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Analysis, modelling and simulation of hydrogen peroxide ultrapurification by multistage reverse osmosis

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ABSTRACT

Very high purity chemicals are required for preparation of semiconductor materials and manufacture of printed circuit boards because low presence of metallic impurities is needed to avoid defects on silicon surface. Hydrogen peroxide is one of the most demanded chemical by the semiconductor industry and it must be submitted to ultrapurification processes to achieve the exigent requirements the chemical must fulfill to be accepted for semiconductor uses. In this paper, the potential of multistage reverse osmosis processes to reduce the metallic content of technical grade hydrogen peroxide below the limits fixed by the semiconductor industry is investigated. SEMI Grade 1 quality hydrogen peroxide was obtained by a two-pass reverse osmosis process in an experimental lab scale. A model based on Kedem-Katchalsky transport equations together with system material balances was proposed to describe the behavior of the installation. A full analysis of the influence of the design (recovery rates) and operation (applied pressures) variables over the performance of a simulated industrial scale plant was carried out. The economic viability of the simulated plant was demonstrated.

Keywords: Ultrapurification; Electronic grade chemicals; Hydrogen peroxide; Reverse osmosis

1. Introduction

There is probably no industry more concerned for and committed to contamination control than the semiconductor industry. The production of semiconductor devices requires very exigent demands for the environment and the equipment. All the critical manufacturing steps are performed under cleanroom conditions in order to minimize contamination in the working environment and semiconductor manufacturing equipment is made of non-contaminating materials. The chemicals and materials used to manufacture and package semiconductors and printed circuit boards are considered electronic chemicals (Daigle et al., 2007). The purity of these electronic chemicals is as important as the environment and the equipment. A typical silicon wafer might be treated with several different liquids (wet electronic chemicals) during the manufacturing process. Because the wet chemicals are in intimate contact with silicon surfaces, their particulate and ionic impurity levels are of great concern. Particles that adhere to the wafers can cause short circuits or open circuits resulting in devices failure (Duffalo and Monkowski, 1984). Metallic ionic impurities also entail problems: certain metals and other ionic impurities are known to deposit on bare silicon or silicon dioxide. These trace impurities on the surfaces of silicon wafers adversely affect the electrical characteristics of silicon devices: they cause a loss of oxide integrity and act as minority carrier lifetime killers (Atsumi et al., 1990).

Hydrogen peroxide (H_2O_2) is one of the most employed wet electronic chemical (Sievert, 2001) because of its use for cleaning silicon wafer surfaces of foreign contaminants, removing photoresists or etching copper on printed circuit boards (Daigle et al., 2007). Most usual cleaning baths for silicon wafer surface cleaning (SC1, SC2 or SPM) include hydrogen peroxide in their formulations (Olson et al., 2000). Said baths remove particulate, organic and metallic pollutants from silicon surfaces. Semiconductor Equipment and Materials International (SEMI) is the global industry association serving the manufacturing supply chains for the microelectronic, display and photovoltaic industries. This entity

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