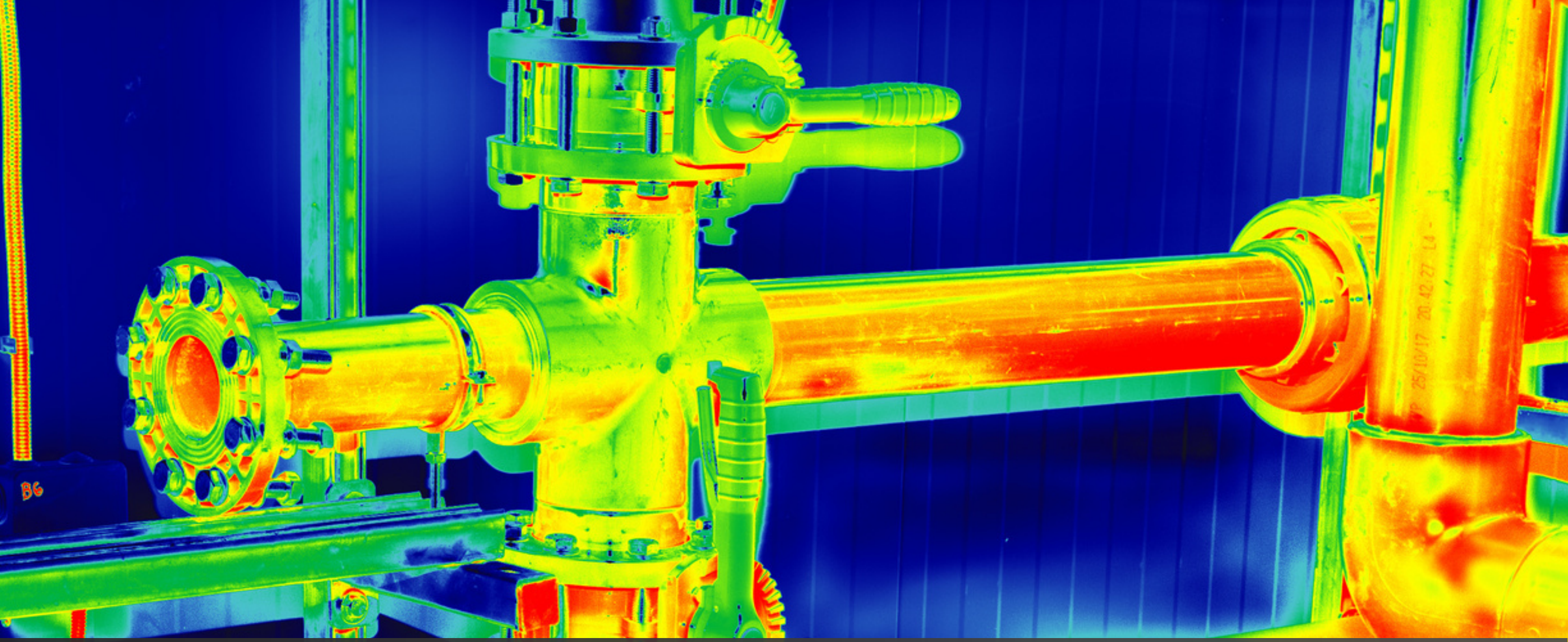
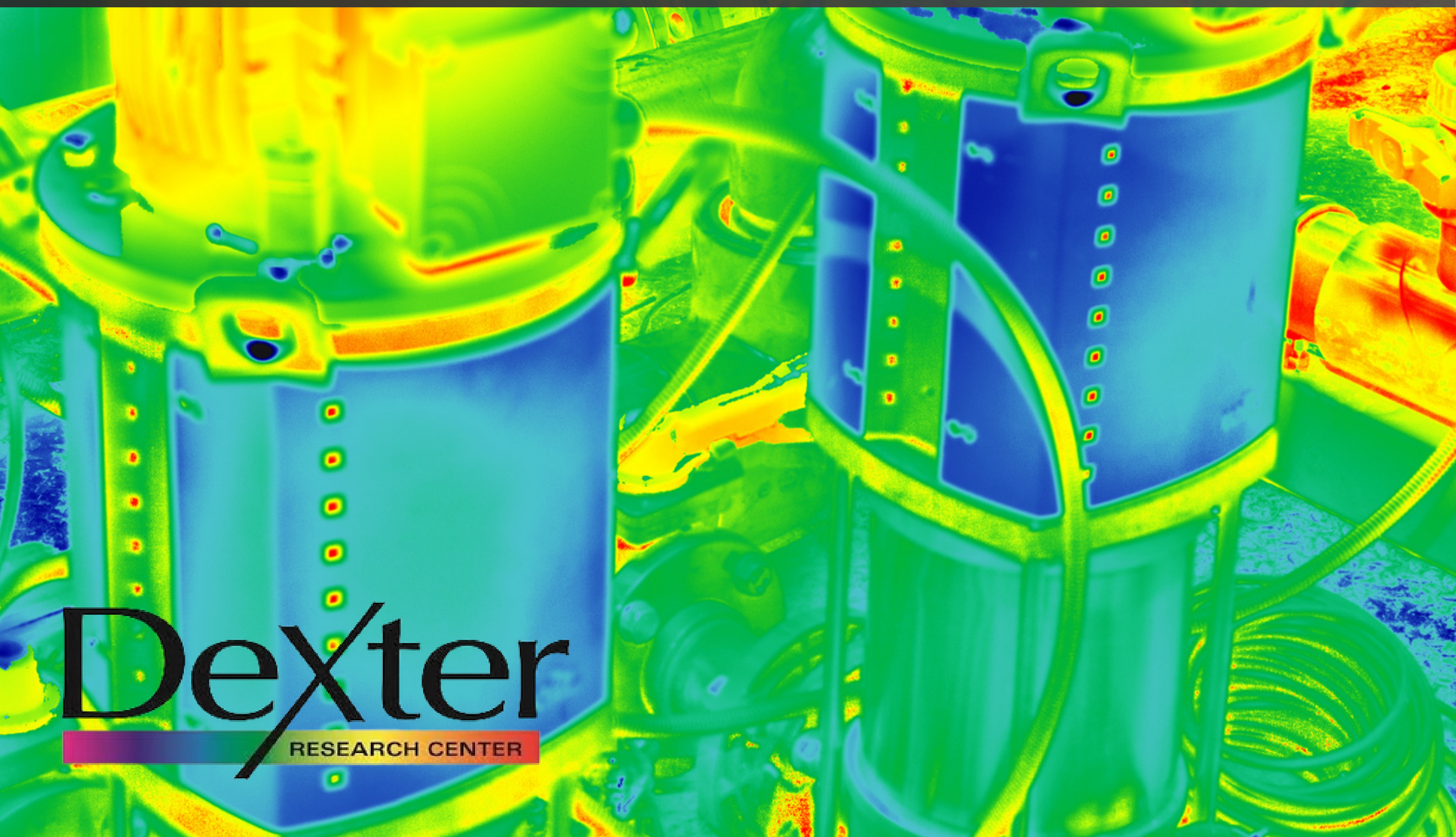


An Introduction to

Thermopile Detectors



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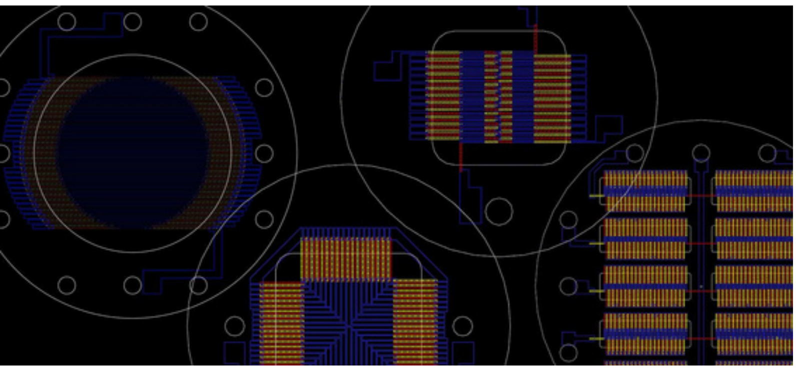
Introduction

Welcome to the fascinating world of thermopile detectors. Since the invention of the first thermopile by Macedonio Melloni in 1830, the field of radiation sensing technology has witnessed an evolution marked by groundbreaking advancements.

In this concise ebook, brought to you by the Dexter Research Center (DRC), we embark on a journey to unravel the intricacies of thermopile detectors, highlighting their various applications, and revealing their pivotal role across diverse industries.

Chapter 1: An Introduction to Thermopile Detectors

Our journey begins with an overview of thermopile detectors. In this chapter, we unpack the fundamental components of thermopiles, explore the different types of detectors, discuss the specialized offerings by DRC, and touch upon some common thermopile applications. In doing so, we lay the groundwork for understanding the core principles behind these remarkable instruments.



Chapter 2: An Overview of Thermopile Detectors

Infrared thermopile detectors represent the pinnacle of technological advancement in temperature measurement. Learn about infrared radiation, the advantages and limitations of thermopiles, as well as the superiority of these devices over other infrared sensors in this incisive chapter.

Chapter 3: Encapsulation Gas in Thermopile Detectors

Delving deeper, we investigate the crucial role of encapsulating gas in optimizing the performance of thermopile detectors. Focusing on key performance parameters for silicon- and thin film-based thermopiles and encapsulation gas calculations for Dexter's models, we break down how encapsulating gas influences the efficiency and reliability of thermopile detectors.

Chapter 4: Determining the Thermopile Time Constant

Unlocking the secrets of thermopile detectors entails mastering the measurement of their time constant. Through various methodologies and practical insights, gain an understanding of how to accurately determine the time constant—a vital aspect in ensuring the precision and effectiveness of thermopile detectors.

Chapter 5: What are Thermophile Detectors Used for?

Venturing into operational principles for thermopile detectors, we then survey their diverse applications across industries. From aerospace processes and automotive workflows to medical diagnostics and solar cell monitoring, uncover the myriad ways thermopile detectors boost efficiency, safety, and precision in numerous domains.

Chapter 6: Thermopile Detectors for Gas Measurement and Analysis

We round our tour of thermopiles by evaluating their application in the specialized domain of gas measurement and analysis. Discover how these detectors assist early warning systems, trace-level detection, and sophisticated gas analysis, revolutionizing industries from environmental monitoring to healthcare. Finally, learn about Dexter's range of customizable detectors designed to meet the diverse needs of modern applications, providing unmatched precision, reliability, and adaptability.

As Dexter Research Center guides you on this enlightening journey through the world of thermopile detectors, prepare to expand your knowledge, gain valuable insights, and uncover the boundless possibilities that these extraordinary devices offer.

FIND OUT MORE

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An Introduction to Thermopile Detectors

A thermopile detector is a passive radiation sensing voltage-generating device. It does not emit any radiation and require cooling or bias. Dexter Research Center (DRC) provides stable, high output radiation sensing thermopile detectors covering linear dynamic range from the UV to long wave IR.

The spectral absorption of DRC detectors is flat from the ultraviolet to the far infrared. Based on target size, radiance and temperature, the output of thermopiles is typically in the range of microvolts to millivolts.

Key Components of Thermopile Detectors

Thermopile detectors consist of an array of thermocouple junctions linked in series as differential pairs. These differential pairs form the hot and cold junctions as shown in Figure 1.

Alternating n-type and p-type materials called ‘Arms’ connect these junctions and generate a Seebeck effect between them. A voltage is generated in proportion to the temperature gradient between the cold and hot junctions.

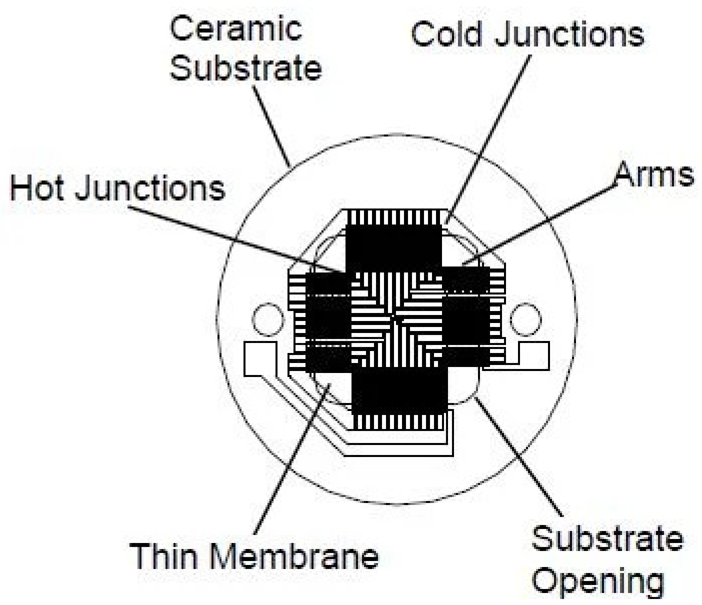

Figure 1. *Key features of the Model 2M Thin Film thermopile detector*

Bismuth and antimony are the arm materials for thin film-based thermopiles. Alternating n-type and p-type poly-silicon or n-type with aluminum or gold are the arm materials for silicon thermopiles. The cold junctions and the detector package are normally thermally connected. These junctions are positioned around the perimeter of the substrate opening.

The hot junctions have a coating of an energy absorber and are positioned in the center of the detector pattern. The detector's active area is defined by these hot junctions, which are thermally isolated from the rest of the package by means of a thin membrane.

It is necessary to know the detector cold junction temperature to perform a radiometrically calibrated measurement with a thermopile detector. This can be done by determining the temperature of the detector package using a thermistor or active device like a LM20 from National Semiconductor.

Most accurate temperature measurements are possible when the thermistor or other device is thermally connected to the detector package and is in the proximity to the detector.

Thermopile detectors have very low noise at the level of a resistor of equal resistance. They generate only the Johnson noise of their resistance and yield a consistent output for DC radiation up to a frequency restricted by the time constant. In addition, they do not require chopper.

DRC Thermopile Detectors

DRC thermopile detectors are in tiny TO-18, TO-5, or TO-8 transistor type packages. The ambient air is removed from the detector package and one of the four encapsulating gases is then filled in prior to hermetically sealing the package. The encapsulating gas presents one of the key thermal paths to dissipate energy from the active area.

DRC detectors have a flat spectral response over the ultraviolet to the far infrared owing to the use of unique energy absorbing materials. The selection of optical band-pass filters decides spectral sensitivity depending on the application of the detector.

Besides having a variety of optical filters and window materials, DRC can customize them depending on the detector application. Internal heatsinks, optional internal apertures, and different options of package aperture sizes are also offered by Dexter Research to address the design requirements of customers.

Types of Thermopile Detectors

Bismuth-Antimony thin-film and Silicon-based detectors are the two types of thermopiles offered by DRC. The resistance and noise voltage of thin film-based thermopiles are lower when compared to silicon-based thermopiles, thus providing a higher signal-to-noise ratio.

The time constant of a thin film thermopile with an output equivalent to a silicon-based thermopile is comparatively slower. The active area of thin film thermopiles is typically large. The following table compares the two types of thermopiles:

Parameter	Thin Film	Silicon
Output Voltage	Higher	Lower
Signal-to-Noise Ratio	Higher	Lower
Temperature Coefficient of $\Re$	-0.36%/°C	-0.04%/°C
Noise Voltage	Lower	Higher
Time Constant	Slower	Faster
Cost	Higher	Lower
Operating Temperature	100°C	125°C*

* Specific configurations to 225°C

An internal compensating element is available in most of the thin film thermopiles and is blinded. It is generally linked in opposition to the active element to reduce the effect of an unexpected change in ambient package temperature.

This temperature compensation is useful for roughly the first few seconds of thermal shock to the detector package. Compensated silicon thermopiles are also available from DRC.

DRC also supplies different kinds of thermopile detector modules with digital output. The company's silicon thermopile detector technology is the cornerstone of its Temperature Sensor Module (TSM) , which consists of an integrated ASIC in the detector package to yield a calibrated digital output for precise non-contact temperature measurements.

Applications of Thermopile Detectors

Thermopile detectors find use in the following applications:

- Non-contact temperature measurements in process control and industrial applications
- Hand-held non-contact temperature measurements
- Thermal line scanners
- Tympanic Thermometers Infrared Radiometry Refrigerant Leak Detection
- Automotive exhaust gas analysis of HC, CO_2 and CO
- Commercial building HVAC and lighting control

- Security human presence and detection
- Black ice detection and early warning
- Blood glucose monitoring
- Horizon sensors for satellites, aircraft, and hobbyist applications
- Medical gas analysis such as blood alcohol breathalyzers, incubator CO and CO_2, and anesthetic
- Automotive occupancy sensing
- Automotive HVAC control
- Aircraft flame and fire detection
- Fire detection in transportation tunnels
- Hazard detection including flame and explosion
- Household appliance temperature measurement

This information has been sourced, reviewed and adapted from materials provided by Dexter Research.

For more information on this source, please visit Dexter Research.

Encapsulation Gas in Thermopile Detectors

Time constant, signal-to-noise ratio (SNR), responsivity and output voltage are the four key performance parameters affected based on the selection of an encapsulating gas in a thermopile detector package.

The effect of the molecular thermal conductivity of gases on the thermal resistance of the detector and package affects the time constant, responsivity and output voltage.

Thermopile model, type of package (resistance weld versus cold weld) and the amount of black absorber are the other factors affecting these performance parameters.

The selection of the encapsulating gas has less impact on these three parameters in the case of silicon-based thermopiles when compared to thin film-based thermopile detectors.

Encapsulation Gas Effect on Silicon- and Thin Film-Based Thermopiles

The specifications presented in the Dexter Research Center (DRC) data sheets are for nitrogen or argon encapsulation gas based on the detector model. The specifications of all “ST” detectors are with nitrogen.

The specifications of all other models are with argon. These parameters vary by the same percentage, approximated by the multipliers presented in Tables 1, 2, and 3, for thin film-based, “S” type silicon-based, “ST” type silicon-based (thick rim) thermopiles, respectively.

As shown in Table 1, the use of encapsulating gas xenon in place argon in a detector package will increase the time constant, responsivity and output voltage by 2.4 times in the case of thin film-based thermopiles. Similarly, the increase in these parameters for “S” type silicon-based thermopiles will be by 1.6 times as shown in Table 2.

Table 1. Output voltage, responsivity, SNR, and time constant multipliers for thin film-based thermopile detectors relative to argon

Thin Film Based Thermopile in Argon (Ar)	
Gas	**Multiplier**
Nitrogen (N2)	.75
Xenon (Xe)	2.4

Neon (Ne)	.4

Table 2. Output voltage, responsivity, SNR, and time constant multipliers for "S" type silicon-based thermopile detectors relative to argon

"S" type Silicon Based Thermopile in Argon (Ar)	
Gas	**Multiplier**
N2	.87
Xe	~1.6
Ne	0.6

Table 3. Output voltage, responsivity, SNR, and time constant multipliers for "ST" type silicon-based thermopile detectors relative to nitrogen

"ST" type Silicon Based Thermopile in Nitrogen (N2)	
Gas	**Multiplier**
Ar	1.1
Xe	1.55
Ne	0.9

Table 2 and 3 are for silicon-based thermopiles, of which "S" type silicon-based models using argon as encapsulating gas are shown in Table 2. The "ST" type silicon-based models with nitrogen (all multi-channel models) as encapsulating gas are presented in Table 3. At present, the LCC package is only offered with nitrogen.

The multipliers shown in the aforementioned tables can differ by more than 25%. This difference is restricted by the fact that if a multiplier is more than 1.0, then it cannot have a value lower than 1.0. Similarly, if a multiplier is below 1.0, then it cannot have a value above 1.0. Argon, neon, xenon and nitrogen are the four standard encapsulating gas options offered by DRC. For each gas, the effect varies based on the type of the detector.

The encapsulation gas calculations for Dexter thermopile detector models are summarized in Table 4.

Table 4. Encapsulation gas calculations for Dexter thermopile detector models

		Argon	
Single-Channel	**Output Voltage (μV)**	**Signal-to-Noise Ratio (Vs/Vn)**	**Time Constant (ms)**
M5	35.0	5,000	28.0

M14	20.0	2,857	14.0
ST60 Micro	59.4	1,896	19.8
ST60 TO-18	66.0	2,108	16.5
ST60 TO-5	68.2	2,179	19.8
ST60 with Lens	324.5	10,368	19.8
1M	60.0	8,571	32.0
1SC Compensated	48.0	3,582	48.0
M34	115.0	10,088	38.0
DR34 Compensated	115.0	7,099	38.0
ST120 TO-5	198.0	5,161	27.5
ST150	253.0	7,228	41.8
ST150 with Lens	357.5	10,215	41.8
DR46 Compensated	210.0	11,602	40.0
2M	250.0	19,531	85.0
3M	440.0	25,581	100.0
6M	370.0	18,317	221.0
Multi-Channel			
ST60 Dual	68.2	2,179	19.8
DR26	54.0	5,684	38.0
DR34	115.0	10,088	38.0
ST120 Dual	181.5	4,731	27.5
ST150 Dual	253.0	7,228	41.8
DR46	210.0	16,406	40.0
T34 Compensated	115.0	7,099	38.0
ST60 Quad	68.2	2,179	19.8
ST120 Quad	154.0	4,014	27.5
ST150 Quad	253.0	7,228	41.8
2M Quad	250.0	19,531	85.0
10 Channel	115.0	10,088	38.0
Single-Channel	**Output Voltage (µV)**	**Nitrogen Signal-to-Noise Ratio (Vs/Vn)**	**Time Constant (ms)**
M5	26.3	3,750	21.0
M14	15.0	2,143	10.5
ST60 Micro	54.0	1,724	18.0
ST60 TO-18	60.0	1,916	15.0
ST60 TO-5	62.0	1,981	18.0

ST60 with Lens	295.0	9,425	18.0
1M	45.0	6,428	24.0
1SC Compensated	36.0	2,687	36.0
M34	86.3	7,566	28.5
DR34 Compensated	86.3	5,324	28.5
ST120 TO-5	180.0	4,692	25.0
ST150	230.0	6,571	38.0
ST150 with Lens	325.0	9,286	38.0
DR46 Compensated	157.5	8,702	30.0
2M	187.5	14,648	63.8
3M	330.0	19,186	75.0
6M	277.5	13,738	165.8
Multi-Channel			
ST60 Dual	62.0	1,981	18.0
DR26	40.5	4,263	28.5
DR34	86.3	7,566	28.5
ST120 Dual	165.0	4,301	25.0
ST150 Dual	230.0	6,571	38.0
DR46	157.5	12,305	30.0
T34 Compensated	86.3	5,324	28.5
ST60 Quad	62.0	1,981	18.0
ST120 Quad	140.0	3,649	25.0
ST150 Quad	230.0	6,571	38.0
2M Quad	187.5	14,648	63.8
10 Channel	86.3	7,566	28.5

Single-Channel	Output Voltage (μV)	Xenon Signal-to-Noise Ratio (Vs/Vn)	Time Constant (ms)
M5	84.0	12,000	67.2
M14	48.0	6,857	33.6
ST60 Micro	83.7	2,672	27.9
ST60 TO-18	93	2,970	23.25
ST60 TO-5	96.1	3,071	27.9
ST60 with Lens	457.2	14,609	27.9
1M	144 .0	20,570	76.8
1SC Compensated	115.2	8,597	115.2
M34	276.0	24,211	91.2

DR34 Compensated	276.0	17,038	91.2
ST120 TO-5	279	7,273	38.75
ST150	356.5	10,185	58.9
ST150 with Lens	503.7	14,393	58.9
DR46 Compensated	504.0	27,845	96.0
2M	600.0	46,874	204.0
3M	1056.	61,394	240.0
6M	888 .0	43,961	530.4
Multi-Channel			
ST60 Dual	96.1	3,071	27.9
DR26	129.6	13,642	91.2
DR34	276.0	24,211	91.2
ST120 Dual	255.7	6,667	38.75
ST150 Dual	356 .5	10,185	58.9
DR46	504.0	39,374	96.0
T34 Compensated	276.0	17,038	91.2
ST60 Quad	96.1	3,071	27.9
ST120 Quad	217	5,656	38.75
ST150 Quad	356.5	10,185	58.9
2M Quad	600.0	46,874	204.0
10 Channel	276.0	24,211	91.2

Single-Channel	Output Voltage (µV)	Neon Signal-to-Noise Ratio (Vs/Vn)	Time Constant (ms)
M5	14.0	2,000	11.2
M14	8.0	1,143	5.6
ST60 Micro	48.6	1,552	16.2
ST60 TO-18	54	1,724	13.5
ST60 TO-5	55.8	1,783	16.2
ST60 with Lens	265.5	8,483	16.2
1M	24.0	3,428	12.8
1SC Compensated	19.2	1,433	19.2
M34	46.0	4,035	15.2
DR34 Compensated	46.0	2,840	15.2
ST120 TO-5	162	4,223	22.5
ST150	207	5,914	34.2

ST150 with Lens	292.5	8,357	34.2
DR46 Compensated	84.0	4,641	16.0
2M	100.0	7,812	34.0
3M	176.0	10,232	40.0
6M	148.0	7,327	88.4
Multi-Channel			
ST60 Dual	55.8	1,783	16.2
DR26	21.6	2,274	15.2
DR34	46.0	4,035	15.2
ST120 Dual	148.5	3,871	22.5
ST150 Dual	207	5,914	34.2
DR46	84.0	6,562	16.0
T34 Compensated	46.0	2,840	15.2
ST60 Quad	55.8	1,783	16.2
ST120 Quad	126	3,284	22.5
ST150 Quad	207	5,914	34.2
2M Quad	100.0	7,812	34.0
10 Channel	46.0	4,035	15.2

Time Constant and Output Voltage Calculations for DRC model 2M

As shown in Table 4, the time constant for the DRC model 2M with argon encapsulating gas is 85ms. The approximate time constant for the model 2M using xenon encapsulating gas can be calculated by multiplying the time constant value of argon by 2.4 (xenon multiplier in Table 1), which gives 204ms.

Similarly, the output voltage of the model 2M with argon encapsulating gas under exposure to 330μW/cm^2 radiation is 250μV (Table 4). By multiplying this value with xenon multiplier of 2.4 given in Table 1, the approximate test stand output voltage can be calculated for the model 2M using xenon as encapsulating gas. The resulting output voltage for the 2M encapsulated with xenon is 600μV.

This information has been sourced, reviewed and adapted from materials provided by Dexter Research.

For more information on this source, please visit Dexter Research.

Determining the Thermopile Time Constant

There are several methods available to determine the time constant of thermopile detectors based on the specific waveform of the radiation utilized in the excitation of the detector. The response of a detector, when it is exposed to a step function of radiation, follows the function $V_t = V_{max} (1-e^{-t/τ})$, of which V_t is the output of the detector at any time t.

The time taken when V_t reaches 63.2% of the maximum static value V_{max} is defined as the time constant (τ) of the thermopile detector.

The frequency response of a thermopile detector when it is exposed to sinusoidally modulated radiation follows the function:

$V_d = V_s [1+(2πτ/T)^2]^{-1/2}$,

Where,

V_d = The dynamic amplitude of the output voltage of the detector at any wave period T

V_s = The static amplitude of the output voltage produced by un-modulated radiation

V_d decreases by 3dB (.707 Vs) from the static value during T_o, which is correlated to the time constant of the thermopile detector by the following expression:

$τ = T_o/kπ$

Here, the value of the coefficient k is 2 for sinusoidally modulated signals. The waveform of chopper-modulated radiation resembles a square wave and the corresponding value of k is 1.124.

Determination of Thermopile Time Constant

For both methods, a red LED can be employed when the thermopile window/filter transmits in the visible spectrum. It is necessary to apply the appropriate coefficient based on the waveform used. At Dexter Research Center (DRC) , the following methods have been used to determine the time constant:

- A square wave modulated red LED is used when the thermopile window/filter transmits in the visible spectrum
- A chopped blackbody is used when the thermopile window/filter does not transmit in the visible spectrum

It is simple and quick to perform direct measurement of the approximate time constant using a modulated signal. The peak-to-peak trace of the DC output of the thermopile detector is adjusted to seven divisions on an oscilloscope utilizing a very slow modulation frequency.

The frequency is increased until the peak-to-peak trace covers five divisions (.707 x 7div. = 4.95div.). This is roughly –3dB of V_{max}. It is then possible to determine the time constant from the wave period or from the frequency by applying the suitable coefficient for the waveform employed.

This information has been sourced, reviewed and adapted from materials provided by Dexter Research.

For more information on this source, please visit Dexter Research.

What are Thermophile Detectors Used for?

Thermopile detectors are used to measure the temperature of distant objects by converting infrared (IR) radiation into an electrical signal. This primary function finds use across various industries and scientific fields, allowing for precise temperature measurement without direct contact with various materials.

Highly sensitive thermopile sensors also exhibit favorable qualities compared to alternative temperature sensor modules in terms of ruggedness and reliability, making them well-suited for demanding and routine applications.

This article will delve into the operational principles of thermopile detectors and the diverse applications they find in numerous industries.

Image Credit: Ivan Smuk/Shutterstock.com

What is the Working Principle of a Thermopile Detector?

Understanding thermopile detectors necessitates a basic comprehension of thermocouple technology. Thermocouples, the most common type of electrical temperature-sensing components, consist of two distinct metal wires joined to form a "hot junction" and a "cold junction."

When the joint is heated or cooled, it generates a subtle voltage (V), also known as the Seebeck voltage, corresponding to temperature changes.

Although there is a proportionality factor to consider, for this article, it suffices to know that the voltage generated is directly linked to temperature differences between the hot and cold junctions.

Thermopile detectors encompass an array of thermocouples interconnected in a series. The fundamental concept is to amplify the impact of each element.

They can be likened to a cluster of miniature thermocouple junctions, similarly separated into hot and cold junctions consisting of alternating n-type and p-type materials, commonly referred to as "arms."

The specific materials used in the arms can vary between different thermopile types. For example, thin film systems often employ antimony and bismuth arms, whereas silicon thermopiles feature alternating n-type and p-type Poly-Silicon or n-type and Gold or Aluminum.

The cold junctions are usually linked to the detector package and positioned around the periphery, while the hot junctions, defining the active area, are situated at the center and coated with an energy absorber.

These hot junctions are suspended on a thin membrane to thermally isolate them from the remainder of the package.

The multiple thermocouples within a thermopile detector are connected in series. This implies that the voltage difference generated by each thermocouple is combined to produce a total voltage output. This total voltage output is directly proportional to the temperature of the measured object.

Given that the Seebeck effect generates a relatively weak signal, thermopile detectors are equipped with voltage amplifiers to ensure the signal's readability by a meter or data acquisition (DAQ) system. Subsequently, a calibration factor or transfer function is applied to convert the signal into a readable temperature measurement.

Applications of Thermopile Detectors

Thermopile detectors have a wide range of applications across various industries due to their precision, stability, and durability. The critical applications of thermopile detectors encompass:

- **Energy:** Thermopile detectors serve in temperature control for boilers and heating systems, as well as in solar panels to monitor panel temperature, ensuring optimal efficiency.
- **Automotive:** These detectors find use in temperature sensing for engines, exhaust systems, and catalytic converters, along with temperature monitoring in electric vehicle battery packs.
- **Aerospace:** In the aerospace sector, thermopile detectors play a role in temperature monitoring for spacecraft and satellites, and they are essential for temperature control in aircraft engines.
- **Medical:** Within the medical field, thermopile detectors contribute to temperature measurement in equipment like infrared thermometers and enable non-invasive body temperature monitoring, such as fever detection.
- **Industrial:** Thermopile detectors are integral for temperature control and monitoring in various industrial processes, including drying, baking, and heat treating, as well as in industrial ovens and furnaces.

Looking for Thermopile Detectors?

Dexter Research Center provides infrared sensing solutions for diverse detection needs. To learn more about thermopile detectors, users can refer to the technical papers section on the M5 Thin Film-based thermopile detector product page for a comprehensive introduction to Thermopile Detectors.

This information has been sourced, reviewed and adapted from materials provided by Dexter Research Center, Inc.

For more information on this source, please visit Dexter Research Center, Inc.

An Overview of Thermopile Detectors

Infrared thermopile detectors are used for temperature measurements without direct contact, relying on an object's infrared (IR) energy. These detectors consist of small sensors called thermocouples, which generate an electric voltage when exposed to IR.

In various industries, infrared thermopile detectors play a crucial role and often serve in industrial manufacturing processes and environmental monitoring. This article introduces infrared thermopile detectors, outlining their benefits and applications.

Image Credit: Ivan Smuk/Shutterstock.com

Understanding Infrared Radiation

Before delving into the operation of IR thermopile detectors, it is essential to grasp the fundamentals of infrared radiation. Infrared radiation is a form of energy characterized by wavelengths longer than visible light but shorter than radio waves, ranging from 780 nm to

1 mm.

Although invisible to the human eye, it manifests as heat. Infrared radiation is emitted by every object, aiding researchers in assessing properties such as heat distribution and temperature fluctuations.

How Infrared Thermopile Detectors Work

Infrared thermopile detectors primarily consist of thermopile sensors based on the Seebeck effect principle. As mentioned, these sensors comprise several thermocouples. Each thermocouple consists of at least two wires made from different metals, with the wires joined at one end to form a junction.

These wires produce a voltage proportional to the temperature gradient across their junctions. This signal can be subsequently amplified, processed, and converted into meaningful temperature data.

Advantages and Limitations of Infrared Thermopile Detectors

Numerous advantages come with using infrared thermopile detectors, including the ability to measure temperature without direct contact, facilitating remote sensing in challenging environments. Their rapid response time allows real-time monitoring, and their heightened sensitivity ensures the detecting of even slight temperature changes.

These detectors can also be sealed hermetically, safeguarding them from environmental factors.

Recognizing Limitations

Despite their remarkable capabilities, infrared thermopile detectors do have certain limitations. They typically operate within a specific spectral range, which can restrict their suitability for particular applications.

Fluctuations in ambient temperature may impact accuracy, necessitating careful calibration and compensation techniques. Evaluating these limitations when choosing an appropriate detection solution is crucial, as they may not be suitable for every application.

Comparison with Other Infrared Detectors

Infrared thermopile detectors offer distinct advantages over other types of infrared sensors, such as bolometers or pyroelectric detectors. Thermopiles provide greater sensitivity, a broader field of view, and enhanced temperature measurement capabilities, making them ideal for various scientific and industrial applications.

Infrared Thermopile Detectors from Dexter Research Center

Dexter Research Center, a pioneer in infrared thermopile detectors since 1977, leads the industry with a comprehensive selection of state-of-the-art thermopiles. The product line comprises high-quality Bismuth-Antimony thin-film and silicon-based thermopile detectors renowned for their exceptional performance and dependability.

Not only does the company offer an extensive range of standard products, but it also specializes in custom thermopile detectors and modules. The company's expertise guarantees tailored solutions for specific application requirements, while its dedication to quality and reliability ensures unmatched performance.

This information has been sourced, reviewed and adapted from materials provided by Dexter Research Center, Inc.

For more information on this source, please visit Dexter Research Center, Inc.

Thermopile Detectors for Gas Measurement and Analysis

Thermopile infrared gas detectors have many applications, from providing early warning systems for trace levels of atmospheric gases to analyzing several gases in an anesthetized patient in the operating room.

Dexter Research Center has a range of highly versatile thermopile detectors developed over forty years that can be custom-designed for each specific application. Thermopile detectors are passive radiation sensing voltage-generating devices, which require no bias or cooling and do not emit any radiation.

Thermopile Infrared Gas Sensors

Infrared (IR) gas detection is a well-established sensing technology. When exposed to infrared light, gas molecules absorb some of its energy and vibrate more vigorously: different gases absorb IR at specific frequencies. The amount of energy absorbed is related to the concentration of the gas, and results in a rise in temperature: the temperature increases in proportion to the concentration of gas present.

A thermopile converts this heat into electrical energy, generating an output voltage which offers information on the levels of gas or gases present. A thermopile is a range of miniature thermocouple junctions connected in series as differential pairs. These differential pairs consist of hot and cold junctions connected by alternating materials called arms, creating a Seebeck effect - where a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference - between the junctions. The voltage produced is proportional to the temperature gradient between the hot and cold junctions.

A Dexter IR gas detector is sensitive to changes in temperature as small as 0.1 °C and can operate between -40 °C to 85 °C without being affected by ambient temperature fluctuations.

Advantages of Thermopile IR Gas Detectors

In IR instruments, only the sample cell and related components are directly exposed to the gas sample stream: gases of interest, including carbon monoxide, carbon dioxide, methane hydrocarbons and refrigerants, are often corrosive and reactive.

In other types of sensor, such as those based on semiconductors, oxidation and catalytic technologies, the sensor itself is directly exposed to the gas, causing the sensor to stop working properly or fail entirely.

IR thermopile gas detectors are sealed against corrosion, making them robust, reliable, stable and long-lasting. And the remain active without a battery or external power source.

Dexter's Design Capabilities

Dexter boasts a family of 20 models of thermopile and over 1,000 individual parts meaning they can be quickly customized based on customer's specific application requirement, whether the quantity is one or one million.

Dexter's detectors are designed in small transistor-type packages and before each package is hermetically sealed, air is removed and the package is backfilled with one of four gases (argon, nitrogen, xenon or neon). This provides one of the key thermal paths for energy loss from the active area and affects four important performance parameters: the output voltage, responsivity, signal-to-noise ratio (a measure of signal strength relative to background noise) and time constant (how quickly charge falls in a circuit). Different backfill gases have different molecular thermal conductivity, and this property affects the thermal resistance of the detector and package, which affects the output voltage, responsivity and time constant. Dexter's four standard gas options have varying effects depending on the type of thermopile.

Dexter offers two distinct types of thermopile detectors with different performance characteristics: thin film-based (based on antimony and bismuth) and silicon-based (poly-silicon or silicon combined with gold or aluminum). Thin film-based thermopiles provide a higher signal-to-noise ratio than silicon-based thermopiles but will have a slower time constant than a silicon-based thermopile with equal output and are available with larger active areas. Silicon models are cheaper, and operate at higher temperatures of 125 °C compared to thin film models, which work best around 100 °C although some silicon models can be configured to work at 225 °C.

Dexter's IR gas sensors can be used in a wide variety of applications, from continuously monitoring combustible, flammable and toxic gases, as well as falling oxygen levels, often as part of a safety system. They can be used as fixed 'open-path' gas detectors which send out a beam of infrared light, detecting gas anywhere along the path of the beam - widely used in the petroleum and petrochemical industries to detect leaks of flammable gases.

Detectors can also be portable and handheld, for example blood alcohol breathalyzers. Detectors can also be used to perform sophisticated gas analysis to monitor the critical levels of gases exhaled by a hospital patient under general anesthetic, or premature babies in incubators for example.

References and Further Reading

1. What are IR gas detectors - Enggcyclopedia
2. Effects of encapsulation gas on thermopile detectors - http://dexterresearch.com/?module=Page&sID=technical-library
3. Introduction to thermopile detectors - http://dexterresearch.com/?module=Page&sID=technical-library and http://dexterresearch.com/?module=Page&sID=gas-analysis

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About

Dexter Research Center, Inc. was founded by Robert Toth, Ph.D in 1977. A leading thin film and materials expert, Bob believed then and now that:

- **No other infrared device outperforms a thermopile as an affordable detector.**
- **There is no substitute for collaboration as a means to optimize infrared detector performance, packaging, reliability and durability to surpass the current benchmarks and beyond our customer expectations.**

Dexter Research offers 31 core thermopile products, more than all global competitors combined, each 100% tested for industry-leading quality. We now provide our customers with a choice from over 500 thermopile configurations, and we have new thermopile detectors coming on-line and new customers using our products around the world.

Strategically and tactically, we're in a great business position, and we're not done improving our products and performance. In particular, Dexter Research has responded to our competitors with new aggressive marketing and pricing strategies.

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