Production of Solar Grade Silicon and Oxygen in an Environmentally Friendly and Cost Effective Process

Jeffrey Lin[1], Yihong Jiang[2], Uday B. Pal[2, 3]
[1]Fremont High School, Sunnyvale, CA 94087, USA
[2]Division of Materials Science and Engineering, Boston University, Brookline, MA 02446, USA
[3]Department of Mechanical Engineering, Boston University, Boston, MA 02215, USA

ABSTRACT

Currently, silicon is mainly produced through the Siemens process, which is rather energy intensive and releases many greenhouse gases. Solid oxide membrane (SOM) electrolysis technique, an environmentally friendly and cost effective process, is employed to produce solar-grade silicon. A SOM electrolysis experiment has already been conducted to successfully produce silicon. A liquid tin cathode was employed for silicon deposition and a one-end closed yttria-stabilized zirconia (YSZ) membrane was employed to separate a liquid tin anode from a molten flux salt containing silica. When an applied electric potential between the cathode and the anode exceeds the dissociation potential of silica, the silicon cations are reduced to silicon at the liquid tin cathode. At the same time, the oxygen ions are pumped through the YSZ membrane and react with hydrogen flowing through the liquid tin anode to form water vapor. Instead of oxidizing oxygen ions with hydrogen gas, the liquid tin anode can be replaced by an inert liquid silver anode to allow the evolution of pure oxygen. The inert anode current collector is made from an Inconel 601 alloy rod, a strontium-doped lanthanum manganite ($La_{0.8}Sr_{0.2}MnO_{3-\delta}$ or LSM) bar, and silver paste. This inert anode current collector contacts the inert liquid silver anode and allows for the direct production of silicon without the need for hydrogen gas. With the proposed inert anode design, both solar grade silicon and pure oxygen will be produced without the release of harmful greenhouse gases into the environment.