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Removal of fluoride, SDS, ammonia and turbidity from semiconductor wastewater by combined electrocoagulation–electroflotation

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HIGHLIGHTS

- Organic and inorganic pollutants from semiconductor wastewater were successfully removed by the EC-EF.
- Both SDS and F^- exhibit a good removal by EC while ammonia is weakly sensitive to EC.
- In EF step, in addition of the separation solid/liquid, ammonia oxidation may be efficiently achieved.
- The introduction of the hybrid anode leads to less energy and soluble electrode consumption.

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ABSTRACT

Semiconductor industry effluents contain organic and inorganic pollutants, such as sodium dodecyl sulfate (SDS), fluoride and ammonia, at high levels which consists a major environmental issue. A combined EC–EF process is proposed as a post-treatment after precipitation for simultaneous clarification and removal of pollutants. In EC step, a hybrid Fe–Al was used as the soluble anode in order to avoid supplementary EC step. EC-Fe is more suitable for SDS removal; EC-Al is more suitable for fluoride removal, while EC with hybrid Al-Fe makes a good compromise. Clarification and ammonia oxidation were achieved in the EF step. Effects of anodic material, initial pH, current, anion nature, chloride concentration and initial pollutant concentration were studied. The final concentrations may reach 0.27, 6.23 and 0.22 mg L^{-1} for SDS, fluoride and ammonia respectively. These concentrations are far lower than the correspondent discharge limits. Similarly, the final turbidity was found 4.35 NTU which is lower than 5NTU and the treated water does not need further filtration before discharge. Furthermore, the EC-EF process proves to be sufficiently energy-efficient with less soluble electrode consumption.

1. Introduction

In the semiconductor industry, buffered solutions (BHF) are currently used in the process of etching and cleaning of silicon wafers. These solutions are prepared by mixing HF and NH_4F at different proportions (Yang et al., 2001). The use of BHF solutions allows to make HF less reactive, and then to get a better control over the reaction. In addition, surfactants such as sodium dodecyl sulfate (SDS) are often added to the acidic solutions in order to minimize particles adhesion on wafer surface (Veeramasuneni et al., 1998). Consequently, this type of process may generate wastewaters rich in mixed toxic compounds. In fact, fluoride, ammonia, and SDS are found at higher levels. Fluoride-containing wastewater contributes to 40% of hazardous waste produced by the semiconductor manufacturer with fluoride concentrations up to 3500 mg L^{-1} (Lin and Yang, 2004; Palahouane et al., 2015). The most common method to remove fluoride ions is precipitation by adding an excess of lime (Drouiche et al., 2011, 2013). However, this technique is insufficient to comply with environmental standards. Fluoride concentration can only be reduced to 25–60 mg L^{-1} (Huang and Liu, 1999; Lin and Yang, 2004). Moreover, effluents are beyond the discharge limits for some pollutants such as SDS and

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