6.1 Introduction

Our discussions to this point on the use of semiconductor materials for photo-assisted water splitting have been predicated on the use on a clearly defined anode and cathode geometry as initially described by Fujishima and Honda [1] where the hydrogen and oxygen are evolved separately. While this approach offers the fundamental advantage that no gas separation step is required, the photoconversion efficiency suffers from losses inherent in the transport of the photogenerated electrons and $\text{H}^+$ ions from the anode to the cathode. In variations on a water-splitting theme, in 1977 Schrauzer and Guth used a TiO$_2$-based photocatalyst to carry out the photocatalytic decomposition of water vapor under UV light [2], resulting in the simultaneous co-generation of oxygen and hydrogen. Subsequent efforts investigated the use of various doped TiO$_2$ surfaces for direct photocatalytic splitting of water vapor [2-5] with the mixed evolution of hydrogen and oxygen. Effectively, rather than an electrode-based electrochemical cell each semiconductor particle can behave as its own electrochemical cell, see Fig. 6.1, being considered as a micro-homogenous or micro-heterogeneous system. The logical extension of this idea, bulk to planar to particulate, is a dispersion of semiconductor nano ‘particles’ of various geometry, e.g. sphere, tube, ribbon, or wire, see Fig. 6.2, throughout either liquid or vapor phase water resulting in the photocatalytic splitting thereof. The concept offers an appealing simplicity that has gained considerable academic interest.
Fig. 6.1: A schematic drawing of a semiconductor particle behaving as its own electrochemical cell for water splitting.

Fig. 6.2: A schematic diagram showing suspended nanomaterials in the form of spheres, rods, tubes or wires dispersed throughout some water. Under solar light illumination, hydrogen and oxygen evolved from these small particles. A membrane is placed atop the reaction vessel to separate $\text{H}_2$ and $\text{O}_2$. 