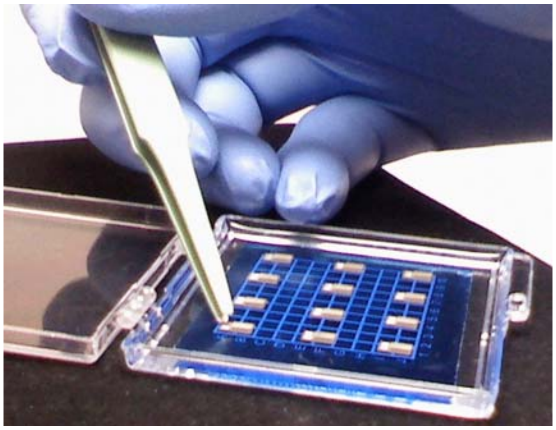
eTEG UPF40 Power Generator Application Notes

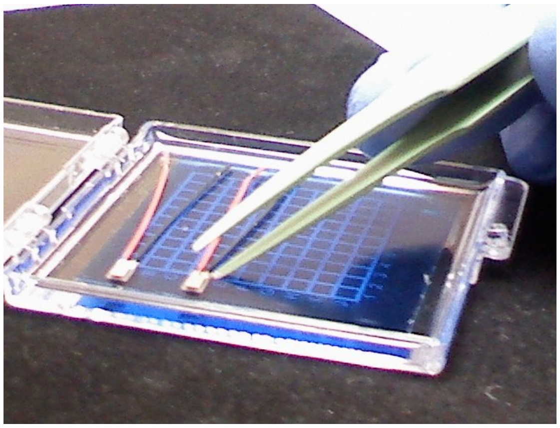
NGU-4004047-0203_W (insulated wires)
NGU-4004047-0203_S (solderable Sn bond pads)

Extraction from Gelpak

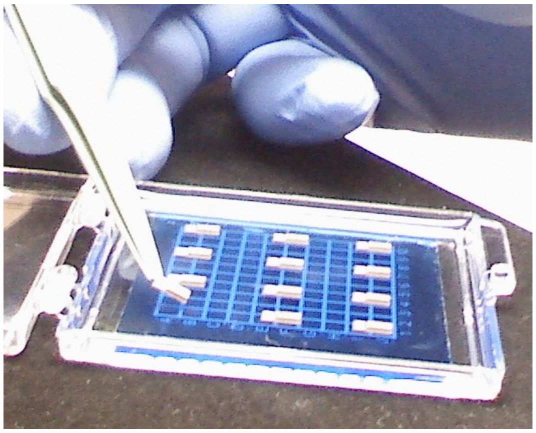
Use typical large blade tweezers   Avoid tweezer contact with Top Header

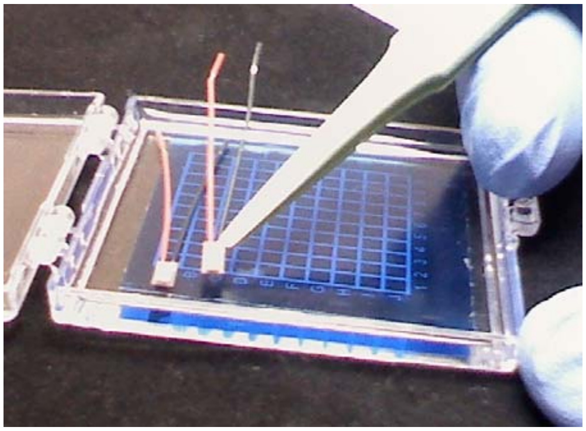
- Place tweezers at Bottom Header (bond side) and Gelpak interface (ref Fig 1, 1A)
- Partially and gently pry Bottom Header away from Gelpak
- Allow a few seconds for Gelpak adhesive to release
- Close tweezers against Bottom Header underside and bond pads (ref Fig 2, 2A)
- Lift UPF40 upward





Figures 1, 1A
Place tweezers at Bottom Header (bond side) and Gelpak interface





Figures 2, 2A
Close tweezers against Bottom Header underside and bond pads

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DESCRIPTION AND FEATURES

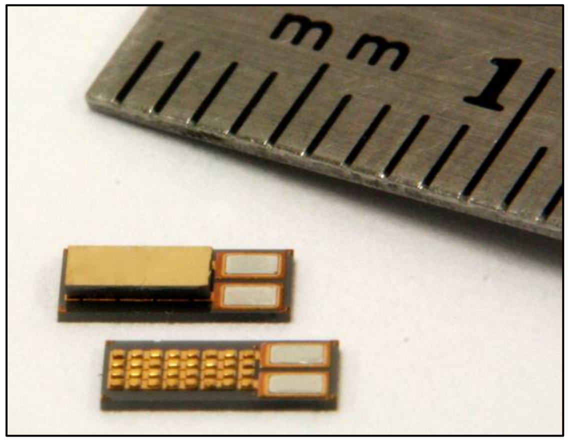
UPF40 Thermoelectric Generation (eTEG) devices are a new high-performance technology for low-profile heat energy conversion systems. The technology combines thin-film thermoelectric materials with solder interconnect processing to convert waste heat into useful electrical energy. The UPF40 device dimensions are 5.1 mm x 2.5 mm x 0.6 mm (l x w x h). Applications for the UPF40 device include battery charging, medical implants or high power applications using large arrays.

FEATURES

- Low profile
- High heat flux
- Small or large ΔT
- Continuous power
- No maintenance

APPLICATIONS

- Industrial heat waste
- Automotive systems
- Increased fuel efficiency
- Battery charging
- Wireless sensors
- Implantable medical devices



eTEG UPF40 Power Generator

ASSEMBLY FOR TESTING

- The following procedure describes the techniques a customer may use to test the Nextreme eTEG. Figure 4 depicts a typical eTEG assembly.
- For best results, Nextreme recommends that the top header be attached to the heat source. Heat will be rejected out of the larger bottom header.
- Attach the eTEG to the bottom mounting surface using a thermal interface material (TIM) or a low temperature solder. High thermal conductivity grease (>3 W/mK), thermally conductive epoxy or liquid metal (e.g., GaSn) can be used for this purpose. If grease or epoxy are used, a thickness of 4 mils (100 um) or less is recommended for optimal performance.
- Gently apply pressure on both sides of the eTEG bottom header, firmly setting the device into the TIM. Follow recommended curing instructions for the TIM (if required) being careful not to exceed 120°C. If wires are not provided it is possible to heat the device to 150°C.
- After mounting, the attached wires may be soldered to power and ground pads to the customer circuit board (not provided) or to flexible leads. Care should be exercised to provide adequate strain relief and not to expose the solder attachments of the wires on the module to temperatures above 120°C.
- Attach the heat source to the top header in a similar fashion to the bottom header attachment, described above.
- Avoid excessive vertical pressure on the module top header (Figure 3).

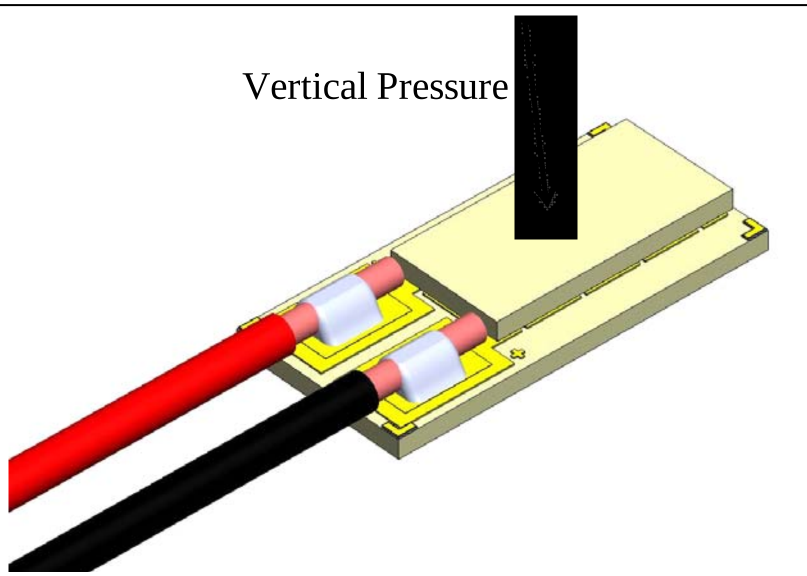


Figure 3: *Representation of eTEG UPF40. Avoid excessive vertical pressure on top header*

RECOMMENDED TESTING METHOD

1. Prepare Instrumentation

- Verify integrity of assembly by checking eTEG resistance. Refer to the data sheet for the eTEG and compare the specified resistance to the measured resistance.
- Separate the leads to prevent an electrical short between them.
- Solder leads for current and voltage measurements, and a series resistor for an electrical load. The resistor should be matched to the module resistance cited in the specifications sheet. The current meter is connected in series with the device, while the voltage meter is connected in parallel.

2. Attach Thermocouples (T/C) to eTEG Bottom and Top Headers

- Use thermal grease for T/C attachment.
- On eTEG bottom header, attach the T/C as close as possible to the top header without allowing the thermal grease to touch the top header. If it does touch the top header, it will thermally short the two headers and lead to performance degradation.
- On top of unified AlN header, attach a T/C as close as possible to the heater without making contact with the heater.

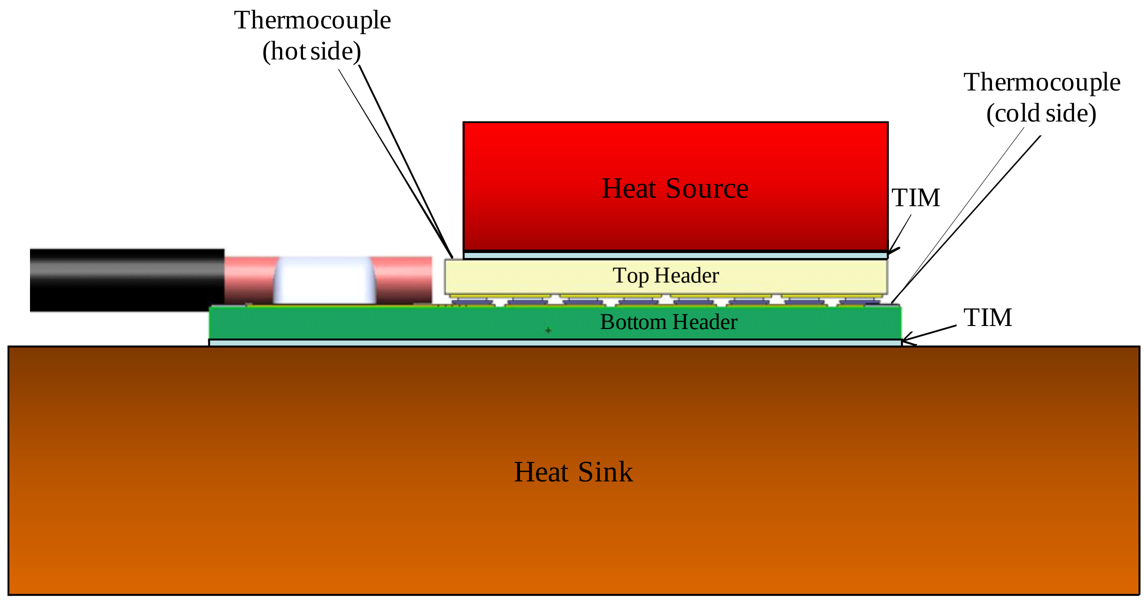


Figure 4: *eTEG Assembly*

3 Control Test Conditions

- By controlling the temperature of the source, the heat flow through the eTEG can be set, and the resulting temperature difference can be measured. The delivered power is equal to the product of the voltage and current across the load.
    - $P_{out} = I_{load} * V_{load}$
- If a source with heat flow measurement capability is available, the resulting Q_{in} measurements can be used to calculate the power generation efficiency, η:
    - $\eta = P_{out} / Q_{in}$
- Note that operation in atmosphere and without appropriate thermal shielding, significant thermal losses can affect the accuracy of the calculated efficiency.

GENERAL OPERATING INSTRUCTIONS

- Do not operate device beyond maximum operating conditions.
- Inadequate heat rejection can result in module overheating.
- The temperature of the module should **not exceed 120°C**. This is to avoid melting of the solder used to attach the power and ground wires. If there are no power and ground wires, the module can be taken to 150°C.
- For optimal performance, the thermal resistance of the interfaces on each side of the module should be minimized. The use of high quality thermal materials and thin bond lines (< 4mils) to provide a thermal path for heat rejection is recommended. High conductivity thermal interface materials (TIM) include liquid metal alloys (GaSn) or thermal grease (Shin-Etsu G751).
- Care should be taken to prevent the thermal interface material from penetrating into the module interior. Do not apply excess TIM.
- In power generation mode, when the heat source is applied to the bottom header, a positive voltage will develop from the red to the black lead. If the heat source is applied to the top header, a positive voltage will develop from the black to the red lead.
- The specification sheet depicts typical power generation voltage vs. current load lines, as well as output power and efficiency as a function of applied DT. Maximum power generation efficiency will occur at maximum DT.

DEFINITIONS

Parameter	Definitions
eTEG	Thermoelectric Generator
Q_{in}	Input heat applied to eTEG, measured in Watts.
ΔT	Temperature difference measured from top to bottom header of module.
T_{hj}	Temperature of hot junction
T_{cj}	Temperature of cold junction
P_{out}	Output power generated by eTEG, measured in Watts.
V_{load}	Voltage across load resistor, measured in Volts.
I_{load}	Current through load resistor, measured in Amperes.
GaSn	Gallium Tin
AlN	Aluminum Nitride
T/C	Thermocouple