4.2.7. MICROSTRUCTURE CHARACTERIZATION AND IMAGING IN TITANIUM ALLOYS BY ATOMIC FORCE ACOUSTIC MICROSCOPY

Hirsekorn S., Rabe J., Rabe U., FRAUNHOFER IZFP, Saarbrücken, Germany

Titanium is a strong, highly creep-resistant, light, heat-resisting, biocompatible, and corrosion resistant transition metal with a broad field of applications in industry. The most commonly used titanium alloy is Ti-6Al-4V covering 60% of the titanium market in which 80% accounts for aerospace industry. Titanium alloys primarily consist of two different crystal structures: the hexagonal close-packed (hcp) α-phase and the body-centred cubic (bcc) β-phase. Pure titanium cooled slowly enough to allow diffusion will contain 100% α-phase at room temperature. Above the β transition temperature the bcc structure is stable. Depending on temperature and cooling rate the β-phase may either transform to the metastable β-phase or be replaced by stiff hcp α'-or soft tetragonal close-packed (tcp) α''-martensite structures. The α-phases show a high indentation modulus but exhibit strong elastic anisotropy.

The much less anisotropic bcc structure (β-phase) has a lower indentation modulus. Both phases can be stable even below the β transition temperature if stabilizing elements are added to the titanium solution. Ti-6Al-4V contains α stabilising aluminium and β stabilising vanadium, respectively. Depending on the thermodynamic heat treatment the α- and β-phases form different microstructures and arrangements. The structures are classified into three categories; lamellar, equiaxed, and a mixture of both. Elastic properties and shape of the different phases forming the microstructure of a material determine its macroscopic behaviour. Thus quantitative characterization of microstructures in titanium alloys having undergone different heat treatment processes will provide with guidelines for materials design.

Atomic Force Microscopy (AFM) in combination with ultrasound is the near-field acoustic microscopic method Atomic Force Acoustic Microscopy (AFAM). This technique enables to image and measure local elastic properties of sample surfaces with a spatial resolution in the nm range and hence is convenient for this purpose. A series of Ti-6Al-4V samples were imaged and characterized by AFAM in order to visualize the microstructures formed by different heat treatments and to determine quantitatively the local elastic properties. Furthermore, a correlation of applied heat treatment and resulting microstructure was aimed for.