Dexter Research Center, Inc.

We're Everywhere It Matters…

Introduction to Thermopile Detectors

Thermopile Detector Overview

Dexter Research Center is a leader in the manufacture of stable, high quality, high output radiation sensing thermopile detectors with a linear dynamic range from the UV to long wave IR. Thermopile detectors are passive radiation sensing voltage-generating devices, that require no bias or cooling and do not emit any radiation. Our detector's spectral absorption is flat from the ultraviolet to the far infrared. Spectral sensitivity is defined by the selection of optical band-pass filters. Thermopile output is generally in the micro-Volt to milli-Volt range depending on target size, temperature and radiance.

What are Thermopile Detectors?

Thermopile detectors can be thought of as a series array of miniature thermocouple junctions connected in series as differential pairs. These differential pairs make up the cold junctions and the hot junctions (see figure 1). In fact, the hot and cold junctions are connected by alternating n-type and p-type materials, called "Arms", creating a Seebeck effect between the junctions. A voltage is produced, proportional to the temperature gradient between the hot and cold junctions. For Thin Film based thermopiles, the arm materials are antimony (Sb) and bismuth (Bi). For Silicon thermopiles, the arm materials can be alternating n-type and p-type Poly-Silicon or n-type with gold (Au) or aluminum (Al). The cold junctions are typically thermally connected to the detector package and are located around the perimeter of the substrate opening. The hot junctions are located in the center of the detector pattern and are coated with an energy absorber. The hot junctions define the active area of the detector and are suspended on a thin membrane, thermally isolating them from the rest of the package.

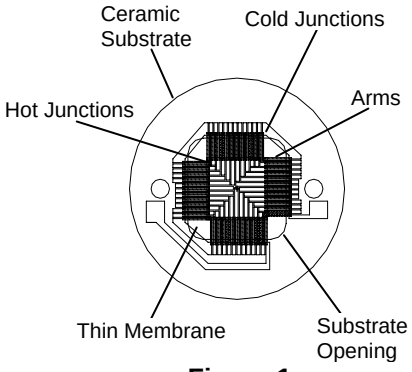

Figure 1:
Key features of the Model 2M Thin Film thermopile detector

Our detectors are designed in small TO-18, TO-5, or TO-8 transistor type packages. Before the detector package is hermetically sealed (encapsulated), the package is evacuated of ambient air and back-filled with one of four gases. The backfill gas provides one of the key thermal paths for dissipation of energy from the active area. Please reference Application Brief #7: "Effects of Encapsulation Gas on Thermopile Detectors" for a discussion of these effects on detector performance.

The unique energy absorbing materials used by Dexter Research Center enable our thermopile detectors to have a spectral response that is essentially flat from the ultraviolet to the far infrared. Depending on the detector application, spectral sensitivity is limited by the choice of optical band-pass filters. We have a wide range of optical filters and window materials in stock and available for customization of your detector for your application. Dexter Research also offers optional internal apertures, internal heatsinks, and several choices of package aperture sizes to meet your design requirements.

Thermopile detectors are very low noise detectors and have the same amount of noise as a resistor of equal resistance. Unlike Pyroelectric detectors, thermopile detectors generate no $1/f$ or microphonic noise, but only the Johnson noise of their resistance. Thermopile detectors provide a stable output for DC radiation up to a frequency limited by the time constant. Unlike Pyroelectric detectors, no chopper is required.

Types of Thermopile Detectors

Dexter Research Center offers two distinct types of thermopile detectors, the Bismuth-Antimony Thin Film based and the Silicon based. There are several performance differences between the two types of detectors as follows. Thin Film based thermopiles have lower resistance and lower noise voltage than a Silicon based thermopile, therefore Thin Film detectors provide a higher Signal-to-Noise ratio. A Thin Film thermopile with equal output to that of a Silicon based thermopile will have a slower time constant. In general, Thin Film thermopiles are available with larger active areas. Please see the table below for a comparison of these two types of thermopiles.

Several Thin Film thermopile models are designed with an internal compensating element. The compensating element is blinded and is typically connected in opposition to the active element, thus minimizing the effect of a sudden change in ambient package temperature. This temperature compensation is effective for no more than 5 seconds. Dexter Research Center has also created compensated Silicon thermopiles (the models starting with "ST"). Please ask our sales representative for more information.

Examples of Thermopile Detector Applications

- Hand-Held Non-Contact Temperature Measurements
- Non-Contact Temperature Measurements in industrial applications and process control
- Infrared Radiometry
- Tympanic Thermometers
- Automotive Exhaust Gas Analysis and Emissions Control
- Refrigerant Leak Detection
- Medical Gas Analysis including Anesthetic monitoring, incubator CO and CO_2, Blood Alcohol Breathalyzers
- Horizon sensors for Aircraft, Satellites, and hobbyist applications
- Thermal Imaging
- Thermal Positioning and Targeting
- Automotive Climate Control
- Automotive Occupancy Sensing
- Household Appliance Temperature Measurement
- Aircraft Flame and Fire Detection
- Hazard Control including Flame and explosion Detection
- Fire Detection in transportation tunnels
- Black ice detection and warning
- Blood Glucose monitoring
- Security Human Presence and Detection
- Humidity measurement

Thin Film based vs. Silicon based thermopiles

Parameter	Thin Film	Silicon
Output Voltage	Higher	Lower
Signal-to-Noise Ratio	Higher	Lower
Temperature Coefficient of $\mathscr{R}$	-0.36%/°C	-0.01%/°C
Noise Voltage	Lower	Higher
Time Constant	Slower	Faster
Cost	Higher	Lower
Operating Temperature	100°C	125°C