

## Investigation 5

### Changing the Shape of a Memory Metal Rod

So far in our investigations we have been changing NiTi rods from one phase to another using hot water or liquid nitrogen. We have found that heating the rods returns them to their rigid austenite phase. The rods we have used thus far straightened as they returned to the austenite phase.

You may have wondered if it is possible to change the shape of the Nitinol rod so that it returns to a different shape when heated. You may have also wondered how the rod's original shape is always "remembered." This ability to "remember" its original shape is caused by small gaps or defects. All the atoms in the metal are not perfectly arranged.

Consider the cob of corn we used to understand what a unit cell is. For the most part, the kernels of corn repeat over and over again in regular ways to form a full cob. Usually there are straight rows from one end of the cob to the other. However, some kernels of corn do not neatly fit into the rows and may even form small, distorted rows. There may even be gaps between rows in some places. We could call these areas of "misplaced" kernels and the gaps between rows defects. In a very similar way, "misplaced" atoms and gaps form defects in the NiTi. This unique set of defects and atom arrangements give the Nitinol its "remembered" shape, the shape to which it returns when heated. Your teacher might also show you another analogy using BB boards that demonstrates this same concept.

To give the metal a new shape it is necessary to create a new set of defects that will in turn force the metal to return to this new shape upon mild heating through the martensite-to-austenite phase change. This new set of defects can only be obtained by heating the metal sample to approximately 500°C while it is secured in the new shape. This large amount of thermal energy excites the atoms. As the metal cools, atoms settle into lower energy positions specific to the new shape, thus creating a new set of defects.

1. Using two tongs, grasp the wire at its ends (CAUTION, the ends may be sharp!), and hold the middle of the wire over the flame. When the middle of wire becomes red hot, bend it into a V-shape using the tongs and place the middle of the V into the center of a candle flame.
2. Cool the wire by blowing on the wire, straighten out the wire, place in a cup or beaker, and cover with hot water. What happens?
3. In a similar fashion, return the wire to its original shape.
4. Why can't you use hot water to retrain the wire to "remember" a new shape?