1 Introduction and Historical Context

1.1 Introduction

High-Resolution Transmission Electron Microscopy (HRTEM) uses a self-supporting thin sample (typically tens of nanometres) illuminated by a highly collimated kilovolt electron beam. A series of magnetic electron lenses image the electron wavefield across the exit face of the sample onto a detector at high magnification. HRTEM has evolved from initial instrumentation constructed by Knoll and Ruska (1932a–c) to its current state where individual atom columns in a wide range of materials can be routinely imaged (Smith, 1997; Krakow et al., 1984) using sophisticated computer-controlled microscopes (Figure 1–1). For this reason HRTEM now occupies a central place in many characterization laboratories worldwide and has made a substantial contribution to key areas of materials science, physics, and chemistry [for key examples showing its wide ranging influence see the frontispiece in the book by Spence (2002)]. Instrument development for HRTEM also supports a substantial commercial industry of manufacturers (Hall, 1966; Hawkes, 1985; Fujita, 1986).1

Numerous HRTEM studies of bulk semiconductors (Smith and Lu, 1991; Smith et al., 1989), defects (Figure 1–2) (Olsen and Spence, 1981), and interface structures (Figure 1–3), (Bourret et al., 1988; Gutekunst et al., 1994) in these materials, of metals and alloys (Penisson et al., 1988; Krakow, 1990; Ishida et al., 1983; Amelinckx et al., 1993; Thomas, 1962), and of ceramics, particularly oxides (Lundberg et al., 1989; Buseck et al., 1989), have been reported in a vast literature spanning four

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1 We note that HRTEM has also made substantial contributions to structural biology (see, Burge, 1973; Unwin and Henderson, 1975; Henderson, 1995; Koehler, 1973, 1978, 1986 for reviews of selected representative examples from this field; see also Chapter 7 by Plitzko and Baumeister in this volume). However, due to limitations of space we will not consider this aspect further.
Figure 1–1. A modern 200-kV HRTEM fitted with a (a) field emission gun, (b) probe and (c) image forming aberration correctors, and (d) an omega geometry energy filter.

Figure 1–2. HRTEM image of a [110] oriented CVD deposited diamond film showing twins, stacking faults, and nanograins. Note the local disorder at the intersection of the stacking faults and twins.