ThermOptics™

ALUMINUM NITRIDE HEATERS FOR FIBEROPTIC APPLICATIONS

Aluminum Nitride (AlN) is a thermally conductive ceramic with low temperature coefficient of expansion. These properties make AlN ceramic an ideal platform for mounting silicon optical waveguides.

Silicon Arrayed Waveguides (AWGs) are used to combine and to separate optical signals in fiber optic DWDM systems. An AWG is very sensitive to temperature variations. Therefore, they must be maintained at constant temperature to guarantee proper operation over ambient temperature extremes. Temperature control of an AWG can be achieved by mounting the device on a temperature controlled AlN heater. The heater is screen printed, using a thick film process on the side opposite the mounting surface for the AWG. A temperature sensing device such as a thermistor or a Platinum RTD is mounted on the heater side of the substrate to provide feedback information to a temperature controller. Since the thermal resistance of AlN is low, the temperature on the AWG side of the substrate will be within 0.1°C of the temperature on the heater surface. The temperature coefficient of expansion of AlN is 3.3ppm/°C which is very close to silicon (2.8ppm/°C). This minimizes the effect of stress on the AWG at its operating temperature.

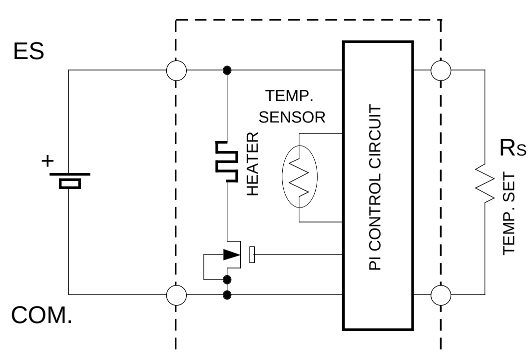
ThermOptics produces two basic types of AlN heaters. The first consists of a serpentine heater that is screen printed on one side of the substrate. A temperature sensor such as a 100kΩ thermistor is also mounted on the heater surface. The resistance of the heater can be specified between one and four ohms. Temperature control of the heater is achieved by using an external controller such as the ThermOptics DN1225.

The temperature controller is integrated on the AlN heater surface in the second type of heater manufactured by ThermOptics. This type of device consists of a serpentine heater element, a 100kΩ thermistor temperature sensor, a PI control circuit and a Power Transistor.

Both heater types can maintain 0.1°C temperature stability at the exact location of the thermistor. Temperature gradients across the surface of the heater will occur as the ambient temperature changes. The smallest temperature gradients occur in the heater type that does not contain the integrated control circuit. This is because all of the heating comes from the serpentine heater which provides uniform heating across the surface of the AlN substrate.

Heating comes from the serpentine heater and the power transistor in the integrated temperature controller. The transistor is a point source of heat while the serpentine heater is a distributed heat source. The proportion of heat supplied to the AlN substrate by these two heating elements changes with ambient temperature. This creates temperature gradients across the surface of the heater which, in many applications, is acceptable. When this is the case, this type of integrated temperature controlled heater, which occupies less space and is less expensive than the stand alone heater with external controller, is the solution of choice.

BLOCK DIAGRAM OF THE AlN HEATER WITH INTEGRATED TEMERATURE CONTROLLER



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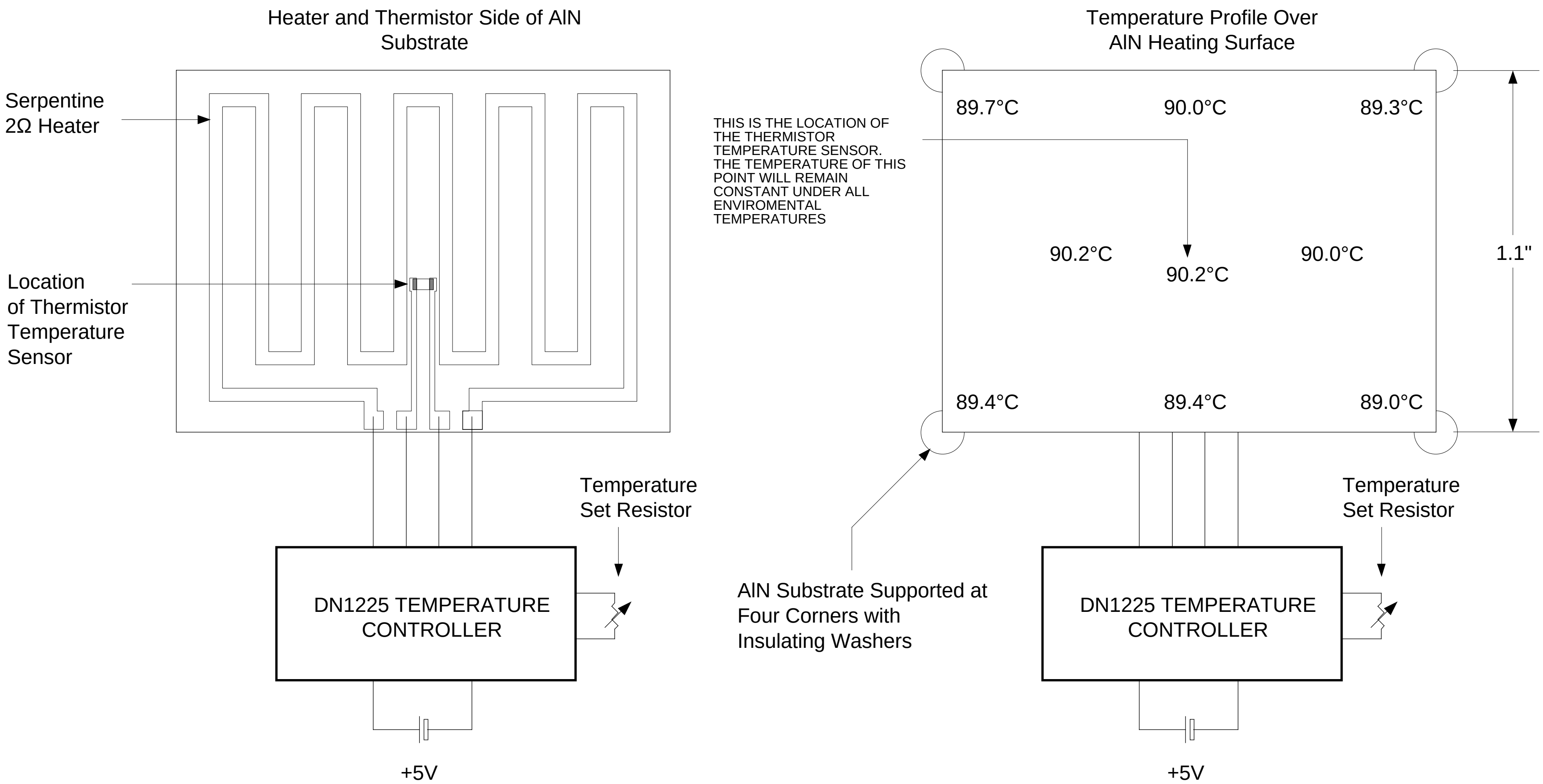

AlN HEATER WITH THERMISTOR TEMPERATURE SENSOR

This is anAluminum Nitride (AlN) heater with a thermistor temperature sensor. Temperature is controlled using an external PI temperature controller such as the ThermOptics DN1225.   This temperature control system is capable of supplying a maximum of eight watts of power to the heating element. Temperature stability of better than 0.1°C is achieved at the point where the thermistor is located.

TA = 23°C
TSET = 90.2°C
IL = 0.560 Amps
ES = 5.00V
PT = 2.80 Watts

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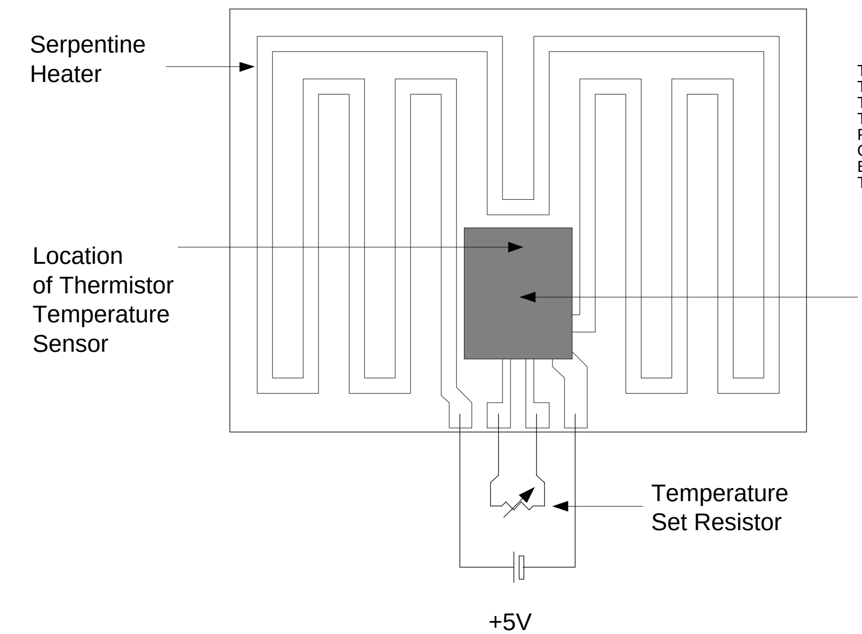
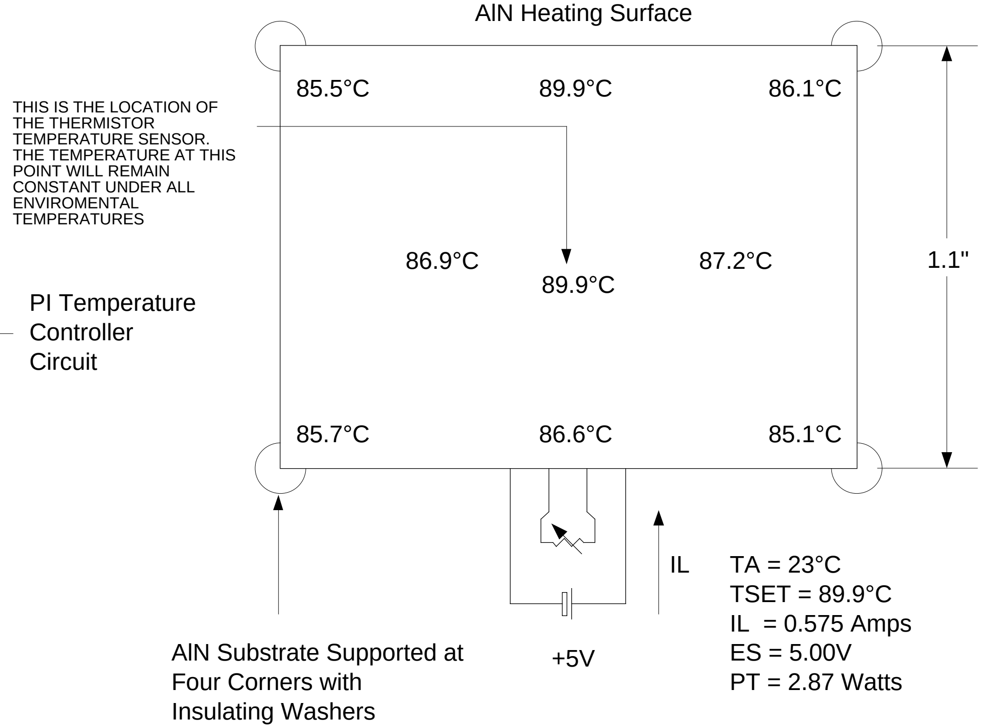
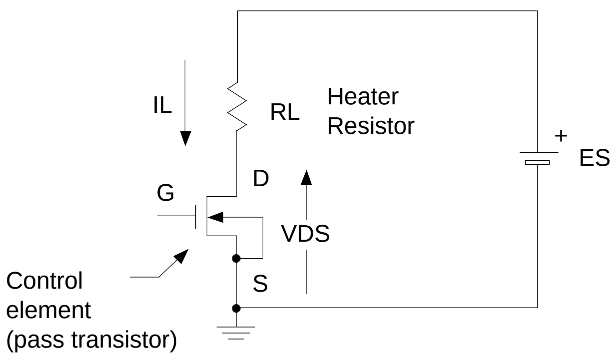
Heater and Control Electronics Side of AlN Substrate



Temperature Profile Over AlN Heating Surface



Power Stage of the Temperature Controller



ES ---------- Power supply voltage
VDS -------- Drain to source voltage
PMAX ------ Maximum power delivered to the load. PMAX Occurs when VDS = 0.
PT ---------- Total power delivered to the load.
PQ ---------- Power dissipated in the pass transistor.
PR ---------- Power dissipated in the power resistor.

SELF CONTAINED AIN PI TEMPERATURE CONTROLLED HEATERS

The Aluminum Nitride Temperature Controlled Heater illustrated in this drawing is typical of semi-custom devices that can be fabricated by ThermOptics. These devices can be laser tooled in almost any shape required by the customer. These devices typically operate from a five volt power supply and can deliver up to eight watts of heating power. The drawing above shows the temperature profile across the surface of the heater. The heater will be maintained at a constant temperature at the location of the thermistor over all enviromental temperatures. Temperature at other locations on the surface of the heater will vary depending on the heat dissipated by the serpentine heater and the series pass transistor.

Normalized equations for the power dissipated in the heat producing elements of the temperature controller

$$\frac{PT}{PMAX} = \left(1 - \frac{VDS}{ES}\right)^2 + \frac{VDS}{ES}\left(1 - \frac{VDS}{ES}\right) = \frac{PR}{PMAX} + \frac{PQ}{PMAX} \quad \text{where} \quad PMAX = \frac{ES^2}{RL} \quad \text{and} \quad \frac{PR}{PMAX} = \left(1 - \frac{VDS}{ES}\right)^2 \quad \text{and} \quad \frac{PQ}{PMAX} = \frac{VDS}{ES}\left(1 - \frac{VDS}{ES}\right)$$

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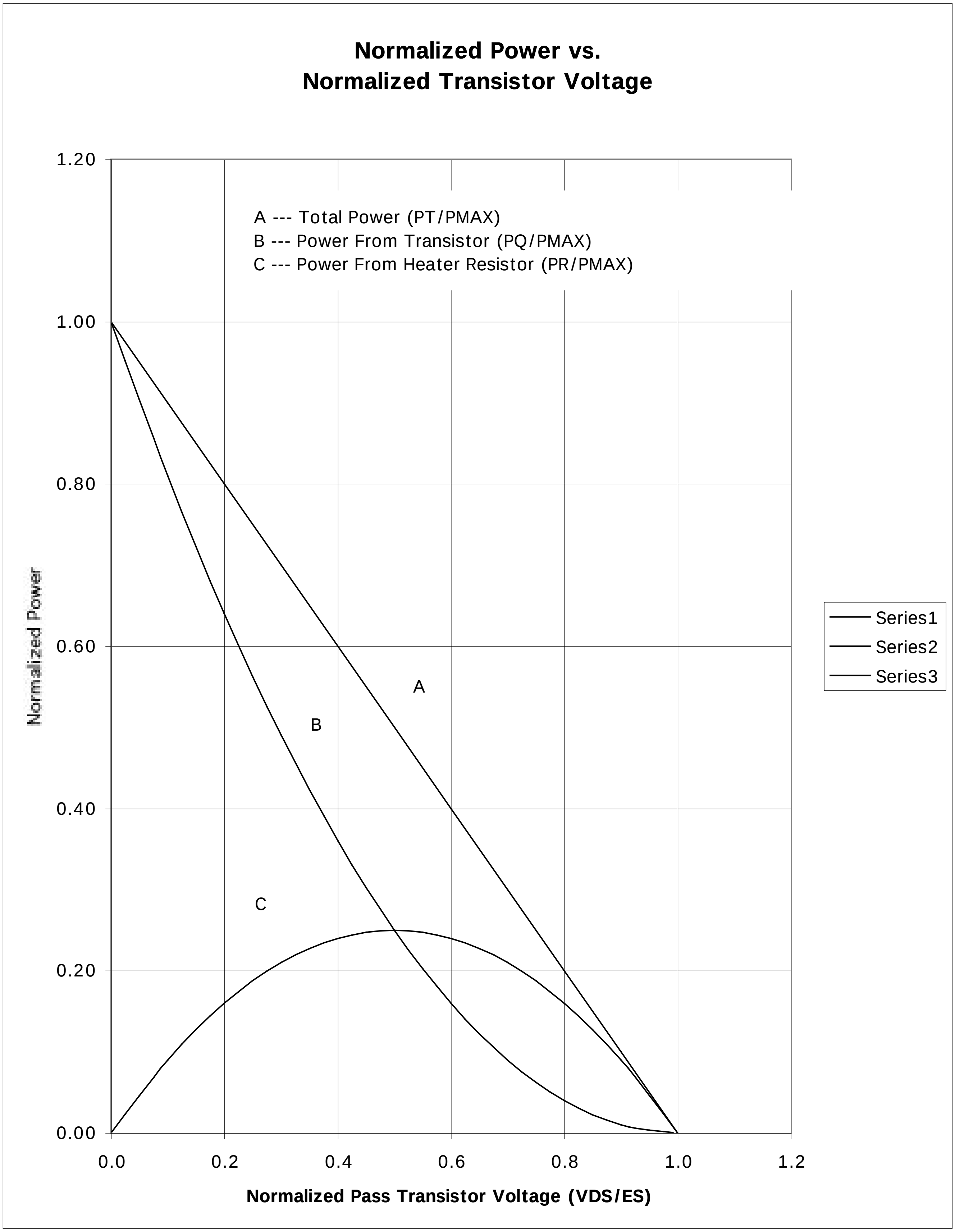
Normalized Power vs.
Normalized Transistor Voltage
A --- Total Power (PT/PMAX)
B --- Power From Transistor (PQ/PMAX)
C --- Power From Heater Resistor (PR/PMAX)
Normalized Power
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.0
0.2
0.4
0.6
0.8
1.0
1.2
A
B
C
Series1
Series2
Series3
Normalized Pass Transistor Voltage (VDS/ES)