Design of Acoustic Resonators for High Temperatures

Keith A. Gillis [C, S] and Michael R. Moldover
Process Measurements Division, National Institute of Standards and Technology, Gaithersburg, MD, U.S.A.

Acoustic thermometry is perhaps the most accurate method for measuring thermodynamic temperature in the range 100 K - 550 K. Because acoustic transducer systems degrade at high temperatures, future acoustic thermometers may rely on acoustic sources and detectors located near room temperature. If so, they will use ducts to transmit the sound between the transducers and the thermometer at high temperatures. To mitigate the effects of outgassing at high temperatures, ducts will also provide a continuous flow of clean argon (or helium) to the thermometer. Because these ducts pass through temperature gradients, the properties of the gas in the ducts change along the duct's length and ducts generate the perturbations of the acoustic modes that are temperature dependent. Therefore, these perturbations must be estimated and the uncertainty of the estimates must be small enough to avoid compromising the accuracy of the thermometry. However, the ducts cannot be too thin without degrading the acoustic signal-to-noise ratio. To reduce the thermal equilibration times and the complexity of large thermostats, future acoustic thermometers may be smaller than those in use today. We present design recommendations for high temperature thermometers that consider the size of resonant cavity, perturbations from ducts (including the temperature gradient), and signal-to-noise ratios.