MANUAL
FOR USING
GMCH LLC
THERMALLY SENSITIVE DIE

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Introduction

GMCH LLC has developed two families of test chips for use in measuring thermal resistance. The chips are used whether measuring thermal resistance junction to case (0jc) or junction to ambient (0ja). The chips are made in different sizes to allow a choice that will approximate active die sizes being produced.

Thermal resistance data is sensitive to a great number of variables. Typically, questions arise when speaking with others in the semiconductor industry as to the location of the temperature sensor, attachment method, and validity of the data obtained. That is part of the reason GMCH LLC has chosen to generate two specialized families of chips for thermal testing. The goal is to reduce the variability in data gathered while remaining as flexible as practical. No separate temperature sensor such as a thermocouple is required. Therefore, the location and mounting technique of the sensor is not a variable. Yet the chip may be mounted to a wide variety of test vehicles by many means. Thus, it is the test vehicle, means of attachment, or both which influences the data. In this way, the test chip may be thought of as a process monitor. The data reflects the die attach influence, or lead frame material influence, or any number of factors and combination of factors.

The next section deals with the basis of how the GMCH LLC thermal chips work.

Test Chip Basic Theory

The temperature dependency of diodes is well known. The forward current through a diode may be equated to raising e to a power expressed as the product of constant times the ratio of the forward voltage to the temperature. Thus, the diode equation is expressed as:

$$I = Vq/kT$$

Where: I = Forward Current
V = Forward Voltage
k = 1.38 E-23 Joules/Deg K
q = 1.6 E-19 Coulombs
T = Absolute Temperature

Because it is relatively easy to measure the forward voltage and forward current, temperature T can be easily calculated. It turns out that a diode's forward voltage drops 2 mV/Deg C of rise.

The predictable thermal response of the diode is widely used in the semiconductor industry. However, the exact use of the thermal response of the diode varies widely. GMCH LLC has chosen two slightly different uses of diode thermal response as the basis for two families of thermal test chips. The details of each use are given in succeeding chapters.

Bridge Chip

In the previous chapter, it was established that the thermal response of a diode is a decrease in the forward voltage drop by 2 mV for each degree C rise. The equation expressing the relationship between voltage, current and temperature was given. Assume a circuit can be manufactured which will have two diodes at the same temperature but one conducting ten times the forward current of the other. The diode equation still applies to both diodes. The expression of that equation solving for forward voltage is:

$$V = (kT)/q*\ln I$$

By simultaneous solution of this equation for the difference in forward voltage (ΔV) where the current in one circuit is ten times (10*I) that of the other, the thermal response is:

$$\frac{\Delta V}{\Delta T} = 2 \text{ mV/Degree C}$$

A bridge configuration containing two diodes and two resistors will produce this set of conditions so long as the resistors are fabricated in a 10:1 ratio. Figure 1 shows the arrangement of such a bridge. Using one diode rather than the bridge would require the use of a precision constant current source for the forward current component. The bridge also has the advantage of providing good electrical noise immunity. The Temp family of chips at GMCH LLC goes further by placing the diode legs of this circuit in three locations on each chip. If the chip is isothermal, all three networks will read the same temperature. If not, a means of detection and measurement is provided.

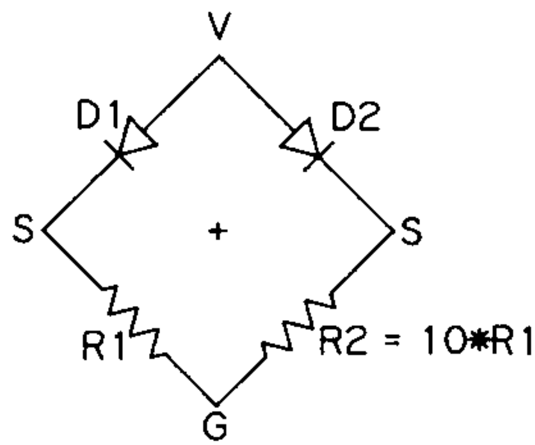


Fig 1. DIODE BRIDGE ARRANGEMENT

Figure 2 shows the layout of the Temp chip. The V1 connection goes to a diode pair located at the center of the chip. The V2 connection goes to a diode pair located at the center of one edge of the chip. The V3 connection goes to a diode pair located in one corner of the chip. Any or all three can be used depending on need and monitoring equipment capability.

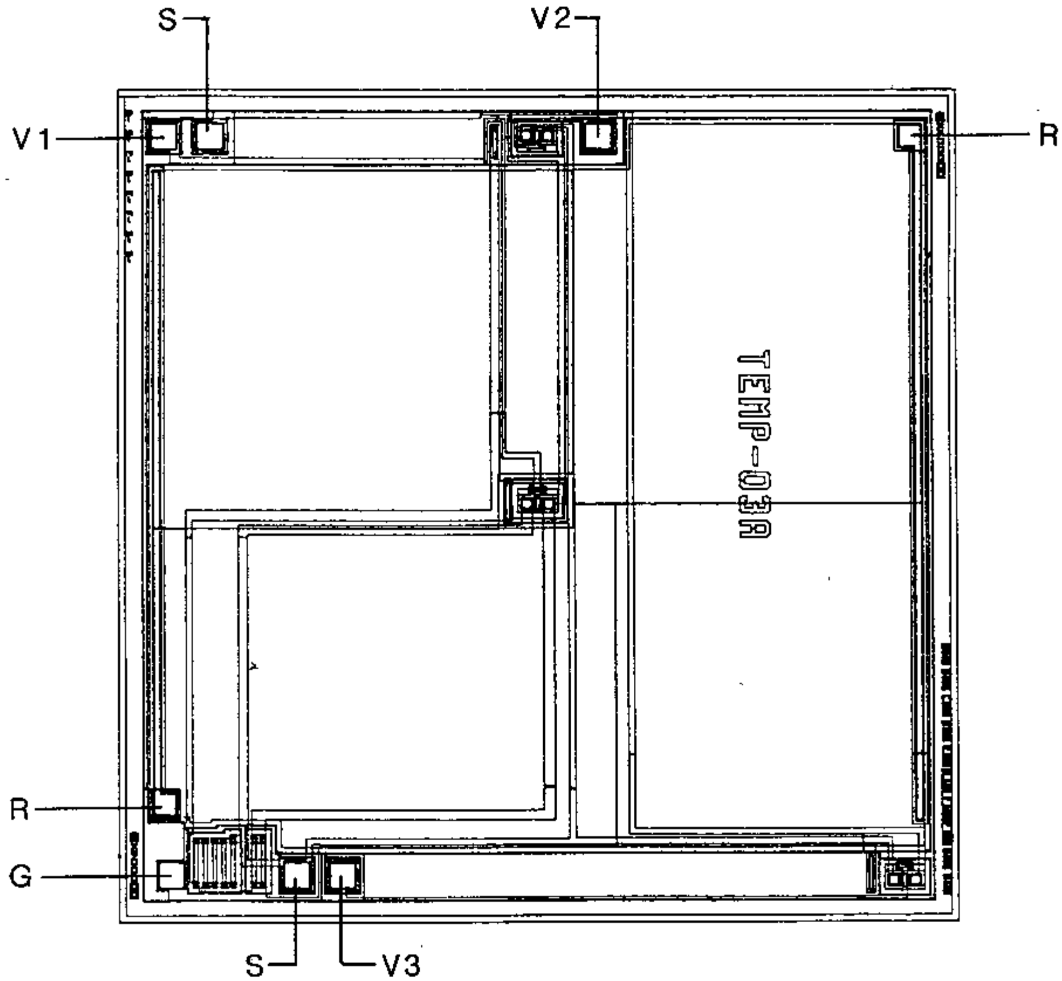


Fig 2. TEMP CHIP LAYOUT

No mention has been made yet of the connections labeled R1 and R2. Figure 3 is a more accurate representation of the circuitry actually contained on a Temp chip. In every case at GMCH LLC, thermal response results are most meaningful when expressed as the temperature rise in C as a function of power dissipated in Watts. The function of R1-R2 is to provide that power to be dissipated. If the initial state (no power being dissipated) is established, then any temperature rise detected when power is supplied much is the direct result of that power. The temperature rise will directly reflect the flow of heat in the system of packaging, mounting or environment. That is, the more easily that heat flows away, the lower the temperature rise of the silicon surface will be for any given power level. If the temperature rise and power generating the rise is measured, the thermal resistance for that particular set of conditions can be calculated. The resulting rise in temperature is simply divided by the power in Watts that produced the rise. Note that neither the initial temperature nor the final temperature were measured or calculated. Only the difference in the two states was measured as the initial temperature is assumed to be equivalent to ambient.

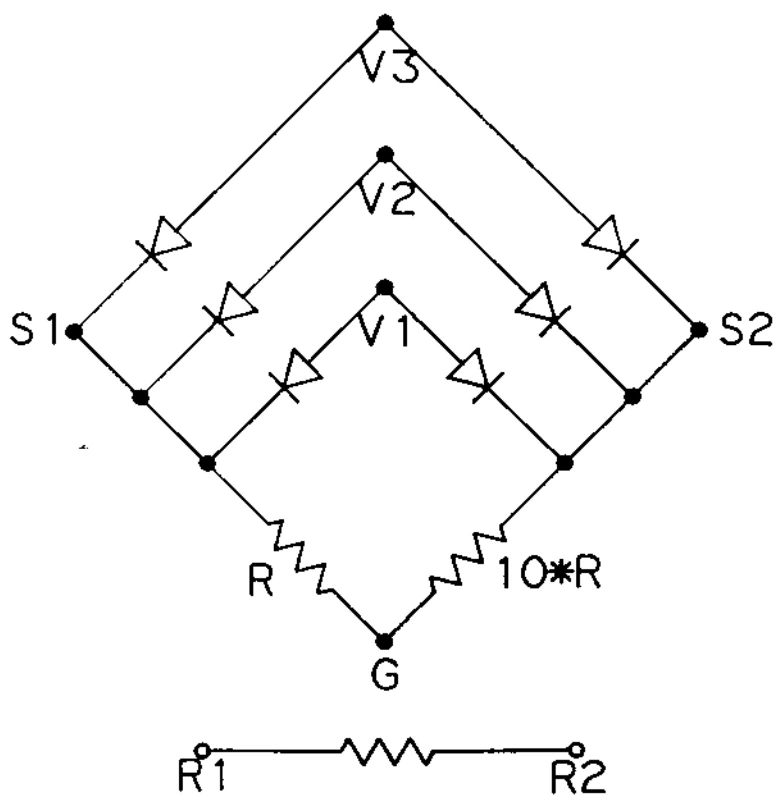


Fig. 3 Temp Chip Circuit

This approach will work whether the junction to case or junction to ambient thermal resistance is desired. Testing specifics are covered in the next chapter. The chip functions the same whether it is operating in still or moving air. The chip works the same whether it is operating in room conditions or an elevated temperature environment such as an oven. This circuit simply measures the surfaces (diode location) die temperature rise when power is dissipated.

Using the Bridge Chip

The thermal chip using two diodes with two resistors in a bridge arrangement as shown in Figure 1 in the proceeding chapter can be used to measure thermal resistance.

	Physical Size	Area
Temp01	.050 x .050	.0025 sq. in

Table 1 Temp Chip Die Sizes

Since each thermal measurement is a record of a unique set of parameters, the cardinal rule for thermal testing more than one sample is: DO EVERYTHING THE SAME, as much as practical for each part in a group from assembly through testing. The number of variables is controlled in this way. Otherwise, the data gathered will have little relevance. It is imperative to keep in mind that little differences in method of assembly, processing or testing can produce unpredictable difference in resulting data.

After the test die and processes are chosen, assemble a relevant number of samples. At GMCH LLC, a group size of 25 data points is considered to be the minimum to give statistically meaningful results. Control the assembly process as much as needed in order to avoid introducing new variables or eliminating the normal variables from the processes being investigated. Since the samples are always built as a "special" group, this is more difficult than would first appear.

Before wirebonding, you may want to choose which of the diode sites to monitor. Unused or unwanted sites need not be wirebonded. Bonds must be made to R1, R2, G, S1, S2 and the appropriate V sites. If the temperature rise at the center of the chip is to be monitored, bond to V1. If the temperature rise at the middle of one side is to be monitored, bond V2. If the temperature rise in a corner is to be monitored, bond V3. There will be a minimum of six wires to a maximum of eight. Bond all the parts of a group with the same pond pattern and records that pattern somewhere. Knowing the wirebond pattern saves much time and frustration later.

It was established in the proceeding chapter that the thermal response is measured by monitoring the change in the forward diode voltage before and during the dissipation of power by the buried resistor R1-R2. To achieve this, the Diode Bridge must be biased to get a forward voltage to measure. Attaching a 5V supply to the V and G contacts with the positive pole connected to V does this. A voltmeter capable of reading millivolts must be connected across S1-S2. A negative reading indicates that the voltmeter polarity is backwards. Simply switch the leads going to S1 and S2. A properly functioning and connected diode bridge will read approximately 59 millivolts forward voltage drop at room temperature. Readings below 56 or above 62 millivolts indicate the bridge is probably faulty and should be discarded. The power to R1-R2 is supplied by a second power supply. The output of this supply needs to be variable if the power is to be controlled or varied. Half-watt power dissipation will require approximately 3.5 volts drawing 160 milliamps. In order to monitor the power being dissipated, a voltmeter and ammeter must be connected to this second supply. Assuming adequate range capability and a means of switching, the same voltmeter can be used for measuring R1-R2 and S1-S2. A schematic representation of this setup is given in Figure 4.

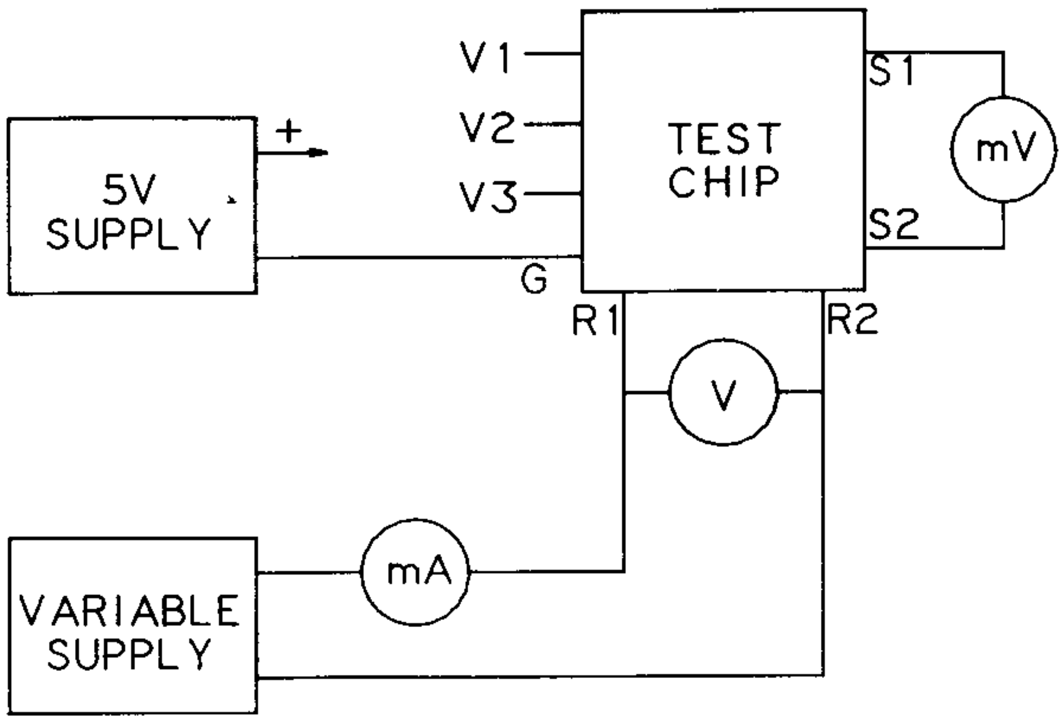


Figure 4 Test Set Up Schematic

The fixturing required for the testing depends on the device being tested and conditions being monitored. The figure should hold the device under test in a stable and repeatable manner. Simultaneously, the fixture should make it easy to connect wires to the two power supplies, ammeter and voltmeter(s). If the test is to be done in still air, an enclosure of proper size is needed. If the data is to be gathered in moving air, a source of moving air and equipment to control and measure air movement must be obtained. Testing in still air to obtain junction to ambient data usually involved the least fixturing. Gathering junction to case data is more difficult from the fixturing perspective. The way junction to case data is collected at GMCH LLC requires the use of a temperature controlled "infinite" heat sink. The device under test must be attached to the sink well enough to insure that the package remains at the sink temperature. The use of thermal grease between device and heat sink aids this. Making electrical connections is normally more difficult. The leads are not normally situated in a manner that lends itself to the situation. It may be necessary to bend the leads in some different than normal configuration for connection. Whatever the approach, it is usually best to determine the fixturing needs before producing the parts, especially if junction to case data is desired.

A. Junction to Ambient

It is possible to gather the thermal data from Temp chips manually. Following is a brief description of a method of measuring thermal resistance using the Temp chips.

The equipment required includes:

- An enclosure
- Socket or fixture
- 5 volt power supply
- Milliammeter
- Millivoltmeter
- Voltmeter
- Adjustable power supply for heating resistor

The record of the wirebond pattern mentioned earlier is useful at this point. It is necessary to identify contacts on the test device for proper connection. If no record was made or has been lost, X-ray sometimes speeds the identification process. Wire the socket or fixture to allow connection to R1, R2, S1, S2, G and the desired V contact(s).

Remember that the socket may act as a heat sink or a heat spreader. In order to insure the worst case condition is monitored, DIP's are not allowed to contact the socket with their molded body. In observance of the axiom DO EVERYTHING THE SAME, each DIP is gapped off the socket by means of a 42 gauge (.017 diameter) wire. The wire is removed before testing.

Connect the heating resistor power supply through the milliammeter to R1 and R2. The voltmeter also goes across R1 and R2. By multiplying the voltage read across R1-R2 by the ammeter reading, the power dissipation in watts is obtained.

Connect the 5-volt supply to G and the chosen V with the negative side of G. If more than one V site is desired, it will be necessary to connect to each V site one at a time. Simultaneous connections of V sites will cause the readings at S1 and S2 to be unusable. The millivoltmeter connects to S1 and S2. With the 5 volt supply connected and turned on, the voltmeter should read approximately 59 millivolts. If the reading is negative, reverse leads S1 and S2. IF the reading at room temperature is more than 52 or less than 56 millivolts, discard the device. (This assumes the power supply to the heating resistor is turned off.)

Prior to testing, the power dissipation level should have been established. For most applications at GMCH LLC, data gathered for junction to ambient at a half-watt dissipation has proven useful. The resistor power supply should be used to determine what voltage is needed across R1 and R2 to produce approximately the power desired. Then, turn down the voltage to 0 volts. If the supply will not go to zero, it will be necessary to turn the supply off. It is imperative that NO voltage be applied across R1 and R2 while initial conditions are measured and recorded. It will be noticed that the reading conditions are measured and recorded. It will be noticed that the reading across S1 and S2 will decrease for some time when the 5 volts is first applied at V-6. Monitor the voltage until the reading stabilizes. Due to noise, the reading never settles to one reading. It does quit drifting through after approximately twenty minutes typically. Taking initial data before the drifting has settled will result in an error in the data. After the Diode Bridge (measured across S1 and S2) has stabilized, record the millivolts reading. Turn on the power supply to apply voltage to the heating resistor, R1 and R2. Turn up the voltage until the power being dissipated is at or near the desired level. For a half-watt dissipation, the voltage level is typically near 3.5 volts. For a properly connected and functioning device there will be a rapid increase in the millivolts reading across the bridge.

Wait for the bridge to stabilize. The definition of "stable" used at GMCH LLC results in the testing taking between twenty and thirty minutes. Stable conditions are defined currently at GMCH LLC as a change of less than three-hundredths of millivolts (.00003 V) in a two-minute interval. The part must maintain this stability for four intervals or eight minutes. This calculates out to a temperature change of 0.15 Degrees C. A noisy setup can make it impossible to achieve such stable readings. A less demanding definition of stable conditions will result in a corresponding lessening of test time. The users will have to decide what definition of stable is adequate for his or her setup and needs. Once the stable condition is reached, record the readings from the milliammeter, voltmeter across R1 and R2, and millivoltmeter across S1 and S2. Then turn down and off the heating resistor power supply. The part can now be removed and another part placed in the fixture to stabilize.

To analyze the data, calculate the power dissipated by multiplying V (voltage reading of R1-R2) * I (variable supply for R1*R2). The temperature rise is calculated by subtracting the initial diode reading from the final diode reading. Divide the result by .2 to get the temperature rise of the junction in Degrees C. Divide the temperature rise by the power dissipated to get the thermal resistance in Degrees C per watt.

The foregoing deals with junction to ambient thermal resistance. Junction to case thermal resistance is quite similar. There are enough subtle differences that gather junction to case data will be treated separately.

B. Junction to Case

Gathering data for junction to case is quite similar to gathering data for junction to ambient as just covered in the preceding paragraphs. The connections and mechanics are identical. Most differences are physical.

There are several ways to gather junction to case data. Many people monitor the case temperature by means of an externally attached thermocouple. Then the measured case temperature rise is subtracted from the data gathered as junction to ambient and described previously. The drawback to this method is the need to attach a thermocouple to the case. Frequently, the location and method of attachment of the thermocouple generates disagreement.

One of the reasons for making the GMCH LLC Temp family of chips was to avoid the need for using thermocouples. By mounting a test device containing a temp chip on an infinite heat sink to force the case temperature to remain constant, it is not necessary to measure the case temperature. The infinite heat sink used at GMCH LLC is a large copper block with water flowing through it. The water is held at a constant temperature slightly above ambient by means of a circulating water bath. This insures very good temperature control. The stability of the heat sink temperature needs to be taken into account when defining the point at which a test device is considered to be stable. Experience has shown that is difficult to gather data when the block temperature swings more than the definition for stability!

One drawback to the infinite heat sink method is problems of attachment. In an effort to insure that the case is held to the sink temperature, thermal grease is applied to that portion of the case contacting the heat sink. The mess from the grease adds to the difficulty of making electrical connection to the device. The device is rarely designed to be mounted to a large copper block; accommodations are usually required to make the electrical connections. It may be necessary to bend the leads in a manner other than normal.

Junction to case testing on an infinite heat sink results in a lower temperature rise at the junction. It is usually necessary to significantly increase the power dissipation level in order to get a meaningful temperature rise at the junction. A power device recently tested shows the magnitude of this statement. A device tested at a half-watt dissipation in the junction to ambient mode had a temperature rise at the junction of 26 Degrees C. That same part attached to a 30 Degree C heat sink exhibited only a 5 Degree C rise at the junction while dissipating three watts.

The point is that power dissipation targets and power supply requirements for junction to case measurements are greater than for junction to ambient.

It will be observed while making junction to case measurements that it takes less time to stabilize the readings to the same definition of stable as junction to ambient. Typically, at GMCH LLC, junction to case measurements take ten to fourteen minutes to stabilize to the same three-hundredths of a millivolts reading within a two minute span for four consecutive intervals. Also, it takes less time for the part to stabilize initially when the 5 volts is applied to the bridge. In fact, if lying on the copper block ahead of time preconditions the parts, there will be no drift observed in the bridge when the 5 volts is applied.

In order to measure junction to case thermal resistance in the manner used at GMCH LLC, the following is needed:

Thermal grease
Heat sink
Circulating water bath
Meters and supplies from junction to ambient list

The data is gathered in exactly the same manner for junction to case as junction to ambient.

5 SERIES DIODE TEMPERATURE SENSING

It was established in the second chapter that the forward voltage decreases 2 mV/Deg C of rise for a diode. The Temp family of test chips built upon this fact by using a bridge arrangement to increase noise rejection and avoid the need for a constant current source. The resulting sensitivity was .2 mV/Deg C rise. This required very sensitive test equipment. Also, a minimum of six connections is required to use the bridge in this manner.

The temperature-sensing portion of the PST family of chips consists of five diodes connected serially and located in the center of the die. Because of the serial connection, the temperature sensitivity is 10 mV/Deg C. Such a large response makes temperature monitoring easy. Figure 5 shows the layout of the chip functionally. Figure 6 shows the layout graphically. The reason that there are four S and four R contacts where two of each would be sufficient are to allow the use of Kelvin contacts for parameter measurements. Experience has shown that the runners going to test devices particularly thick film palladium-silver on alumina can cause significant errors unless Kelvin measurements are made. Runner resistance on the substrate can easily exceed the resistance value on the chip.

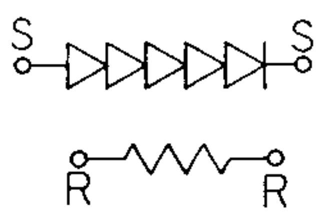


Fig. 5 SERIES DIODE CIRCUIT

As with the Temp chips outlined in the Bridge Chip chapter, we have a temperature sensitive circuit and a means of providing power for dissipation. The next chapter deals with how to use this family of chips.

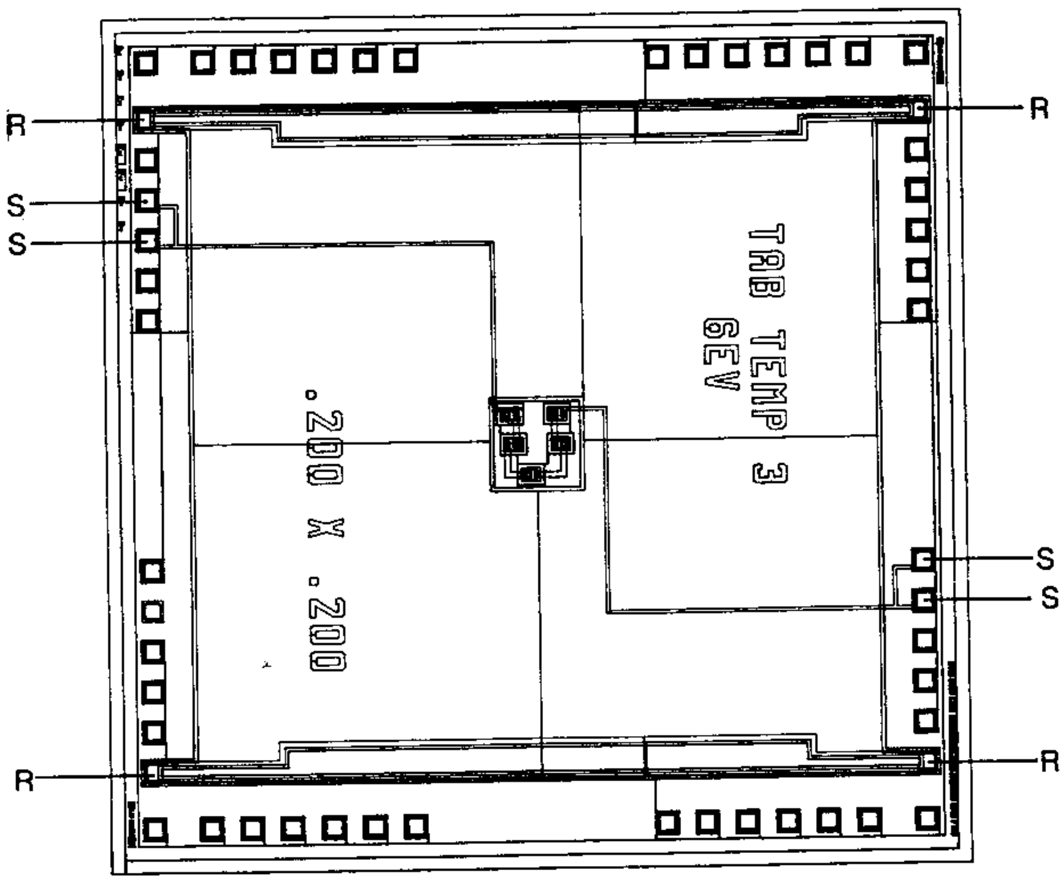


Fig 6. Tab temp chip layout

USING THE SERIES CHIP

The use of the TAB Temp chips making use of the series diodes is similar to the use of the bridge chip covered previously. One major difference is the requirement for a constant current source in place of the 5-volt supply used on Temp chips. The constant current supply should be capable of providing 500 microamps of current to the series diodes. The forward voltage drop across S terminals will be on the order of 3.5 volts. Temperature response will be 10 mV/Deg C as indicated in the preceding chapter.

Everything covered in the USING THE BRIDGE CHIP chapter with regard to producing parts and fixturing applies when using TAB Temp chips. It is no fewer imperatives to control the variables throughout the process when producing samples with TAB Temp chips. The same care and concerns apply to fixturing.

Connect the constant current supply to S connections on opposite sides of the chip. If the polarity is reversed, the power supply will indicate an open condition. Reverse the leads. If the supply indicates an open circuit with both methods of connection, either the die is bad or the S contacts are not being contacted. Once the polarity is established, there should be no need to change for the duration of the testing. That assumes that the cardinal rule of thermal testing has been observed: DO EVERYTHING THE SAME. The remaining two S contacts may be used to make Kelvin measurements of the forward voltage on the diodes.

Connect the heating resistor power supply to two R contacts. Make certain the contacts used are on opposite ends across the resistor. This results in a short when the power supply is turned on. The power supply should be connected through the ammeter to monitor current draw. The other R contacts may be used to make Kelvin measurements of the voltage across the resistor. These two numbers result in the power dissipation when multiplied together.

A. Put the device in the proper fixture making certain that the device does not touch the fixture anywhere but the leads. A 42 gauge (.017 diameter) wire is used for standardizing the gap of part body to fixture at GMCH LLC.

Take the initial reading of the diode voltage. There must be NO power to the resistor during or immediately preceding this reading. In other words, take care to get stable initial conditions then power the resistor to the proper voltage to dissipate the desired power. When the system comes to steady state, read the hot diode voltage. Again, the definition of stability is somewhat subjective. The definition used at GMCH LLC is NOT more than one millivolts (.001 volt) change in a two minute interval for four consecutive intervals Recalling that the sensitivity is 10 mV/Deg C, this means the device is stable within .1 Deg C each two minutes for eight minutes. The test time to achieve this stability is twenty to twenty-six minutes. The choice of a tight definition for stability reflects the trade off of measuring capability, noise rejection, and total test time.

The rise in junction temperature is calculated by subtracting the hot diode voltage from the initial diode voltage and dividing the result by 10 mV/Deg C. The power is calculated by multiplying the current drawn by the resistor by the voltage across the resistor. Thermal resistance can then be calculated by dividing the temperature rise by the power dissipated.

B. Junction to Case

The method of collecting junction to case data at GMCH LLC requires the device to be attached to an infinite heat sink. The purpose of the sink is to force the case temperature to remain constant during testing. One way to do this is to circulate temperature-controlled water through the sink. A circulating water bath set slightly above room temperature does this well. The device should be in good thermal contact with the sink, which implies that thermal grease, be used between device and sink.

The connections and measurements are exactly identical to the methods described in the junction to ambient section immediately proceeding. Calculations are also identical.

VARIATION ON BRIDGE CHIP

The chapter on USING THE BRIDGE CHIP covered gathering data with the Temp family of chips. The method described used a minimum of six connections. It is sometimes impossible to provide six connections. For instance, TO220, TO3 or TO202 packages simply cannot provide six separate contacts. It is possible to use the Temp chip to gather data from these packages. Using only half of the Diode Bridge allows the contact requirement to be reduced to three contacts. The trade-off costs are the need to use a constant current supply in place of the 5-volt supply and the increase in noise susceptibility.

There is another common reason to use only half of the bridge. One of the diodes may be defective. Data may still be gathered from the built up device using one diode thus avoiding the wasting of a device. An otherwise low yielding wafer can thus turn out to be quite high yielding. The same trade-off mentioned above applies.

The wirebond pattern to the die is quite different when using the half bridge. Both S1 and R1 are bonded to the same terminal. R2 is bonded to one of the other terminals and V1 (for temperature sensing at the center of the die) is bonded to the other. A constant current supply capable of providing 500 microamps is connected across V1-S1. A voltmeter is used to monitor the voltage across this one diode. The other power supply is connected through an ammeter across R1-R2. A voltmeter is needed to monitor the R1-R2 voltage for calculating the power dissipated. Figure 7 shows this hook up schematically.

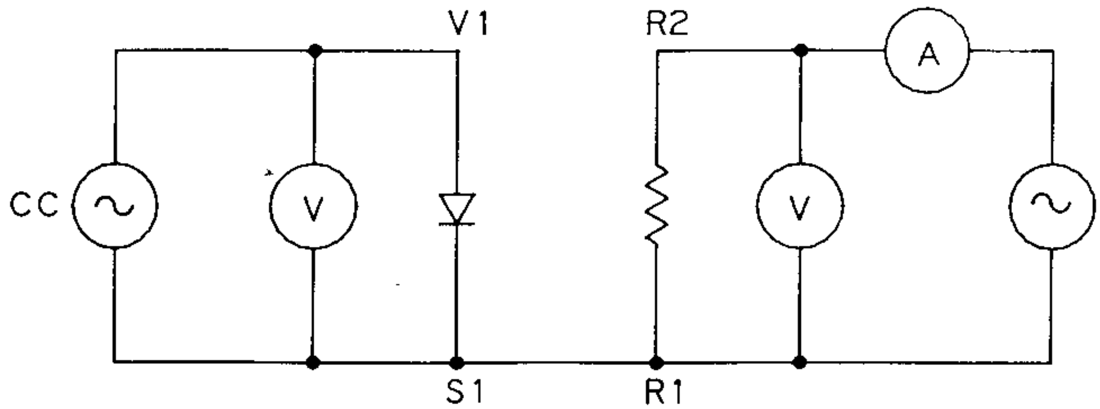


Fig. 7 HALF BRIDGE TEST SET UP SCHEMATIC

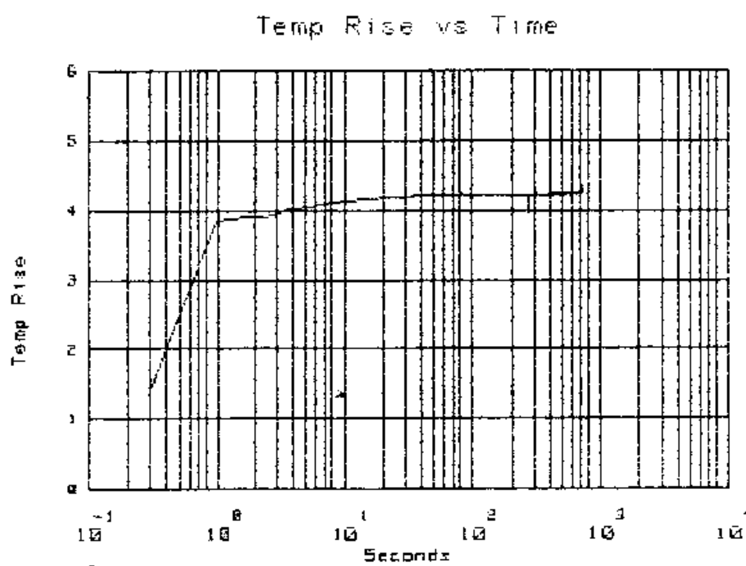
If the polarity of the two power supplies, which share the common contact at R1-S2 is not correct, no data can be obtained. In other words, there is only one correct way to connect the device. The constant current supply may indicate a closed circuit in only one direction across the diode. Or, it may indicate a completed circuit while biasing the diode in reverse. If that happens, the diode will not respond to the changing temperature. It will then be necessary to reverse the supply polarity. If the voltmeter across the diode makes a drastic change as soon as the resistor power supply is turned on, in the order of volts rather than millivolts, the resistor power supply polarity must be reversed. Occasionally, both supplies will be connected in reverse polarity initially. So, if changing the polarity of one supply doesn't correct he problem, also change the other supply polarity.

Data gather precedes the same as for a full bridge or TAB Temp series diode chip. The main point to remember in interpreting the data is the sensitivity of the diode. As was shown in the THEORY chapter, a diode's thermal response is 2 mV/Deg C. Take care not to use the .2 mV/Deg C response level of the bridge. The temperature rise, power dissipation and thermal resistance are calculated the same as for the full bridge or series diode chip.

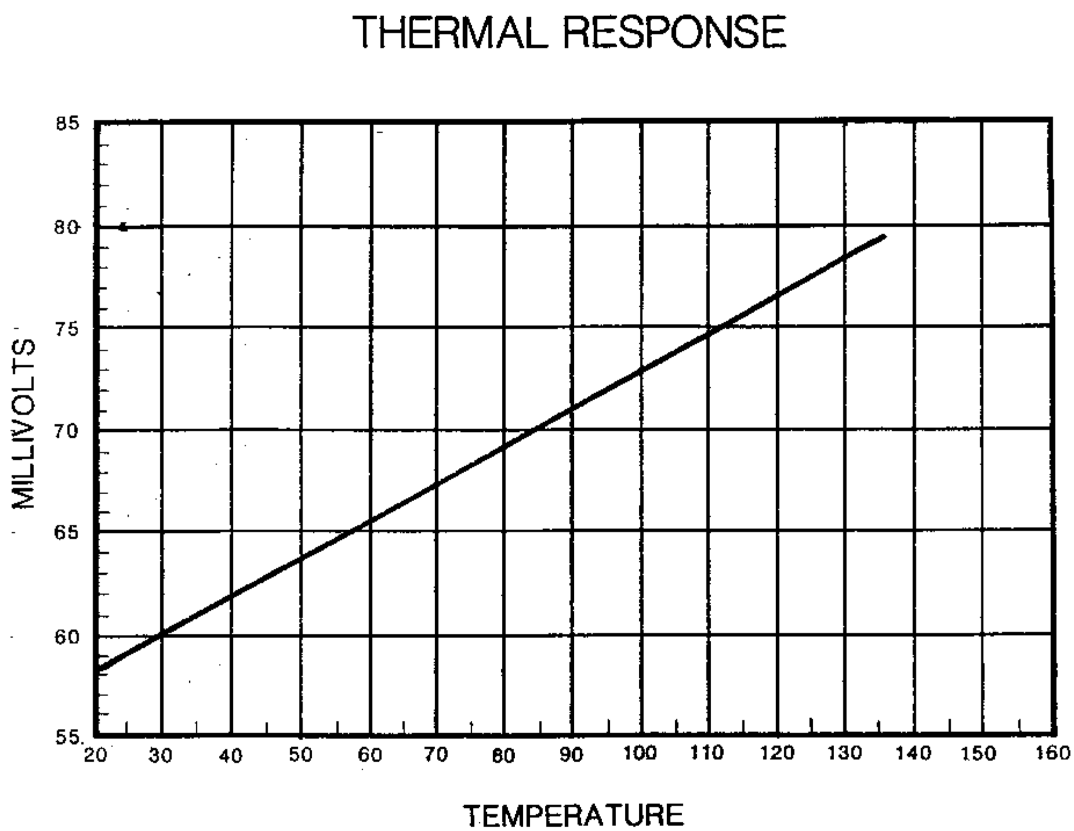
While this chapter deals with using the bridge chip in the half bridge mode, it is opportune to mention that the series diode chip can be similarly used. That is, it is possible to use the series chip with only three electrical contacts. One of the R's and the negative side of the series diodes can be connected together. Like the half bridge method, there is only one proper orientation of supply polarity that will operate.

APPENDIX

Device name:	15 Pin SIP with Temp03 Thermal Chip Junction to Case on 30 C Sink
Device Number:	72
Power Dissipated:	2.939 watts
Test Voltage:	7.7 Volts
Test Current:	. 38174 Amps
Initial Diode Voltage:	60.4192 mV
Temperature Rise:	4.2505 Deg C
Thermal Resistance:	1.4462 Deg C/Watt



Sample Printout from a Run



Calibration Curve For Temp Chip

COMBINATION

Another family of test chips has been developed that combines the Temp and TAB Temp approaches. The same buried heating resistor is used. On the surface of this heater is located both a series diode string and diode bridge sensors. This allows the user to choose the temperature monitoring method preferred or dictated by equipment constraints.

As might be expected, this family incorporates more features than a simple combination of the two previous chips. This new family is designated as PST. The "PS" refers to passivation testing capability. Included on the chips are parallel runners to check for corrosion. Figure 8 shows the layout of this family.

There is a pair of runners at the outside edge of the chip. Since corrosion usually starts at the perimeter of a passivated chip and proceeds inward, these runners could be expected to corrode first. There are two other pairs of parallel runners on the chip. Both are arranged in a serpentine pattern.

One pair of runners is 10 micron wide with a 10-micron spacing. The other pair of runners is 5 micron wide with a 5-micron spacing.

Since this manual deals primarily with the thermal measuring properties of the PST family, further discussion of the passivation testing characteristics will not be pursued here. It should be noted, however, that normal chip fabrication results in loss of most of the passivation testing capability of these devices. Unless prior arrangement is made, wafers of test chips will not be useful for passivation testing.

Table 2 lists the current die sizes of PST chips produced.

	Physical Size	
	Inches	mm
PST 1	.100 x .100	2.54 x 2.54
PST 2	.150 x .150	3.81 x 3,81
PST 3	.200 x .200	5.08 x 5.08
PST 4	.250 x .250	6.35 x 6.35
PST 5	.306 x .306	7.77 x 7.77
PST 6	.400 x .400	10.16 x 10.16

Table 2 PST CHIP DIE SIZES

The number of bonding sites varies with chip size. However, thermal testing using either the bridge sensor or series diode sensor comes with the recommendation to use a total of eight bonds. As with the TAB Temp family, each heating resistor is supplied with four bond pads. This allows Kelvin measurement of the voltage drop across the resistor. That is the recommended measurement technique. The series diode string is also provided with four bond pads to allow making Kelvin measurement of the diode voltage. This has not proven to add significantly to measurement accuracy unlike measuring the heating resistor voltage drop. For those who wish to use Kelvin measurement of the diode voltage, provision has been made. Those who use the diode bridge method will have to bond out the pads for biasing the bridge (V & G) plus the sense leads (S & S).

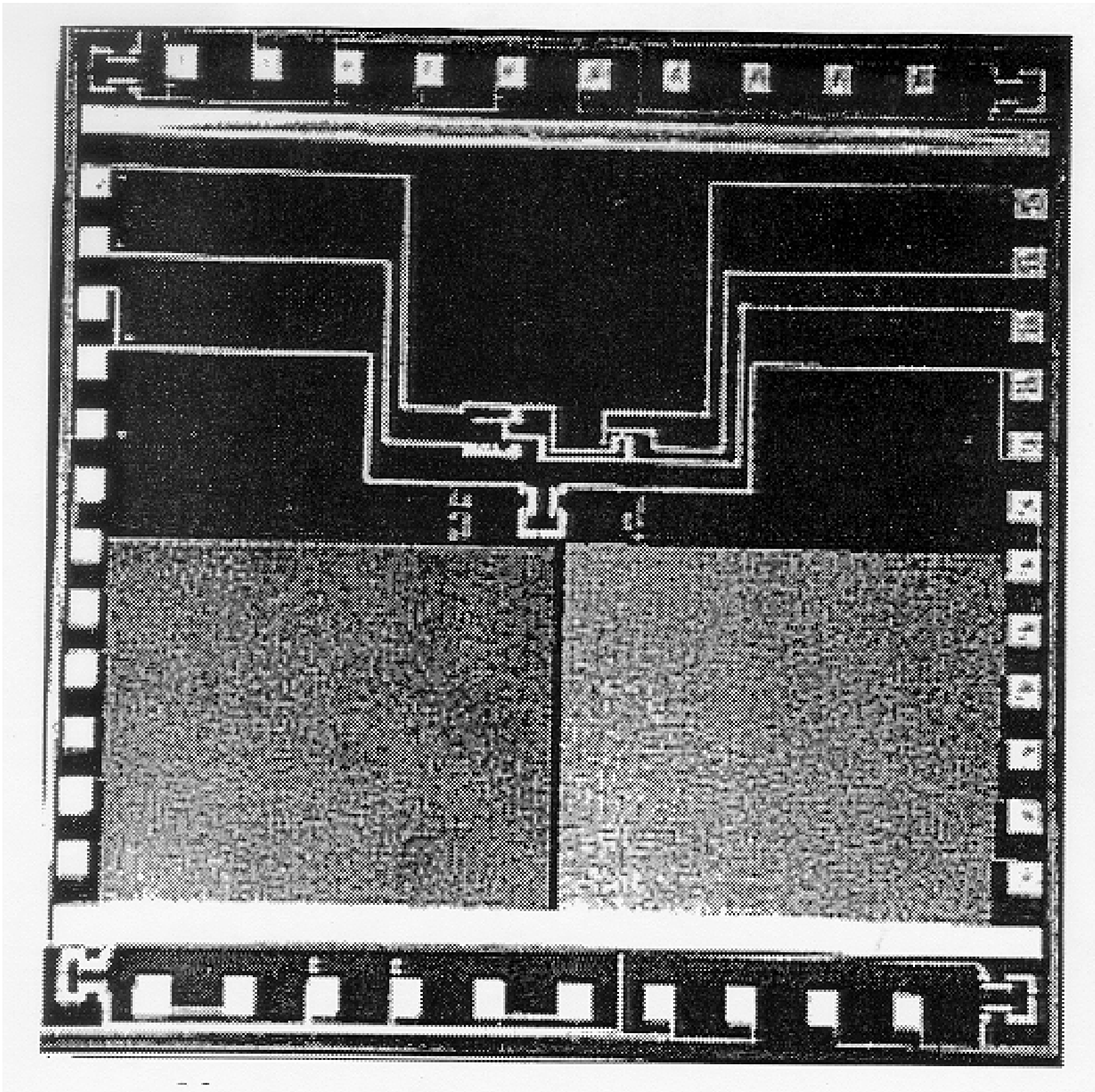
In order to use a PST test chip, before the bonding operation decide whether the series diode or diode bridge method will be used. Then look at a chip under a microscope, 20X is normally sufficient magnification. The two serpentine segments are quite easy to find. Orient the die so that both serpentines are on the right side. Looking at the chip in this orientation, a thick aluminum "bar" can be seen positioned vertically on both the right and left side of the chip. The "bar" defines the buried heating resistor. The aluminum runner insures that the bond sites at each end of the runner are at the same electrical potential. The four resistor bond pads are thus at each end of these two runners. It is recommended that the pads be connected in a diagonal fashion. This helps to avoid connecting the power supply across the "buss bar" rather than across the resistor.

While looking at the chip under a microscope, it will be observed that a number of runners to pads on the left half of the top and bottom rows of bond pads. Those are the connections for the sense circuits. The series diodes are located near the physical center of the die. The runners coming from this structure go to four bond pads, two on the top row and two on the bottom row. These pads may be labeled with a "D" for diodes. It is these four pads that are bonded out when using the series diode sensor in conjunction with a 100 micro-amp constant current supply. If the Diode Bridge is to be used, two runners going to the top row of bond pads go the pad labeled "V" and "S". Two runners also go to pads on the bottom row labeled "S" and "G". These must be bonded out to allow applying 5 volts across V and G while monitoring the millivolts across S and S as covered in the chapter ": USING THE BRIDGE CHIP".

On PST 4 and larger die, examination under the microscope will reveal an additional structure in each corner. The string diode structure was placed in each corner. All four corners are interconnected. It was felt that with particularly large die, die attach failure begins at the corners. The corner sensors give a tool to monitor for such a change. Enough bond pads are located in the interconnect scheme that it should be possible to get information from these sensors even if one or more corners become non-functional. Alternatively, by careful opening of the aluminum runners on the chip surface, it should be possible to interrogate each corner individually. Determination of the bond pads to be used is best determined by using a microscope rather than depending on a written description or drawing.

While looking at the PST under a microscope, it can be seen that one bond pad near the right corner of the bottom row when oriented as described above looks "different". That bond pad is different. Unlike all the other bond pads, this pad connects to the base diffusion, sometimes called the substrate. All other bond pads are isolated from the substrate. Thus, any "good" bond pad connected to the substrate pad forms a diode. This fact can be helpful in checking a chip for bond pad integrity or continuity.

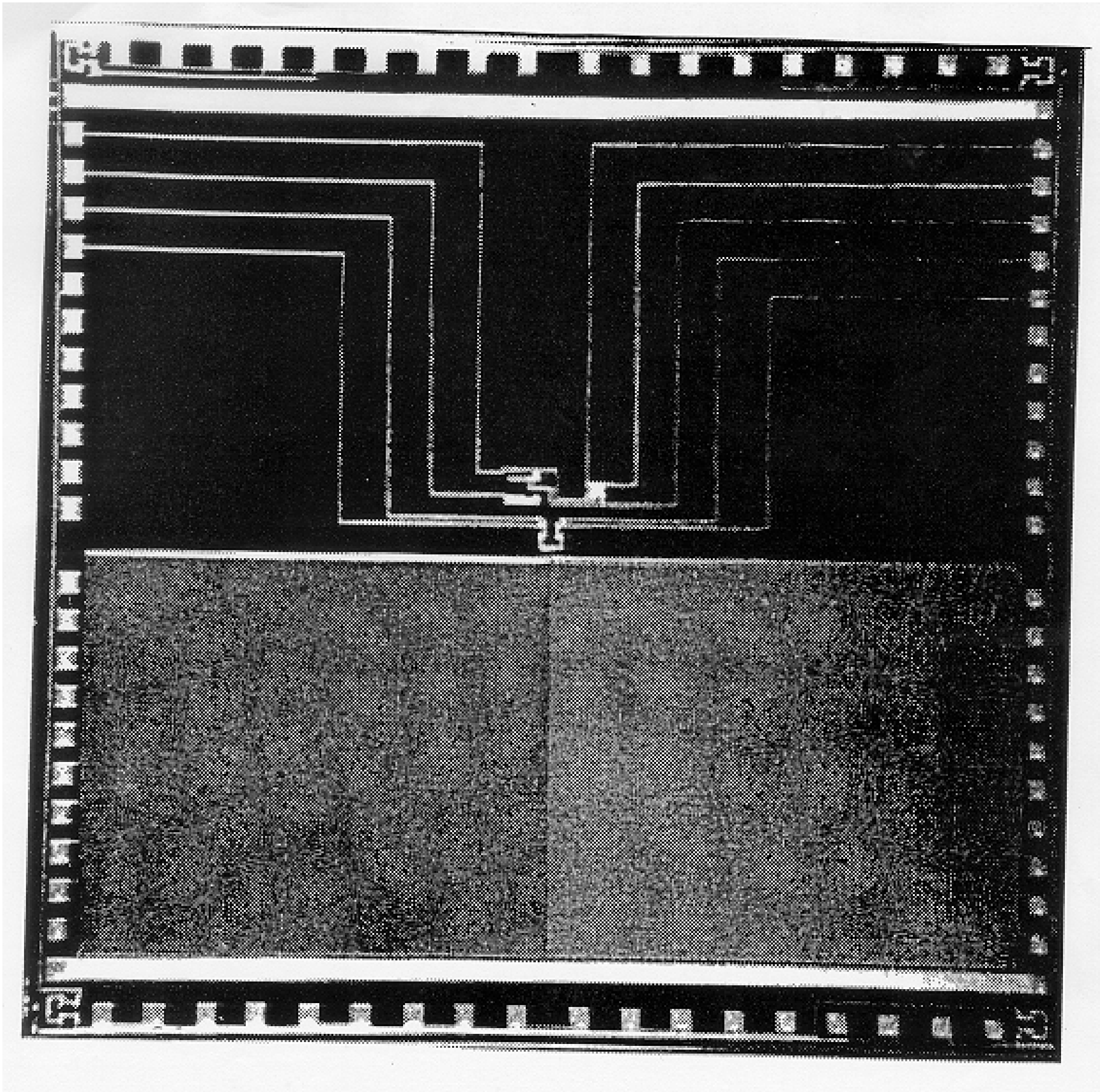
Gather thermal data from a PST chip is identical to the procedures presented in earlier chapters of this manual. Properly connected die show nearly 100 percent yields. If unreasonable results are obtained, confirmation of the chip-bonding pattern is the place to start troubleshooting. Next, check the power supply and meter connections to confirm that they connect to the circuit you received rather than to the circuit you expected. Keep in mind that the diode sensors are polarity sensitive. They perform correctly only when they are correctly biased. Usually, these items will identify any problem with the test set-up.



PST 4

Series diode sensor technique uses 4th - 5th pads from top on left side and 5th - 6th pads from top on right side of this photo.

Diode bridge technique uses 2nd - 3rd pads from top on left plus 3rd - 4th pads from top on right.



PST 6

Series diode sensor technique uses 4th - 5th pads from top on left side plus 5th - 6th pads from top on right side of this photo.

Diode bridge technique uses 2nd -3rd pads from top on left side plus 3rd - 4th from top on right side.

At room temperature with 100-mA constant current, diode string will read approximately 3.2V. Diode Bridge should read approximately 59mv with 5V applied across the bridge.