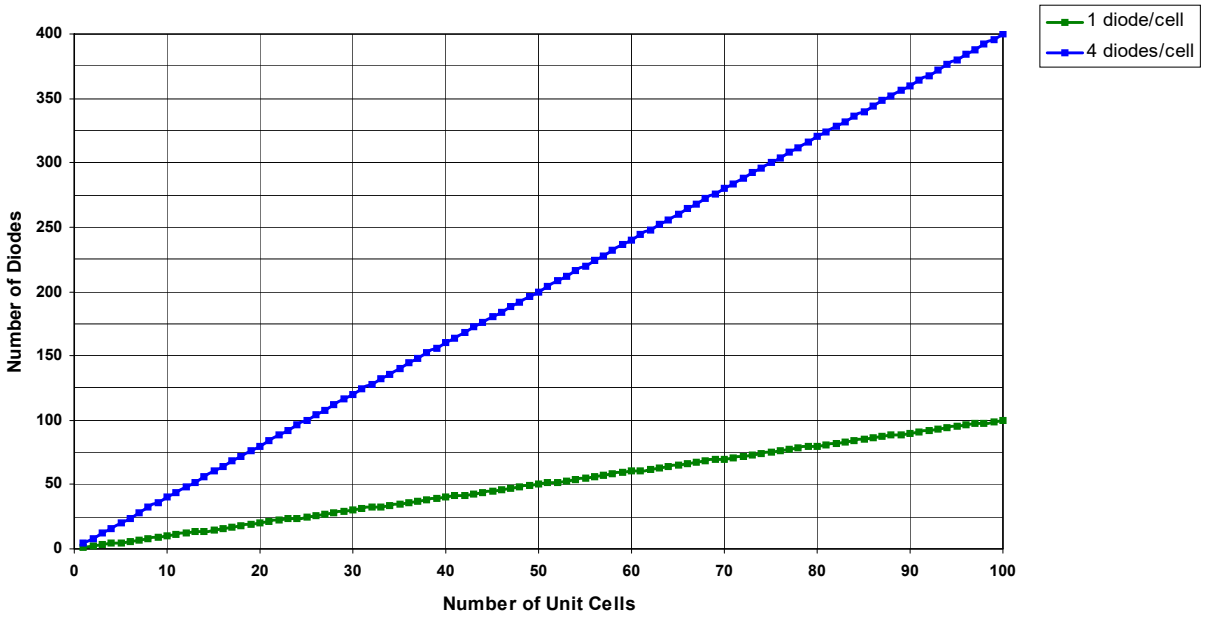
Temperature Diode Matrix Operation

Thermal Test Chips (TTC) are designed with diodes for temperature sensing because of their compatibility to the silicon wafer fabrication process, linear voltage-temperature relationship over the normal semiconductor application temperature range, and general ease of use in applying current and making a voltage measurement.. The diode in the TTC-1001 (1mm X 1mm Unit Cell) and four diodes in the TTC-1002 (2.54mm X 2.54mm Unit Cell) are specifically designed for temperature-sensing as they are very small (about 30µm square) and operate at very low current (I_F = 1mA) to minimize self-heating effects. The diode's small size makes knowledge of the exact temperature measurement spatial location possible.

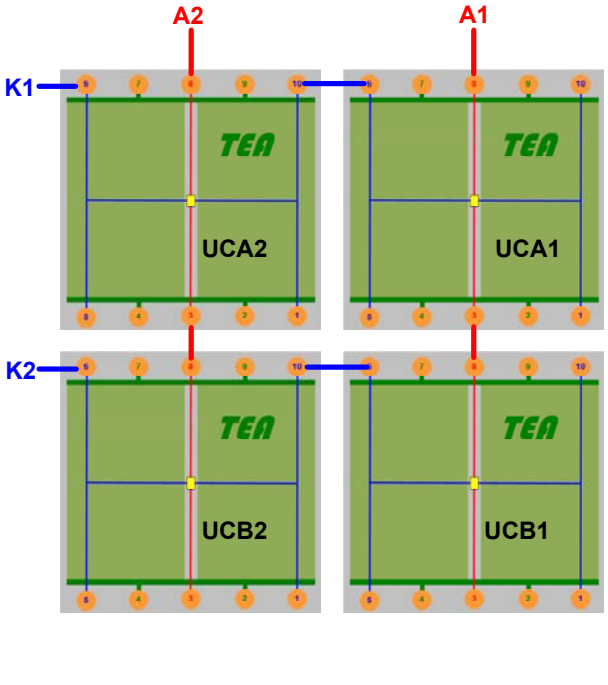
There is one diode temperature sensor per cell in the TTC-1001 (1mm X 1mm Unit Cell) and four diode temperature sensors per cell in the TTC-1002 (2.54mm X 2.54mm Unit Cell). As the typical TTC application is usually an array of Unit Cells, the number of diodes within the array increases dramatically with array size. The chart below shows the number of diodes for a given number of Unit Cells within an arrayed cell chip.



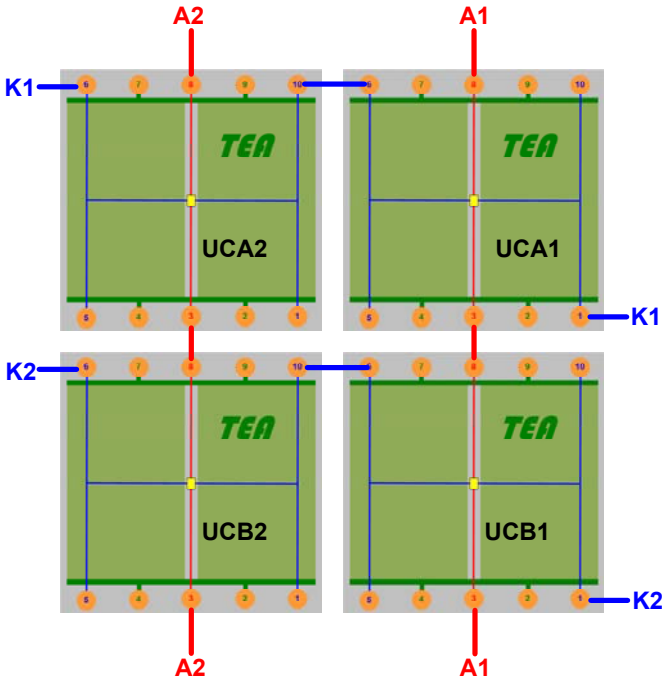
For the case of 2-wire electrical configuration, 200 electrical connections would be required for temperature measurements using 100 diodes. 400 electrical connections would be necessary for the 4-wire (Force & Sense) electrical configuration. In most cases, the number of electrical connections for either configuration can be reduced by sharing connections between diodes – for example, the cathodes for all diodes connected together.

The design of the TTC Unit Cells is optimized for shared connections for either configuration in the Matrix Connection arrangement, as shown below.

Temperature Diode Matrix Operation (cont'd)



2-wire electrical connection



4-wire electrical connection

Using the matrix approach, only 4 connections in 2-wire configuration and 8 connections in 4-wire configuration are necessary to access four diodes. This compares to 8 and 16 connections, respectively, if each diode had separate individual connections.

Diode in cell	2-Wire Configuration		4-Wire Configuration (Force)	4-Wire Configuration (Sense)
UCA1	A1 & K1		A1 & K1	A1' & K1'
UCA2	A2 & K1		A2 & K1	A2' & K1'
UCB1	A1 & K2		A1 & K2	A1' & K2'
UCB2	A2 & K2		A2 & K2	A2' & K2'

The matrix approach also works for TTC-1002 arrays. A 2x2 array with 4 cells will have a total of 16 diodes requiring 32 and 64 connections for 2 and 4 wire configurations, respectively. The corresponding matrix approach would only require 16 and 32 connections, respectively. The savings in electrical connections increases as the total number of diodes is accessed.

Care must be taken when attempting to simultaneously measure many diodes in a matrix configuration. The current force and voltage measurement circuitry must have sufficient electrical isolation between channels so that a measurement of one diode does not materially affect the measurement of any other diode.