Chapter 1—Introduction

The deformation systems in hexagonal close-packed (hcp) metals are not as symmetrically distributed as in cubic metals. Furthermore, because the primary slip systems are not as numerous and are limited to deformations in the *a* direction, twinning competes with slip in plastic deformation and can, depending on the deformation conditions, play an essential role [*1–4*].[1]

In hcp metals, the low offer of slip systems, their asymmetrical distribution, and the strict crystallographic orientation relationships for twinning result in the formation of a strong deformation texture. (If the material is subsequently heat-treated, a pronounced annealing texture develops) [*5–7*].

For textured materials, on the other hand, the deformation mechanisms are also responsible for the strong anisotropy of the mechanical properties [*8–10*].

The foregoing points represent three aspects that are mutually interdependent. This paper is correspondingly divided into three sections: by way of introduction, the generally established relationships for deformation mechanisms in hcp metals are given, together with a discussion of their dependence on the metal-specific parameters, such as the *c*/*a* axial ratio, the transformation behavior, and the correlated stacking fault energy. This includes a detailed consideration of deformation mechanisms in zirconium and Zircaloy. In the second and third section, the influences of the deformation mechanisms on the texture development and on the mechanical anisotropy are discussed. These interactions can be transferred similarly to other hcp metals, if one allows for the metal-specific parameters of the hexagonal structure.

The hcp metals are particularly interesting in the investigation of the preceding relationships for the following reasons:

1. Owing to their marked structural anisotropy, the effects under discussion and their interactions become particularly evident, even though

[1] The italic numbers in brackets refer to the list of references appended to this book.

the relationships here are much more complicated than with cubic metals, for example.

2. They have not as yet been as thoroughly examined.
3. Their technical application is gaining in importance [*11*].

For example, zirconium and zirconium-rich alloys, to which Zircaloy belongs, are employed in nuclear reactors, specifically for the fuel element cladding tubes of light-water reactors, due to their small capture cross-section for thermal neutrons, their relatively good high-temperature strength, and their good resistance to corrosion.

Titanium, which resembles zirconium in its chemical and physical properties, together with titanium-rich alloys are used for chemical plant construction as well as in aerospace technology.

Magnesium and its alloys are employed as structural materials in aviation technology because of their high strength-to-weight ratio. They are also used in pyro- and galvanotechnics because of their strong chemical activity.

Zinc and zinc alloys are used for protective coatings and chemical plant construction. Zinc is also used as an alloy component in brasses and in aluminum-zinc-magnesium (AlZnMg) alloys.

Beryllium is used in nuclear and X-ray measurement technology due to its low absorption coefficient for thermal neutrons and X-rays. It is also used in aerospace technology due to its high strength-to-weight ratio.

In addition, elements such as cadmium and cobalt are used specifically as alloy components in wear-resistant and bearing materials as well as in creep-resistant materials.