

COPPER THERMAL STRAP TECHNICAL DATA AND TESTING INFORMATION

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PREVIOUS APPLICATIONS

- Cryocoolers
- Optical Systems
- IR Sensor Systems
- Cold Laboratory Instruments
- Laser Systems

TAI: CRYOGENIC EXPERTS

Technology Applications, Inc. was founded in 1994 and is located in Boulder, Colorado. We specialize in advanced technology development of cryogenic and thermal management systems for the DoD and NASA agencies, aerospace prime contractors, and other commercial firms.

Our expertise and specialty products include cryocooler integration and interfaces involving vibration isolation, remote/distributed cooling, high-conductance graphite fiber and copper thermal straps, thermal management of electronic components, lightweight insulation systems and high-performance dewars, and vapor compression cycle refrigeration.

Our business strategy includes, using the SBIR/STTR program as a vehicle to acquire leading edge technology, to develop and demonstrate custom products and high-performance systems, and exploit our intellectual property for commercialization of such systems.

Technology Applications, Inc. designs and fabricates copper thermal strap assemblies (CuTS, also known as "thermal links," or "heat straps"), for heat transfer (typically below 120 K) in systems such as cryocoolers, electronics, and optics that reject heat from a few watts to several hundreds of watts and require an efficient but flexible thermal link for transferring heat to the heat rejection interface.

CuTS assemblies are constructed using 100% OFHC copper throughout for the highest thermal conductivity at low temperature. They have demonstrated excellent thermal efficiency at cold temperatures and do not outgas, making them ideal in contamination sensitive environments. The CuTS offers

increased flexibility over our graphite fiber thermal strap (GFTS) assemblies to facilitate installation in complex configurations with tight alignment tolerances, larger relative structural compliance due to vibration and thermal contraction, and large-form bending motion.

TAI's CuTS units use OFHC copper braid manufactured to our custom specifications. All components are integrated within an assembly fixture that shapes the strap and locates the end fitting positions per the customer specification. The OFHC copper strands are integrated into the end fittings using a proprietary process that maintains an extraordinarily high thermal conductivity without compromising flexibility (continued on back)...



Figure 2. Copper Thermal Straps (CuTS).

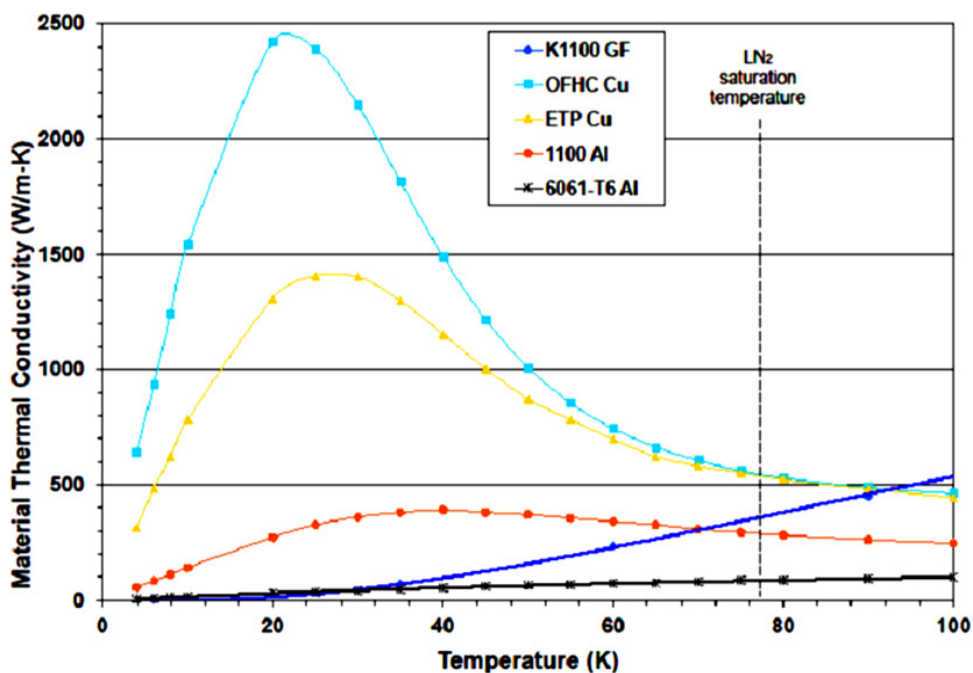


Figure 1. Thermal conductivity of OFHC copper compared with other common conductor materials.

TECHNOLOGY AND DESIGN

Technology Applications, Inc. can perform a complete system analysis to determine the heat transport across component interfaces and the resultant temperature drop as well as the routing geometries required for your system. If your system requires just one CuTS or hundreds, each assembly will pass comprehensive quality checks and undergo thermal conductance testing to verify system compliance. With numerous customer requests for a standard CuTS unit that is suitable for initial evaluation, we produce simplified CuTS units that will allow most performance parameters

to be verified without the need for custom design. Our cost-effective standard CuTS unit (shown in Figure 3) is available on a shortened schedule and does allow for some length variation within reasonable limits.

CuTS Features & Benefits:

- "In house" design and fabrication of custom CuTS assemblies to meet customer specifications.
- Overall thermal conductance is tested before they ship to the customer.
- Low loss attachment end fittings

- Can be routed in very complex geometries
- Highly Flexible
- Very high conductance at low temperatures

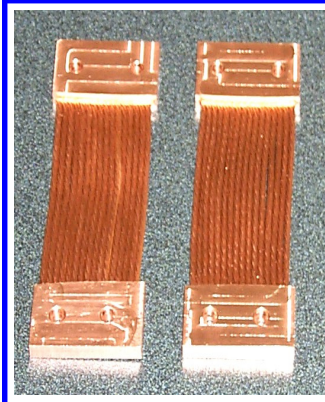


Figure 3: Standard CuTS Evaluator

PERFORMANCE TESTED

TAI has a vacuum chamber that was specifically designed for directly measuring thermal conductance for our product line of thermal straps, including the CuTS. The test chamber is designed to be easily configured for testing a variety of different strap geometries.

To minimize heat leak paths, the vacuum chamber is evacuated to less than 10 mTorr pressure to prevent heat flow due to convection around the apparatus (at room temperature and a pressure of 10 mTorr, the mean free path for air molecules is 0.5

cm). Several layers of multi-layer insulation (MLI) are wrapped around the thermal test assembly to reduce radiation heat transfer to the surroundings. The heat source block mimics the cooled interface and is supported by thin nylon threads that provide nearly complete thermal isolation between the surroundings and the heat source. In our test setup, the total parasitic heat loss due to conduction and radiation is less than 2% of the heat transport across the strap.

The overall test setup is shown

in Figure 4. Heater power is controlled with a variable voltage control. Dual multimeters are used to measure voltage and current flow, providing a direct determination of heat input to the thermal strap. Calibrated Type E thermocouples are used for measuring temperatures at key locations relative to the test article. A PC-based computer data acquisition and control system (DACS) measures and records the thermocouple temperatures and heater power for subsequent data reduction and thermal conductance determination.

TAI has complete test capability to measure the thermal conductance of each individual strap with an accuracy of 98%. Further, several of our multiple strap build programs have demonstrated that a given strap configuration can be reproduced to achieve thermal conductance with less than 4% overall variation. This allows us to minimize the thermal overdesign to assure that thermal performance will be met without adding unnecessary component mass.

RESULTS

This high-conductance, ultra-flexible CuTS has been developed by TAI and subsequently verified through extensive component and subsystem testing. Copper is an excellent choice for thermal straps in systems that require heat transport at cold temperature (typically < 120 K) or when extreme mechanical compliance is required. The CuTS assemblies become more mass efficient than the carbon graphite assemblies when the operating temperature is low.

CuTS assemblies can be designed and fabricated in almost any imaginable end-to-end configuration since the copper braid material remains flexible from fabrication to cold operating temperature and does not kink or deform under reasonable bending or loading conditions.

The unique combination of thermal and mechanical properties in OFHC and the manufacturing methods that TAI applies to fabricate strap assemblies produces a very high performance, yet cost-effective solution to decouple mechanical loading from thermal transport. Custom units can be designed, fabricated, and delivered within a several week window depending upon the complexity of your application and provided that all requirements are well defined from the onset of the design effort. Template thermal strap specification and statement of work (SOW) documents have been compiled from key parameters that have been important in previous development efforts and are made available to our prospective clients.

If your project is not that far along, please don't hesitate to call us early on as there are significant advantages to developing the thermal strap configuration concurrent with the overall system development. We often work with clients to help develop a comprehensive thermal strap specification that will assure our products meet your system requirements. We look forward to hearing from you soon!

-Tyler Link
Marketing Manager

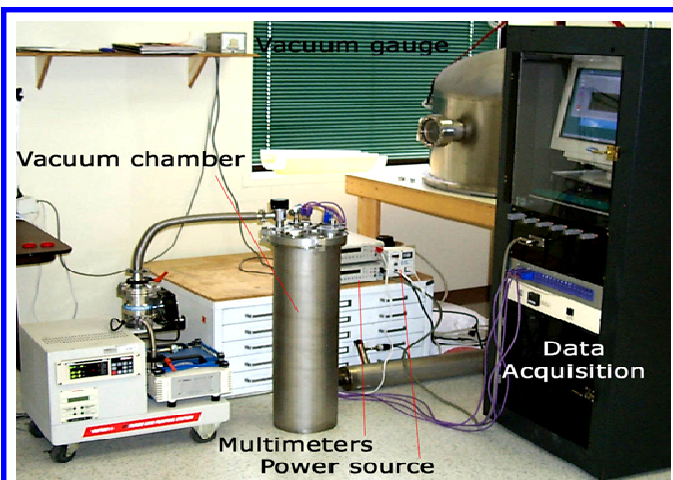


Figure 4. Thermal conductance test equipment setup.