The purified trichlorosilane is then redistributed in two separate steps through fixed bed columns filled with quarternary ammonium ion exchange resins acting as catalyst to both redistribution equations (5.34) and (5.35):

$$2HSiCl_3 = H_2SiCl_2 + SiCl_4 \tag{5.34}$$

$$3H_2SiCl_2 = SiH_4 + 2HSiCl_3 \tag{5.35}$$

Products of (5.34) and (5.35) are separated by distillation. Tetrachlorosilane and trichlorosilane are recycled to the hydrogenation (5.33) reactor and the first redistribution step (5.34), respectively. Silane is further purified by distillation and then pyrolysed to produce polysilicon onto heated silicon seed rods mounted in a metal bell-jar reactor:

$$SiH_4 = 2H_2 + Si \tag{5.36}$$

With hydrogen and chlorine recycled, the only raw material requirement is of metallurgical grade silicon in granular form designed for fluidisation. Because equations (5.33) to (5.35) yield low portions of suitable products and because distillation has to take place after each of them, the intermediates tri- and tetrachlorosilane are recycled and purified many times before conversion to silane. This results in extremely high purity for the silane and the subsequent polysilicon. This is operated as a closed-loop process, not as a batch process.

Other advantages of using SiH_4 are that the pyrolysis may be operated at significantly lower temperature, the decomposition is complete, conversion efficiency is higher and no corrosive compounds are formed. Uniform, large-diameter, long, dense, void-free cylindrical rods of polysilicon produced this way are particularly suitable for single-crystal manufacturing by the floating zone (FZ) method.

The disadvantage of the monosilane-based process is the higher cost of the volatile molecule, since additional steps are requested to convert trichlorosilane to monosilane. Moreover, the recycling of unsuitable chlorosilanes is compulsory when choosing this option because the redistribution equations yield only a small percentage of the suitable silane.

5.4.3 The Ethyl Corporation Process

This process was developed by the US company Ethyl Corporation at the same time, in similar conditions and political context as the above-described Union Carbide process. Although managed differently, the outcome of both projects was similar in the sense that both shifted their focus from solar grade polysilicon and ended up as new commercial polysilicon processes serving the electronic industry. The Ethyl Corporation process is, by comparison with the Siemens and the Union Carbide processes, revolutionary in all aspects except the concept of purifying and decomposing a volatile silicon compound by pyrolysis.

The first radical change was the choice not to use metallurgical grade silicon as the primary raw material for silane. The idea was to make use of silicon fluoride, which is a waste by-product of the huge fertiliser industry. Tens of thousands of tonnes of silicon fluoride every year are available. This is potentially a very low-cost starting