

## INVESTIGATION 5

### Notes for the Instructor

#### PURPOSE

To investigate the acoustic properties of the two phases of the NiTi alloy.

#### METHOD

It is not surprising that the two NiTi phases also exhibit a different “acoustic signature” as well as other physical properties. The propagation of sound is affected by a number of factors but most certainly depends upon structure. The uniform structure of austenite allows sound waves to travel through it readily. In martensite, on the other hand, the boundaries between regions with different orientations of the less symmetric monoclinic structure act to reduce the vibrations and muffle the sound. The net result is a noticeable “ringing” sound when the austenite rod is dropped, compared to a dull “thud” for the martensite.

#### MATERIALS

NiTi rods (one of each phase per group)	string
hot plate	400 mL beaker
thermometer	ring-stand and ring
meterstick	

#### PROCEDURE

- Determine which of the rods is in the martensite phase (recall Investigation 4).
- Using the rod that you selected in (a), tie one end to a string and suspend it in a beaker of water on a hot plate by tying the other end of the string to a ring on the stand at the appropriate height. After several minutes, remove the rod and drop it on the counter-top from a height of 50 cm. The rod should be held parallel to the counter as it is dropped. Note the nature of the sound that the rod produces (thud, ring, intermediate). Record the temperature of the water.
- Return the rod to the beaker, and turn on the hot plate at its lowest setting. Remove and test the rod at approximately 10 °C intervals. Continue until a noticeable change in sound is detected.
- Repeat the above procedure until the water cools to just above room temperature.

#### ANSWERS TO FOLLOW-UP QUESTIONS

- How did you decide which rod was martensite?

**Probably by the “bend test” from Investigation 4.**

2. Describe the changes in sound produced as the rod was slowly heated.

**The sound progressed from a “thud”, through an intermediate sound, to a “ring”.**

3. Do the sounds produced at each temperature depend upon whether the rod is being heated or cooled?

**It may be difficult for the students to detect this “hysteresis effect”, but the phase changes in the two directions do not have the same temperature dependence. The phase change from austenite to martensite occurs over a lower temperature range than that from martensite to austenite. This is simply explained by noting that one solid phase needs to grow within the region of the other. This creates elastic strain in the region surrounding the new crystal growth, which results in a thermodynamic increase in the free energy necessary to continue the growth of the crystal. The overall effect is a displacement of the heating curve to higher temperatures. The thermal history of the rod does then make a difference.**

4. How do you account for this observed change in sound?

**See the teacher notes above. Students will have difficulty in answering this question completely. Most will realize it has to do with structure, but will not be able to fully explain just how. This should be a good topic for a class discussion.**