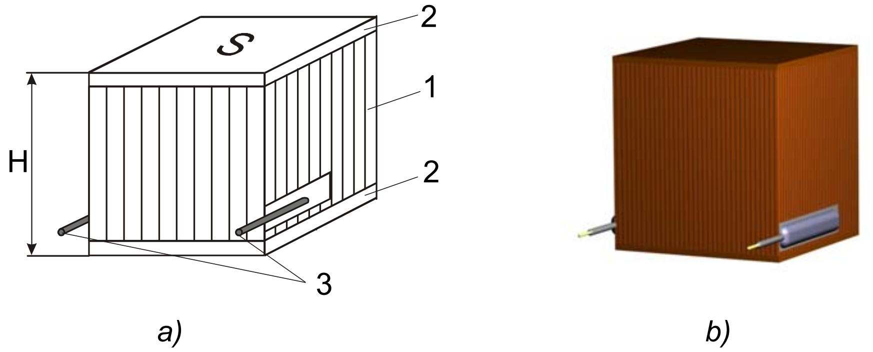

Fig. 1. a) Diagram of micromodule, b) micromodule appearance.

- The microthermopile consists of densely packed rectangular-shaped legs 1, connection units of legs 2 and electric contacts 3. The length of legs is usually 5-25 mm at cross-section 0.01–1 mm^2. The leg materials are *Bi-Te* based alloys made by extrusion method or in the form of perfect single crystals. The strength of microthermopiles is achieved through the use of special high-temperature connecting compounds.

- Special emphasis is placed on the micromodules reliability. It was provided by special technology preventing degradation of legs in manufacturing and highly reliable technologies of legs connection to anti-diffusion layers. Particularly reliable modules of IR series utilize special redundancy systems improving considerably their service life. The use of redundancy provides operating capacity of modules even at complete degradation of some legs. At degradation of one leg the electric power generated by module is reduced only by 1-3 %. The probability of failure-free work of module with redundancy during 10 years is increased by two-five orders.

- Temperature modes of micromodules.
  - Maximum operating temperature of hot side + 230 °C;
  - Admissible overheat of hot side +250 °C
  - Maximum operating temperature of cold side + 120 °C;
  - Admissible overheat of cold side +150 °C;
  - Minimum operating temperature of cold side – 50 °C.

- Parameters of modules with redundancy are given in Table 1.

Table 1

$S = 5 \times 5 = 25$ (mm^2)								**T_c = 25°C T_h = 125°C**				**Sensor mode**
Type	*H*, mm	h_0, mm	s_0, mm^2	*n*	$T_{c\,min}$, °C	$T_{c\,max}$, °C	$T_{h\,max}$, °C	*U*, V	*W*, mW	*Q*, W	η, %	$W^* \cdot 10^{-9}$, W
Altec-GM-1-P-IEIR-72-0.4x0.4-10-230-0-19-E	10,7	10	0,16	144	-50	120	230	1,4	18,5	0,64	2,9	3,4
Altec-GM-1-P-IEIR-47-0.5x0.5-10-230-0-19-E	10,8	10	0,25	94	-50	120	230	0,9	18,5	0,64	2,9	3,3
Altec-GM-1-P-IEIR-72-0.4x0.4-20-230-0-19-E	20,7	20	0,16	144	-50	120	230	1,4	8,8	0,32	2,9	4,8
Altec-GM-1-P-IEIR-47-0.5x0.5-20-230-0-19-E	20,8	20	0,25	94	-50	120	230	0,9	9,7	0,32	2,9	4,7
$S = 10 \times 10 = 100$ (mm^2)												
Altec-GM-1-P-IEIR-290-0.4x0.4-10-230-0-19-E	10,7	10	0,16	580	-50	120	230	5,8	74	2,56	2,9	6,7
Altec-GM-1-P-IEIR-188-0.5x0.5-10-230-0-19-E	10,8	10	0,25	376	-50	120	230	3,8	75	2,57	2,9	6,7
Altec-GM-1-P-IEIR-290-0.4x0.4-20-230-0-19-E	20,7	20	0,16	580	-50	120	230	5,8	37	1,28	2,9	9,5
Altec-GM-1-P-IEIR-188-0.5x0.5-20-230-0-19-E	20,8	20	0,25	376	-50	120	230	3,8	38	1,28	2,9	9,5
$S = 15 \times 15 = 225$ (mm^2)												
Altec-GM-1-P-IEIR-653-0.4x0.4-10-230-0-19-E	10,7	10	0,16	1306	-50	120	230	13,1	167,2	5,76	2,9	10,1
Altec-GM-1-P-IEIR-424-0.5x0.5-10-230-0-19-E	10,8	10	0,25	848	-50	120	230	8,5	169,2	5,78	2,9	10,0
Altec-GM-1-P-IEIR-653-0.4x0.4-20-230-0-19-E	20,7	20	0,16	1306	-50	120	230	13,1	83,6	2,88	2,9	14,2
Altec-GM-1-P-IEIR-424-0.5x0.5-20-230-0-19-E	20,8	20	0,25	848	-50	120	230	8,5	84,5	2,89	2,9	14,2
$S = 20 \times 20 = 400$ (mm^2)												
Altec-GM-1-P-IEIR-1161-0.4x0.4-10-230-0-19-E	10,7	10	0,16	2322	-50	120	230	23,2	296,6	10,53	2,8	13,8
Altec-GM-1-P-IEIR-754-0.5x0.5-10-230-0-19-E	10,8	10	0,25	1508	-50	120	230	15,1	301	10,57	2,8	13,7
Altec-GM-1-P-IEIR-1161-0.4x0.4-20-230-0-19-E	20,7	20	0,16	2322	-50	120	230	23,2	149	5,70	2,6	21,1
Altec-GM-1-P-IEIR-754-0.5x0.5-20-230-0-19-E	20,8	20	0,25	1508	-50	120	230	15,1	150,5	5,72	2,6	21,0

H – thermopile height; *S* – thermopile cross-section; h_0 – thermopile leg height; s_0 – leg cross-section; *n* – number of legs; $T_{c\,min}$ – minimum admissible operating temperature of thermopile cold side; $T_{c\,max}$ – maximum admissible operating temperature of thermopile cold side; $T_{h\,max}$ – maximum admissible operating temperature of thermopile hot side; *U* – voltage on matched load; *W* – thermopile power; *Q* – thermal power; η – efficiency; *W** – minimum detectable power.

Order and additional information: General Post Office, Box 86, Chernivtsi, 58002, Ukraine, e-mail: altec@ite.cv.ua; fax: (380-3722)-41917; phone: (380-3722)-41917; http://ite.cv.ukrtel.net/altec.