Energy Conservation, CO₂, and Other Greenhouse Gas Reduction

Lifeng Zhang and Neale R. Neelameggham

Energy conservation as well as CO₂ and other greenhouse gas reduction present long-term challenges to our society, and the problems are exacerbated by the rapid consumption of materials and energy and significant emissions of greenhouse gas and toxic gases. By 2050 the world's oil production will be half of what it is today. Capping CO₂ in the atmosphere at 450 ppmv will require its sequestration. Metallurgical industries and transportation systems are the main energy users and the main producers of greenhouse gas.

Production of renewable energy and saving energy in metallurgical processing are two keys to energy conservation. As an example, solar cell energy is a well known renewable energy and it is claimed as a green energy by most people. However, if the feedstock, especially for multi-crystalline silicon, is included, solar cell energy is not a green energy since during the production of the high purity silicon, significant energy is consumed, much CO₂ is emitted, and several non-green processes, such as strong acid leaching, are included. Furthermore, during the wafer slicing process of a high-purity silicon ingot, over 50% becomes slurry wastes and there are no successful industrial processes to recycle these valuable wastes. In order to save energy, traditional industrial processes should be optimized. Furthermore, reuse, recycling, and recovery of metals and materials should be emphasized since these processes usually use less energy than the primary production processes.

The control of CO₂ and other green-

house gas has been studied for many years. However, recently more and more topics are changing from "control" to "utilization"—utilizing CO₂ and other greenhouse gas for other processes. In many situations, it is difficult to control or prevent the emission of CO₂, while, the utilization of CO₂ as raw gas to produce other materials (gases) is much easier under special conditions. Then, CO₂ becomes a useful gas rather than a greenhouse gas only.

In this *JOM* topic, two papers consider production and recycling of solar-grade silicon and its wastes, and three discuss how to utilize CO₂ for metallurgical processes.

In the first paper, A. Dong and co-authors review different kinds of wastes resulting from the production of solar grade silicon and discuss the possible technologies to recycle and purify SoG-Si wastes, such as filtration, sedimentation, solidification control, electromagnetic separation, plasma oxidation, centrifugation, and a high temperature remelting process.

Next, Yubo Jiao et al. review the state of the art in the Siemens and Siemens-like processes for the production of high-purity silicon for photovoltaic industries, and discuss their energy payback time and lifetime carbon emissions.

In the third paper, Peter G. Loutzenhiser et al. introduce a two-step solar thermochemical cycle for producing syngas from H₂O and CO₂ via Zn/ZnO redox reactions. The first, endothermic step is the thermolysis of ZnO to Zn and O₂ using concentrated solar radia-

tion as the source of process heat. The second, non-solar, exothermic step is the reaction of Zn with mixtures of H₂O and CO₂ yielding high-quality syngas (mainly H₂ and CO) and ZnO; the latter is recycled to the first solar step, resulting in net reactions CO₂ = CO+0.5O₂ and H₂O = H₂+0.5O₂.

Next, K. Ogura and M.D. Salazar-Villalpando report on a study on the electrochemical reduction of CO₂ utilizing halide ions of KCl, KBr, and KI as electrolytes. The working electrode was a copper mesh, while the counter and reference electrodes were a Pt wire and an Ag/AgCl electrode, respectively. The stronger the adsorption of the halide anion to the electrode, the more strongly CO₂ is restrained, resulting in higher CO₂ reduction current.

Finally, Animesh Jha discusses a 19th century process of solubilizing alumina from bauxite by Louise Le Chatelier. Jha and coworkers investigated alkali roasting reactions of bauxite and red mud below 900°C in air, followed by leaching for selective separation of Al(OH)₃, Fe₃O₄ and ilmenite. The high-temperature process reduces waste by producing co-products such as ilmenite, magnetite, and sodium silicate. The CO₂ generated from alkali decomposition is recycled in the process for regenerating NaHCO₃.

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