9 Titanium Matrix Composites

Titanium matrix composites (TMCs) consist of a titanium matrix containing continuous reinforcing fibers. Development of these materials began more than 20 years ago when the primary reinforcing fiber being considered was boron. Since then, TMCs have evolved and have been improved with the availability of SiC fibers. The principal attractions of TMCs are strength and stiffness. On a density-corrected basis, continuous fiber (SiC) reinforced TMCs have about twice the ultimate strength and the stiffness of conventional titanium alloys, measured parallel to the fiber direction. In principle, this makes them among the most structurally efficient engineering materials known. In practice, it is often difficult to fully capitalize on the unidirectional capability of TMCs in a component, because off-axis loads are usually present. This lessens the impact of TMCs. Moreover, as is often the case, there are many other aspects of a successful material introduction than just one or two material properties (in this case UTS and E). Included are the additional considerations of reproducibility and variability of the properties, the cost and availability of the material, and the cost of finished components made from the material. There also is the question of design methods when the material is significantly different from those that it might replace. Because of the fiber reinforcement, TMCs are extremely anisotropic, which creates a challenge to maximize the benefits of the longitudinal properties while minimizing the penalties associated with the lower transverse properties. When this design situation is achieved, TMCs have much to offer.

This chapter will describe the characteristics of TMCs, the methods used to produce them, some potential applications, and some of the barriers that still exist to their widespread use. The organization of this chapter differs slightly from the previous chapters, each dedicated to a titanium alloy class, because a significant part of understanding TMCs is related to their processing, i.e. the methods by which the fibers are incorporated into the materials and the processes used to make components from the TMC once the material has been made. There is no direct equivalent to this situation, neither for monolithic titanium alloys nor for intermetallics.

9.1 Processing

Titanium matrix composites typically contain 35-40 vol% reinforcing fiber. Early attempts (circa 1970) to produce TMCs used boron reinforcing fibers coated with SiC, the so-called Borosic™ fiber [9.1]. These fibers were extremely expensive, and, as it became clear that titanium Borosic composites were not going to be cost

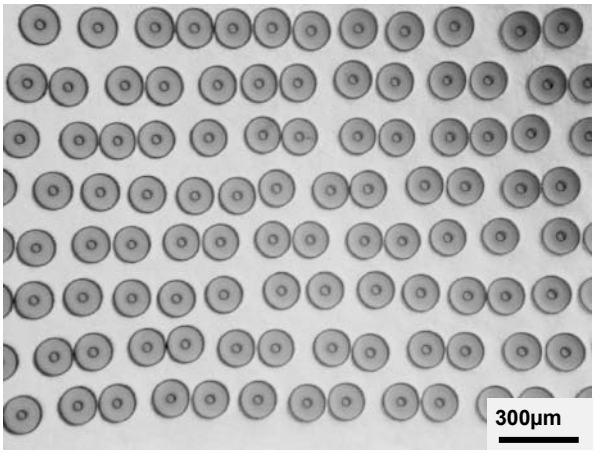

Fig. 9.2. Cross section of an early generation foil-fiber-foil TMC with fibers touching, LM (courtesy J. Jackson, GE Aircraft Engines)

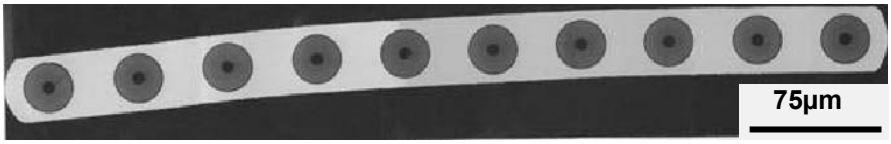

Fig. 9.3. Cross section of a monotape, LM (courtesy L. Johnson, GE Aircraft Engines)

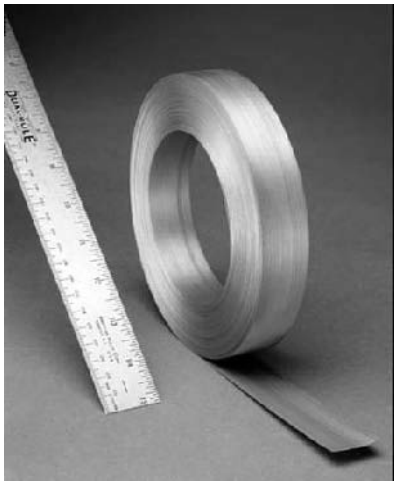

Fig. 9.4. Roll of TMC monotape used as individual plies in articles with multidirectional fiber architectures (courtesy L. Johnson, GE Aircraft Engines)