10.45

They are done vertically so that the gravitational force does not interfere with the operation. The height of ceilings is dictated by product requirements. The height is large enough so that the blown tube can be cooled from a semi-molten state to a solid state suitable for compression, cutting and recoiling.

10.57

By the student. Students should be encouraged to develop answers that rely on their personal experience. The advantages include (a) the low friction of polymers, even when not lubricated), (b) wear resistance, (c) good damping characteristics, so that sound and impact forces are not as severe with plastic gears), and (d) manufacturing characteristics that allow the production of tooth profiles with superior surface finish (see Section 8.10.7). The main drawbacks to polymer gears are associated with low stiffness, especially at elevated temperature, and lower strength than metals (so the loads that can be transferred for an equivalent sized gear is much lower), but they would be suitable for motion translation.

10.60

If a polymer's chemistry can be identified, then a polymer product can be cut into small pieces (such as pellets or particles) and fabricated as is done with so-called virgin thermoplastics. There is some degradation of mechanical properties and a measurable loss of molecular weight, but if properly sorted (see top of p. 607), these drawbacks can be minimized. It is difficult to recycle thermosets because it is impossible to break down a thermosetting resin into its mer components. Thus, the manufacturing strategies for the original polymer and for its recycled counterparts have to be different. Furthermore, thermosets cannot be melted, or chopped up as would thermoplastics.

10.91

Refer to the following figure:
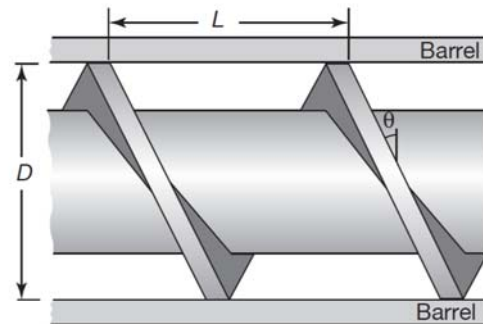
The relationship between the screw angle, θ, the lead, L, and diameter, D, can be best seen by unwrapping a revolution of the screw. This gives

$$\theta = \tan^{-1}\left(\frac{L}{\pi D}\right)$$

For $L = D$, we have

$$\theta = \tan^{-1}\left(\frac{D}{\pi D}\right) = \tan^{-1}\left(\frac{1}{\pi}\right)$$

Therefore, $\theta = 17.6°$.

13.6

Wet etching involves liquid-based solutions into which the workpiece is immersed. The process is usually associated with high etch rates and isotropic etch patterns, and is relatively easy to mask. Dry etching usually involves placing the workpiece into a chamber with gas or plasma, and the plasma drives the etching process. The process is usually associated with low etch rates and anisotropic etching, and is more difficult to mask.

13.17

LIGA is an acronym from the German terms X ray *Lithographie, Galvanoformung und Abformung*, or x-ray lithography, electroforming and molding, as shown in Fig. 13.44 on p. 852. LIGA has the capability of producing MEMS and micromechanical devices with very large aspect ratios. The operation also allows the production of polymer MEMS devices and the mass production of MEMS devices, since the LIGA-produced structure is a mold for further processing.

13.20

As described in Section 13.8.2, chemically assisted ion etching is one type of dry etching. Dry etching involves etching in a plasma, and chemically assisted ion etching uses chemical reactive species in the plasma to remove material, and the ion bombardment is used to help remove the chemical species attached to the surface.

13.24

A die is a completed integrated circuit. A chip is the portion of the wafer used to construct integrated circuits. A wafer is a slice of a single crystal silicon cylinder. It should be noted that there are many dice on a chip, and a chip is part of a wafer.

13.57

For a trench depth is 10 μm, then from Eq. (13.4) on p. 807, we obtain the undercut x as

$$AR = \frac{E_1}{E_2} = \frac{10 \ \mu m/t}{x/t} = \frac{10 \ \mu m}{x}$$

The sidewall slope, θ, is given by

$$\tan \theta = \frac{x}{10 \ \mu m}$$

The following table can now be constructed:

Anisotropy ratio	Undercut, x, (μm)	Side wall slope, θ (°)
200	0.05	0.28
2	5	26.6
0.5	20	63.4