Module Handling and Assembly

Thin film thermoelectric modules have extremely small form factors with footprints smaller than 10 mm^2. These devices are only 0.6mm high, making them the thinnest thermoelectric modules available on the market today. Due to their small form factor, care must be taken when handling and assembling modules into sub-assemblies for validation testing and production use.

Figure 6 shows a typical thin film thermoelectric module. Please note the location of the primary and secondary headers, which are referenced in the assembly instructions that follow.

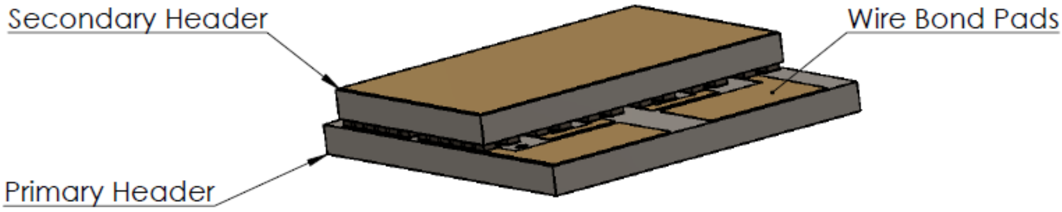

Figure 6: Typical Thin film Thermoelectric Module.

Figure 7 shows a rendered image of an HV56 in a "generic thermal package" consisting of two metal plates with spacers and the eTEC™ (with wires) sandwiched between. The lower metal plate is described as the "heat-rejection surface" while the upper plate is the "temperature controlled surface". The figure indicates typical components used during package assembly, including spacers, hard solders, and liquid metals.

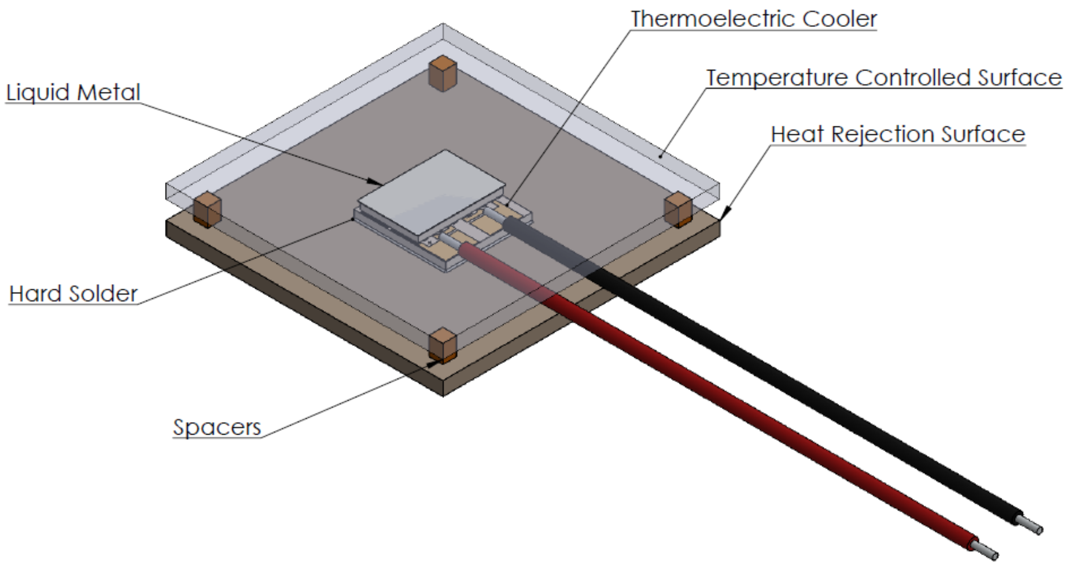

Figure 7: A generic thermal package.

The assembly procedure that follows describes a method for fabricating a thermoelectric assembly as shown in the figure above where a thin film thermoelectric device is packaged between thermally conductive plates. These plates could represent separate heat-spreaders or could be an integral part of the heat-exchangers or temperature controlled target. The package has been optimized to meet the conflicting requirements of highly conductive thermal interfaces while allowing for mechanical isolation of the eTEC™.

Suggested Parts and Supplies List

Solder – available from Indium Corporation in wire or foil preform

- InSn alloy #1E (52/48), MP 118°C
- BiSn alloy #281 (58/42), MP 138°C
- PbSn alloy #106 (63/37), MP 183°C

Flux – available from Indium Corporation

- For InSn and BiSn: TacFlux012
- For PbSn: TacFlux020 or 5RMA

ArticSilver Epoxy

- New Egg, catalog #N82E16835100005

Liquid Metal

- GaSn : Alfa Aesar, stock #18161
- GaInSnZn: Indium Corporation alloy #46L

3M Kapton tape

- Digi-Key # 3M541312-ND

Foam swab

- VWR, cat # TWTX751B

Mechanical Supports

- Fralock, 26 mil thick Cirlex® (custom cut)

Tweezers

- TDI International, part #5C-SA

Assembly Procedure

The recommended assembly procedure is described below:

1. Solder the eTEC to the heat rejection surface

The high heat fluxes provided by thin film eTECs require a metallic interface for optimal thermal performance. Non-metallic contacts will reduce the effective performance (ΔT) of the eTEC. Several solders and related fluxes that have been used successfully are listed in the parts list above. The bond line should be kept as thin as practical for minimal thermal resistance.

It's important to only handle the primary and not the secondary header of the eTEC. Precision tweezers that we have found to be appropriate for eTECs are recommended in the parts list above.

2. Attach the mechanical spacers to the heat rejection surface

Thermal expansion of the heat rejection and temperature controlled surfaces will differ due to different temperatures and possibly also material properties of these surfaces. eTECs are more robust in compression than in shear, due to the material properties that enable high heat flux densities. It is therefore necessary to provide mechanical spacers between the heat rejection and temperature controlled surfaces to avoid transferring shear forces to the eTEC.

There is a tradeoff between mechanical strength and thermal performance. These mechanical spacers are also a thermal shunt that can reduce ΔT if a material with high thermal conductivity is used. We therefore recommend the use of Cirlex®[1] (see the parts list above) with a thermal conductivity of 0.17 W/m-K. An epoxy that we have used successfully with Cirlex® and different metallic surfaces is also recommended in the parts list above.

3. Coat the secondary header of the eTEC with Liquid Metal

We recommend the use of GaSn or GaInSnZn liquid metal as an interface between the secondary header of the eTEC and the controlled temperature surface to provide high thermal conductivity while protecting the eTEC from high shear forces. GaSn is preferred when the controlled temperature surface is always at or above room temperature (22°C). GaInSnZn is preferred for lower temperatures because it has a lower melting point. Gold coated eTECs may need to be lightly scrubbed to wet the secondary header with liquid metal. A foam swab that we have used successfully for this purpose is recommended in the parts list above. It's important not to use so much material that the liquid metal overflows the sides of the eTEC. This can cause electrical shorts or thermal shunts. We recommend the use of Kapton® tape (see the parts list above) to protect the electrical connections.

4. Coat the temperature controlled surface with Liquid Metal

We recommend coating the portion of the temperature controlled surface that will cover the eTEC. This creates a clean void free interface for optimal thermal performance. The area coated should be approximately nine times greater than the area of the secondary header. This allows room for minor misalignments and gives a place for excess liquid metal to reside. Be careful to not coat with liquid metal any surface that the spacer will need to be attached to as the liquid metal will prevent a secure epoxy bond.

5. Attach the temperature controlled surface to the mechanical spacers

Epoxying the temperature controlled surface to the mechanical spacers completes the assembly procedure.

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[1] Cirlex® is a sheet material manufactured by Fralock made from 100% DuPont Kapton® polyimide film.

Precautions

Handling

- DO use precision tweezers for handling of the bare eTECs (see the parts list for a suggestion)
- DO grip the eTEC only by the primary header
- DO NOT grip the eTEC by both headers simultaneously
- DO NOT grip the eTEC by the secondary header

Thermal Interfaces

- DO use premium thermal interfaces such as solders and liquid metals
    - Use of thermal grease or epoxies will provide reduced performance

Liquid Metal

- **Liquid metal can be removed from delicate surfaces by using a pointed swab soaked in isopropyl alcohol. The IPA causes the liquid metal to form small spheres which can then be carefully swept away.**
- **Glass or ceramic surfaces can be cleaned with a quick etch of dilute HCl in deionized water. A concentration of 1 part HCl to 100 parts water (by volume) works in most circumstances**

Solders

- DO use a mid temp solder such as InSn, BiSn, or PbSn for the Primary Header interface
- DO keep the Primary Header thermal interface bond-line as thin as possible (approximately 12 µm or less)
    - This reduces the thermal resistance in the heat rejection path, which improves the ΔT.
    - DO NOT allow the eTEC to “float up” on puddle of solder as a large bond-line will result in excessive thermal resistance
- DO use a liquid metal solder such as GaSn or GaInSnZn, for the Secondary Header interface
- DO keep the Secondary Header thermal interface bond-line greater than 12µm but not to exceed 37µm
    - Bond-lines smaller than 12 µm expose the eTEC to damage from mechanical stresses imposed by the system
    - Bond-lines larger than 37 µm increase the interface thermal resistance
- DO NOT use a nominally solid solder on both thermal interfaces of the same eTEC
- DO use materials consisting of Cu, Ni, Ag, Au, or Sn on the surface to which the Primary Header will be solder attached
- DO use a Ni coating on the surface for liquid metal attachment of the Secondary Header
- DO NOT attempt to solder or liquid metal attach directly to aluminum
    - Soldering to aluminum requires caustic fluxes that can damage the thermoelectric material, which is exposed because sealing the device would reduce the performance due to the resulting thermal shunt
    - The Ga in the liquid metal reacts with aluminum
    - We’ve had excellent results with Ni electroplated on aluminum surfaces

Fluxes

- DO use a mildly activated rosin flux for solder attachment of the eTEC
- DO NOT use Organic Acid or other highly reactive fluxes for eTEC attachment as immediate and irreversible damage will occur due to its corrosive nature.

Solvents

- DO solvent clean any assembly to remove flux residues from inside the eTEC
- DO NOT leave residues of any kind inside the eTEC as it will become a thermal shunt path and result in degraded performance.

Mechanical Supports

- DO use a mechanical support system to carry the stresses applied to the system and also to set the bond-line of the liquid metal interface (hence mechanically decoupling the eTEC)
- DO NOT allow the eTEC to carry any mechanical load, i.e. with the system being in direct contact with both headers at the same time
- DO use thermally resistive, rigid materials for the mechanical support (see for example the spacers in Figure 2 above), e.g. Cirlex®
    - Thermal conductivity < 0.2 W/mK
    - Modulus > 2 GPa