EUTECTIC DIAGRAM WITH NO SOLID SOLUTION

We now turn to a binary system that is the opposite of the one just discussed. Some components are so dissimilar that their solubility in each other is nearly negligible. Figure 9.11 illustrates the characteristic phase diagram for such a

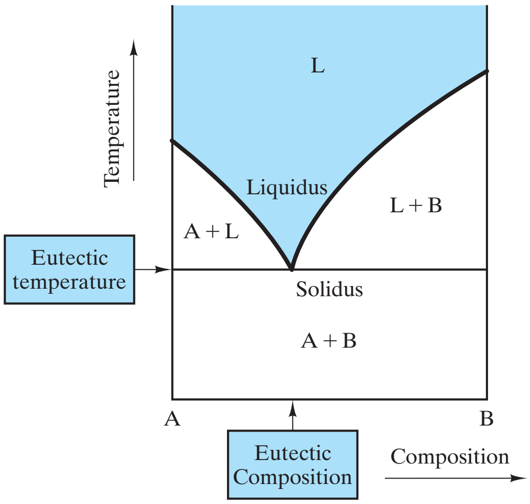

FIGURE 9.11 *Binary eutectic phase diagram showing no solid solution. This general appearance can be contrasted to the opposite case of complete solid solution illustrated in Figure 9.5.*

system. Several features distinguish this diagram from the type characteristic of complete solid solubility. First is the fact that, at relatively low temperatures, there is a two-phase field for pure solids A and B, consistent with our observation that the two components (A and B) cannot dissolve in each other. Second, the solidus is a horizontal line that corresponds to the **eutectic temperature**. This name comes from the Greek word *eutektos,* meaning "easily melted." In this case, the material with the **eutectic composition** is fully melted at the eutectic temperature. Any composition other than the eutectic will not fully melt at the eutectic temperature. Instead, such a material must be heated further through a two-phase region to the liquidus line. This situation is analogous to the two-phase region (L + SS) found in Figure 9.5. Figure 9.11 differs in that we have two such two-phase regions (A + L and B + L) in the binary eutectic diagram.

Some representative microstructures for the binary **eutectic diagram** are shown in Figure 9.12. The liquid and the liquid + solid microstructures are comparable to cases found in Figure 9.8. However, a fundamental difference exists in the microstructure of the fully solid system. In Figure 9.12, we find a fine-grained eutectic microstructure in which there are alternating layers of the components, pure A and pure B. A fuller discussion of solid-state microstructures will be appropriate after the lever rule has been introduced in Section 9.3. For now, we can emphasize that the sharp solidification point of the eutectic composition generally leads to the fine-grained nature of the eutectic microstructure. Even during slow cooling of the eutectic composition through the eutectic temperature, the system must transform from the liquid state to the solid state relatively quickly. The limited time available prevents a significant amount of diffusion (Section 5.3). The segregation of A and B atoms (which were randomly mixed in the liquid state) into separate solid phases must be done on a small scale. Various morphologies occur for various eutectic systems. But whether lamellar, nodular, or other morphologies are stable, these various eutectic microstructures are commonly fine-grained.

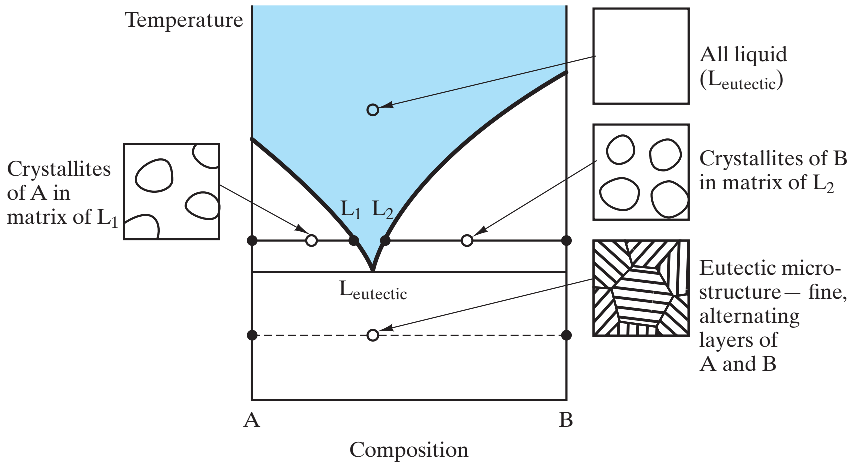

FIGURE 9.12 *Various microstructures characteristic of different regions in a binary eutectic phase diagram with no solid solution.*

The simple eutectic system Al–Si (Figure 9.13) is a close approximation to Figure 9.11, although a small amount of solid solubility does exist. The aluminum-rich side of the diagram describes the behavior of some important aluminum alloys. Although we are not dwelling on semiconductor-related examples, the silicon-rich side illustrates the limit of aluminum doping in producing *p*-type semiconductors (see Chapter 13).