Application Brief 7: Effects of Encapsulation Gas on Thermopile Detectors

The selection of encapsulating gas in a thermopile detector package affects four important performance parameters: the output voltage, Responsivity, Signal-to-Noise Ratio (SNR) and time constant. Different gases have different molecular thermal conductivity. The molecular thermal conductivity affects the thermal resistance of the detector and package, thereby affecting the output voltage, Responsivity, and time constant. Please note that there are other factors that affect these parameters such as: amount of black absorber, type of package (cold weld vs. resistance weld), and thermopile model. The effect of the encapsulating gas on these three parameters is less with Silicon Based Thermopiles than Thin Film Based Thermopile Detectors.

The specifications shown on the Dexter Research Center data sheets are for Argon or Nitrogen encapsulation gas depending on detector model. All "ST" detector specifications as well as the SLA32 are with Nitrogen, all others are with Argon (see individual data sheets for encapsulation gas specified). These parameters change by the same percentage, approximated by the Multipliers shown in Tables 1, 2, and 3, for Thin Film Based, "S" type Silicon Based, and "ST" type Silicon Based (thick rim) thermopiles respectively. For example, when a detector package is encapsulated with Xenon instead of Argon, the output voltage, Responsivity, and time constant will increase by 2.4 times for Thin Film Based Thermopiles (see Table 1 below). Where as these parameters would increase 1.6 times for "S" type Silicon Based Thermopiles (see Table 2 below). See Table 4 for the backfill gas calculations for all of our detector models.

Dexter Research Center (DRC) offers four standard encapsulating gas options: Argon, Nitrogen, Xenon, and Neon. The effect varies for each gas depending on whether it is a Thin Film, "S" type Silicon Based, or "ST" type Silicon Based Thermopile Detector. The tables below show an <u>approximation</u> of the encapsulating gas factor (Multiplier) for these three groups of thermopile detectors. The Multipliers below can vary by more than 25%. This variation is limited by the fact that if a Multiplier is greater than 1.0, then the multiplier can not go below 1.0 and if a Multiplier is less than 1.0, then the multiplier can not go above 1.0.

Thin Film Based Thermopile in Argon (Ar)	
Gas	Multiplier
Nitrogen (N_2)	.75
Xenon (Xe)	2.4
Neon (Ne)	.4

Table 1: Output voltage, Responsivity, SNR, and time constant Multipliers for Thin Film Based Thermopile detectors relative to Argon.

Two tables for Silicon Based Thermopiles are shown below: Table 2 is for "S" type Silicon Based models with data sheets using Argon (model S25, and S60M).

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Table 3 is for "ST" type Silicon Based models with data sheets using Nitrogen (this includes all multi-channel models). Currently, the SLA32 and the LCC packages are only available with N_2 encapsulating gas.

"S" type Silicon Based Thermopile in Argon (Ar)	
Gas	Multiplier
N_2	.87
Xe	~1.6
Ne	0.6

Table 2: Output voltage, Responsivity, SNR, and time constant Multipliers for "S" type Silicon Based Thermopile detectors relative to Argon.

"ST" type Silicon Based Thermopile in Nitrogen (N_2)	
Gas	Multiplier
Ar	1.1
Xe	1.55
Ne	0.9

Table 3: Output voltage, Responsivity, SNR, and time constant Multipliers for "ST" type Silicon Based Thermopile detectors relative to Nitrogen.

Table 4 below, shows the encapsulation gas calculations for our thermopile detector models.

2M Time Constant Example

As an example of how the above encapsulating gas Multipliers work, take the DRC model 2M. From the DRC data sheet for the 2M, the time constant is 85ms when encapsulated with Argon gas.

To calculate the approximate time constant in Xenon, multiply the Argon time constant of 85ms by the Ar to Xe Multiplier of 2.4 (see Table 1) which gives 85ms x 2.4 = 204ms.

Therefore, by encapsulating the model 2M with Xe, the time constant is approximately 204ms instead of 85ms for Ar.

2M Output Voltage Example

The same holds true for the output voltage. From the DRC data sheet for the model 2M, the output voltage is 250μV when exposed to 330μW/cm^2 radiation and encapsulated with Argon.

To calculate the approximate test stand output voltage for the 2M encapsulated with Xenon, multiply the voltage of 250μV by the Ar to Xe Multiplier of 2.4 (see Table 1) which gives 250μV x 2.4 = 600μV.

Therefore, by encapsulating the model 2M with Xe, the test stand output voltage is approximately 600μV instead of 250μV for Ar.

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Single-Channel	Argon			Nitrogen			Xenon			Neon		
	Output Voltage (µV)	Signal-to-Noise Ratio (Vs/Vn)	Time Constant (ms)	Output Voltage (µV)	Signal-to-Noise Ratio (Vs/Vn)	Time Constant (ms)	Output Voltage (µV)	Signal-to-Noise Ratio (Vs/Vn)	Time Constant (ms)	Output Voltage (µV)	Signal-to-Noise Ratio (Vs/Vn)	Time Constant (ms)
S25 TO-18	23.0	1,186	16.0	20.0	1,032	13.9	36.8	1,898	25.6	13.8	712	9.6
S25 TO-5	40.0	2,062	18.0	34.8	1,794	15.7	64.0	3,299	28.8	24.0	1,237	10.8
M5	35.0	5,000	28.0	26.3	3,750	21.0	84.0	12,000	67.2	14.0	2,000	11.2
S60M TO-18	89.0	2,320	18.0	77.4	2,018	15.7	142.4	3,712	28.8	53.4	1,392	10.8
S60M TO-5	120.0	3,125	27.0	104.4	2,719	23.5	192.0	5,000	43.2	72.0	1,875	16.2
M14	20.0	2,857	14.0	15.0	2,143	10.5	48.0	6,857	33.6	8.0	1,143	5.6
ST60 Micro	59.4	1,896	19.8	54.0	1,724	18.0	83.7	2,672	27.9	48.6	1,552	16.2
ST60 TO-18	66.0	2,108	16.5	60.0	1,916	15.0	93	2,970	23.25	54	1,724	13.5
ST60 TO-5	68.2	2,179	19.8	62.0	1,981	18.0	96.1	3,071	27.9	55.8	1,783	16.2
ST60 with Lens	324.5	10,368	19.8	295.0	9,425	18.0	457.2	14,609	27.9	265.5	8,483	16.2
1M	60.0	8,571	32.0	45.0	6,428	24.0	144.0	20,570	76.8	24.0	3,428	12.8
1SC Compensated	48.0	3,582	48.0	36.0	2,687	36.0	115.2	8,597	115.2	19.2	1,433	19.2
M34	115.0	10,088	38.0	86.3	7,566	28.5	276.0	24,211	91.2	46.0	4,035	15.2
DR34 Compensated	115.0	7,099	38.0	86.3	5,324	28.5	276.0	17,038	91.2	46.0	2,840	15.2
ST120 TO-5	198.0	5,161	27.5	180.0	4,692	25.0	279	7,273	38.75	162	4,223	22.5
ST150	253.0	7,228	41.8	230.0	6,571	38.0	356.5	10,185	58.9	207	5,914	34.2
ST150 with Lens	357.5	10,215	41.8	325.0	9,286	38.0	503.7	14,393	58.9	292.5	8,357	34.2
DR46 Compensated	210.0	11,602	40.0	157.5	8,702	30.0	504.0	27,845	96.0	84.0	4,641	16.0
2M	250.0	19,531	85.0	187.5	14,648	63.8	600.0	46,874	204.0	100.0	7,812	34.0
3M	440.0	25,581	100.0	330.0	19,186	75.0	1056.	61,394	240.0	176.0	10,232	40.0
6M	370.0	18,317	221.0	277.5	13,738	165.8	888.0	43,961	530.4	148.0	7,327	88.4
Multi-Channel												
ST60 Dual	68.2	2,179	19.8	62.0	1,981	18.0	96.1	3,071	27.9	55.8	1,783	16.2
DR26	54.0	5,684	38.0	40.5	4,263	28.5	129.6	13,642	91.2	21.6	2,274	15.2
DR34	115.0	10,088	38.0	86.3	7,566	28.5	276.0	24,211	91.2	46.0	4,035	15.2
ST120 Dual	181.5	4,731	27.5	165.0	4,301	25.0	255.7	6,667	38.75	148.5	3,871	22.5
ST150 Dual	253.0	7,228	41.8	230.0	6,571	38.0	356.5	10,185	58.9	207	5,914	34.2
DR46	210.0	16,406	40.0	157.5	12,305	30.0	504.0	39,374	96.0	84.0	6,562	16.0
T34 Compensated	115.0	7,099	38.0	86.3	5,324	28.5	276.0	17,038	91.2	46.0	2,840	15.2
ST60 Quad	68.2	2,179	19.8	62.0	1,981	18.0	96.1	3,071	27.9	55.8	1,783	16.2
ST120 Quad	154.0	4,014	27.5	140.0	3,649	25.0	217	5,656	38.75	126	3,284	22.5
ST150 Quad	253.0	7,228	41.8	230.0	6,571	38.0	356.5	10,185	58.9	207	5,914	34.2
2M Quad	250.0	19,531	85.0	187.5	14,648	63.8	600.0	46,874	204.0	100.0	7,812	34.0
10 Channel	115.0	10,088	38.0	86.3	7,566	28.5	276.0	24,211	91.2	46.0	4,035	15.2

LCC package, SLA32: Available with Nitrogen gas only