conditions and shape of the crystal. The meniscus height, h, away from the influence of the dendrites, is fixed by the surface tension, liquid-silicon contact angle and liquid density. This can be calculated from the solution of the Young–Laplace equation requiring a contact angle of $\Theta = 11^\circ$ at the liquid–solid interface that gives

$$h = a[1 - \sin(\Theta)] \quad \text{where} \quad a = (2\sigma/\rho g)^{1/2}$$

where $\sigma = 720$ dyne/cm is the surface tension, $\rho = 2.53$ g/cm^3 is the density of liquid silicon and g is the gravitational acceleration. Because thermal radiation dominates the heat flow from the ribbon, the geometry of the heat shields and the susceptor lid controls the isotherms in the melt and the ribbon.

Accurate temperature control, within a few tenths of one degree, is necessary to ensure a uniform ribbon width and thickness. The temperature of the melt surface must be constant over the width of the growing web to prevent the dendrites from growing in or out. The dominant impurity in the WEB in production today is oxygen since a quartz crucible is used. Typical WEB thicknesses range from 100 to 150 μm and widths up to 8 cm have been grown. Growth lengths between seedings in pilot production extend to many tens of meters.

EFG. In this technique, the geometry of the ribbon is controlled by a slotted graphite die through which silicon is fed via capillary action (Figure 6.22) [48]. A seed crystal is

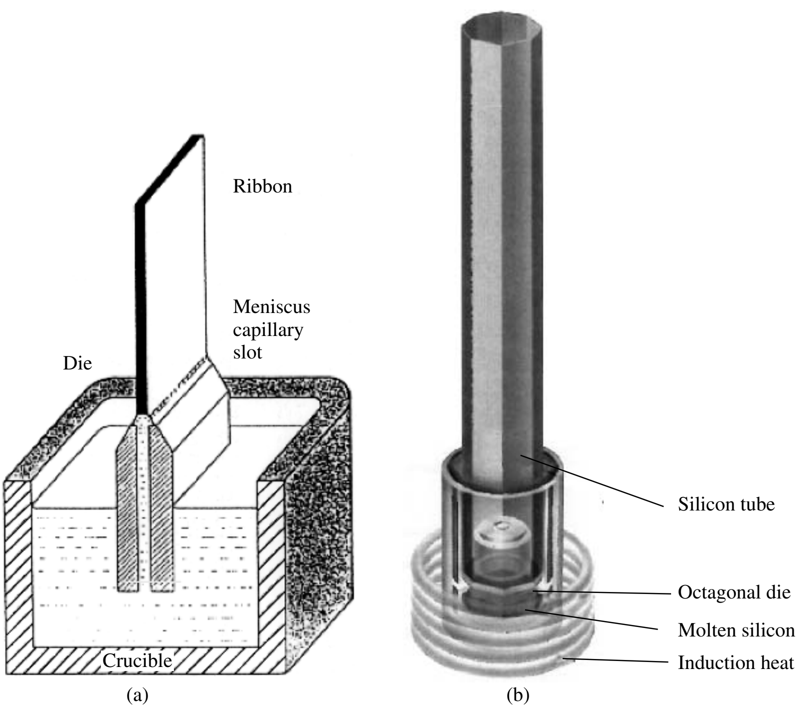

Figure 6.22 Schematics of Edge-defined Film-fed Growth (EFG) growth process: (a) ribbon die and crucible configuration and (b) octagon configuration