important Notice

QUASAR RUSpec can determine elastic constants for technicians

frequently asked Questions

(1) How does RUSpec determine elastic constants?
The RUSpec (Resonant Ultrasound Spectrometer) is an implementation of resonant ultrasound spectroscopy (RUS). It uses this technology to measure the resonant frequencies of sample materials of known dimensions, shape, and density. These measured resonances are compared with calculations of the modal frequencies based on an initial “guess” by the operator of the elastic constants. Typically, the guess is an educated one and is close enough to the actual value(s) so that the calculation algorithm provides a solution. The solution is derived by using a Levenberg-Marquardt scheme to minimize the difference between the measured and calculated resonant frequencies as the estimated elastic constants are iteratively changed. When a best fit between the measured and calculated resonant frequencies is achieved, the elastic constants have been calculated. Accuracy is greatly influenced by how well the sample (a rectangular parallelepiped or a right cylinder) is fabricated and whether or not the sample is uniform and without flaws.

(2) What advantages does RUSpec provide that conventional speed of sound, strain gauge measurements, or other methods do not?
RU Spec takes advantage of the ability to measure high frequency resonances with extraordinary accuracy over a wide temperature range to allow measurements of a wide size range of samples, including the very small (single crystals of a few mm in size), to accuracies previously unattained. These accuracies can be greater than 0.1%. Additionally, for those people interested in measuring material constants as a function of temperature, RU Spec can make measurements very rapidly as temperature changes from 3 degrees K to over 1850 degrees K. Depending on accuracy requirements, each measurement can take from a few seconds to a few minutes without adjusting or touching the sample unless one needs to change from a cryogenic to a heating sample fixture.

(3) Does Quasar provide the cryogenic and high temperature test fixtures?
Quasar provides a room temperature fixture (10 degrees C to 50 degrees C). We can provide information on sources for cryogenic fixtures. High temperature fixtures are typically built by the user to satisfy their particular requirements. Quasar does manufacture transducers with extra long tips for use in high temperature applications.

(4) Why does the sample have to be a rectangular parallelepiped (RP) or right cylinder?
When this technique was first developed, desktop computers were relatively slow such that the most efficient computational algorithms were needed to make this method practical. The RP geometry was most appropriate in order to minimize calculation time. The next fastest shape calculation (cylinder) ran 4 to 8 times slower, depending on the particular computer and the parameters chosen. Since that time, however, computing power has increased dramatically so Quasar now provides a “Cylinder” version of the computational software. Other geometries are possible, however an additional concern is that other geometries require special programming to model and validate, and measurements can be very difficult. Quasar does not plan on including any other geometries in the future.

(5) Which material constants are calculated and how are they calculated?
The material constants measured (dynamic compared to static) are: Young’s Modulus, Shear Modulus, Bulk Modulus, Poisson’s Ratio, and Longitudinal and Shear Sound Velocities. These properties are calculated from the elastic constants. For example, the Shear Modulus for isotropic materials is equal to C_{44}. Other properties are algebraically calculated and the bulk modulus derives from the model itself.