Wireless Passive SAW Temperature Sensor

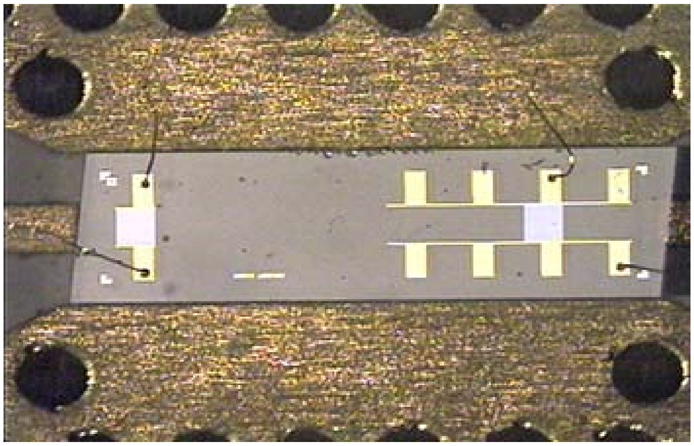

Figure 1. Surface Acoustic Wave (SAW) device.

A novel measurement technique is employed using surface acoustic wave (SAW) devices and passive RF to measure the spatial temperature profile of a body such as a satellite or aero shell. Devices have a very linear response over a range of -60°C to 200°C and allow wireless measurements eliminating the mechanical and thermal disturbance that occurs when wires are used. Variation of the SAW characteristic delay and center frequency allow the manufacture of inexpensive, robust, self-identifying sensor element arrays that can be read using a single antenna and data acquisition system. This wireless temperature sensor is based on the change in minimum insertion loss of a surface acoustic wave device that allows for large arrays of self-identifying sensors to be pre-positioned for measurement of the structure and do not require batteries that add unacceptable mass to the structure or wires to retrieve the data.

The data in Figure 2 was collected using an RF circuit. The method is to send a series of 200 ns bursts of RF energy from the antenna to the device with various carrier frequencies and record the amplitude of the delayed reflected pulse using an oscilloscope. The amplitudes of the reflected pulses are compared and the frequency corresponding to the maximum pulse amplitude is plotted as a function of the temperature.

It was found that while the y-intercept of the linear fit to the data has a different value depending on the resonance frequency of the particular device, the slope of the response has a consistent value of -0.073±0.005 MHz/ºC for all of the tested devices. This value is within 10% of the value of the slope calculated from a model based on thermal expansion and indicates that the effect is predominately due to the thermal expansion of the substrate. We have demonstrated this effect over temperature ranges of -60ºC to 200ºC and found that it is linear over the entire range. Thus, a single point measurement is all that is necessary to calibrate each individual device.

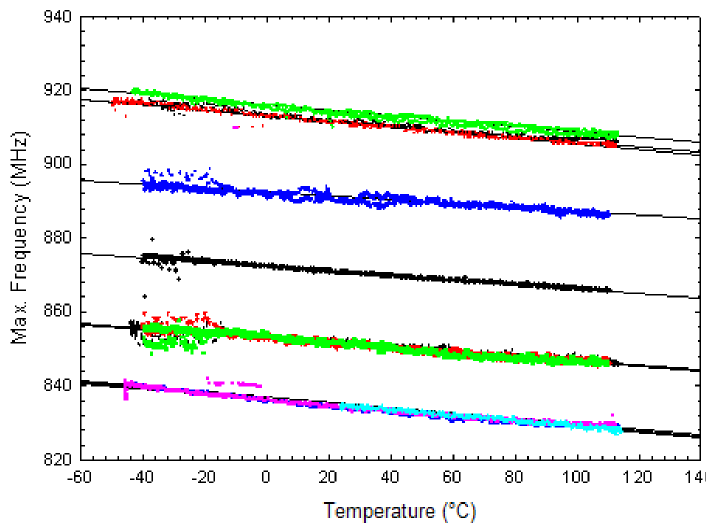

Figure 2. Plot of maximum frequency as a function of temp. Note that while the y-intercept is different on several of the devices, the slope is consistent to within ±5% implying that a single point calibration is all that is needed for the devices.

For additional information or questions, please email us at MGA@sandia.gov.