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Degradation of Titanium Electrodes in the Alternating Polarity Electrolysis

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Electrolysis of water performed by microsecond voltage pulses of alternating polarity has been used to generate nanobubbles in microscopic systems. These nanobubbles exhibit interesting and useful effects, but their production requires a high current density of >10 A/cm^2. Deposited platinum or gold electrodes cannot withstand these conditions for a long time. Titanium showed the best durability, although it also undergoes degradation. The mechanism of degradation differs from that in usual DC electrolysis and was not previously explored. In this paper, the wear of thin film titanium electrodes fabricated on a silicon substrate by surface micromachining is investigated. The electrodes are tested in the alternating polarity process of various frequencies and durations. They are oxidized during operation, but the spatial distribution and chemical composition of the oxide differ from those observed in normal electrolysis. The strongest oxidation occurs at the edges of the electrodes, while the central part is less involved. At a high frequency of voltage pulses (400 kHz) the electrodes are oxidized much less than at low frequency (50–100 kHz). The oxide grows due to misbalance between periodic oxidation and reduction processes. Internal mechanical stress generated due to oxidation causes degradation of the electrodes.

Keywords: Water electrolysis; Alternating polarity; Electrodes; Oxidation; Degradation;

FULL TEXT