A 35 Platinum metals (Ir, Os, Pd, Rh, Ru) and their alloys

It is known that hydrogen can be easily absorbed by palladium and diffuses through palladium. Compact metallic palladium is able to dissolve hydrogen of an amount of about 600 times its volume at room temperature, finely dispersed palladium dissolves 850 times, an aqueous suspension of microdispersed palladium 1,200 times and colloidally dissolved palladium even 3,000 times its volume.

Palladium belongs to the metals in which dissolved hydrogen leads to the formation of two phases ($\alpha + \beta$) with different hydrogen concentrations. Both phases are solid solutions of hydrogen in palladium, have the same crystal structure with a face-centered cubic lattice, however with different lattice parameters, and different solubility for hydrogen (in [51] p. 183–185). At room temperature the lattice constants a of pure palladium are 3.886×10^{-10} m for the α-phase and 4.020×10^{-10} m for the β-phase. The hydrogen solubility limit is H/Pd $\approx$ 0.03 in the α-phase and 0.65 in the β-phase.

Figure 159 shows the lattice constants for the palladium-hydrogen system as a function of the temperature [186] (quoted in [51]). As the temperature increases, the lattice constants approximate the two parallel phases and reach the same value at the critical temperature of about 300 °C. Then, the corresponding values for the concentration and the pressure of hydrogen are H/Pd $\approx$ 0.27 and $p_{H2} \approx$ 22 bar.

Tests regarding the solubility of hydrogen in palladium and palladium-silver alloys are described in [187]. The examined alloys had a silver content of 10, 20, 23, 26, 29 and 40%. The tests were performed in a temperature range from 100 °C to

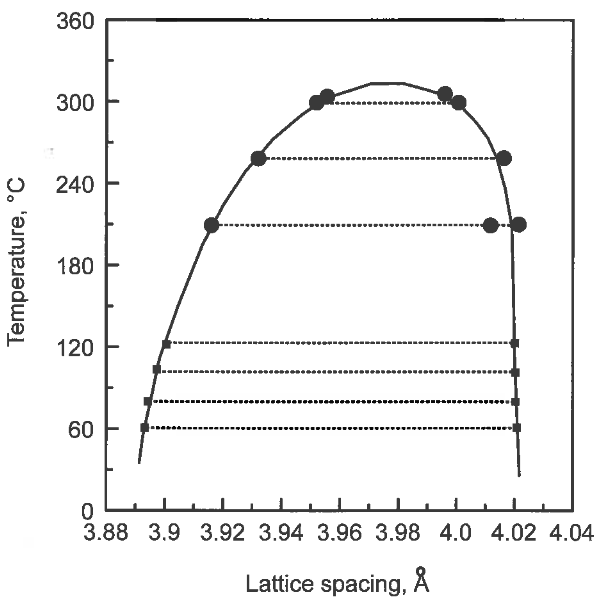

Figure 159: Lattice parameters for the α- and β-phase in the palladium-hydrogen system [186]

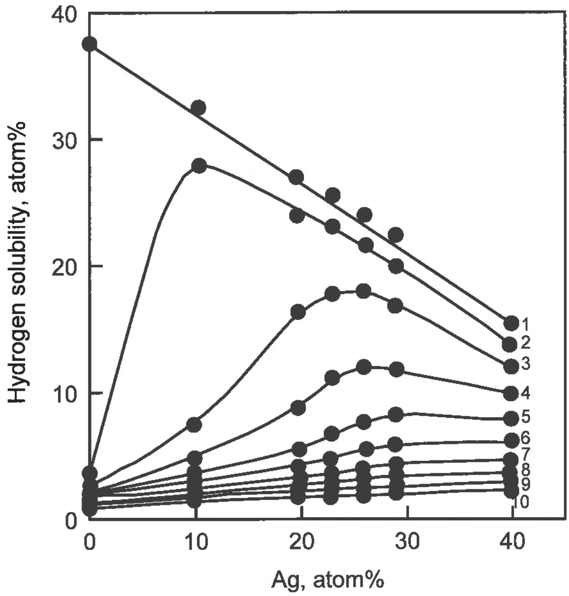

Figure 160: Solubility of hydrogen in palladium–silver alloys with different silver contents at different temperatures in °C 1) 100, 2) 140, 3) 180, 4) 220, 5) 260, 6) 300, 7) 350, 8) 400, 9) 450, 10) 500 [187]

500 °C at a hydrogen pressure of 760 mm Hg. The results of the examinations are summarized in Figure 160.

The solubility for hydrogen decreases with increasing temperature. In the temperature range from 300 °C to 500 °C the solubility slightly increases with increasing silver content of the alloys up to the highest examined content of 40% silver. At temperatures below 300 °C the solubility maximum shifts to lower silver contents and is reached at 140 °C for the alloy with 10% silver. The highest solubility in pure palladium is found at 100 °C. Since in the silver-hydrogen system at temperatures below the range from 140 °C to 160 °C the β-phase is more stable with the highest solubility for hydrogen, it is assumed that with an increasing silver content of the alloy the tendency to form the β-phase and, hence, the solubility from about 25% silver decreases.

Ready diffusion of hydrogen through palladium and palladium-silver alloys makes this material interesting as a diffusion cleaner for hydrogen and as a hydrogen electrode in fuel cells. The dependence of hydrogen diffusion through the palladium membranes on the partial hydrogen pressure on the entry and exit sides is of special importance to the separation of hydrogen from mixtures with other gases. The studies described in [188] examined the relationship between the partial pressure, temperature, diffusion rate and permeability of technically pure hydrogen through 0.015 mm thick membranes from palladium and a palladium-25% silver alloy. The non-dried hydrogen had the nominal composition indicated in Table 127 and contained about 2.5% moisture.