Use of a Simple Cavitation Cell Set-up with Replaceable Single Band Filters for Analysis of Sonoluminescence Signal from Megasonic Irradiated Gasified Aqueous Solutions

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Two types of phenomena, namely acoustic streaming and cavitation, are known to occur during acoustic irradiation of liquids. In the transient cavitation process, due to high temperature conditions reached inside the bubble during its collapse, excitation of solvent molecules as well as formation of radicals are known to occur. When the excited species go back to the ground state, light is emitted, and this phenomenon is known as sonoluminescence (SL) [1, 2]. The intensity of SL can be a good predictor of the extent of feature damage on patterned wafers. Spectral analysis of SL signals to identify various species generated in a meagasonic field at power densities of interest to the wafer cleaning community is very difficult due to extremely weak nature of the signal.

The SL signal generated in aqueous solutions containing dissolved gases was collected using a modified version of cavitation threshold (CT) cell described by the authors in an earlier publication [3]. Specifically, a single band filter was sandwiched between the UV grade fused silica window in the cell and the photomultiplier tube (PMT) to characterize photon emission in a very narrow range of wavelengths. Four different single band filters were used; these are 280 – 305.5 nm, 300 – 340 nm, 335 – 375 nm and 374.5 – 397.5 nm. These filters were chosen based on the fact that excited hydroxyl radicals predominantly emit light in these specific wavelength ranges. Air, Ar or CO_2 containing DI water was pumped through the cell at 130 ml/min and irradiated with a 935 kHz transducer. The power density was ramped from 0.1 to 4.0 W/cm^2 in 90 sec. In some experiments, no filters were used and the spectral signal in the range of 280 – 630 nm was recorded using the PMT.

Figure 1 displays SL signal collected from air (a), Ar (b) and CO_2 (c) containing DI water as a function of power density at 100% duty cycle. The bar graphs in Figure 1 (d) compare SL intensity at specific wavelength ranges for an applied power density of 4 W/cm^2. The overall SL intensity from Ar saturated DI water is higher than that from air saturated DI water. In CO_2 containing DI water with ~90 ppm CO_2 (aq.) (at pH 4.53), the SL intensity is highly suppressed. This is perhaps due to the cushioning effect of CO_2 diffused into bubbles that reduces violent collapse. As may be seen from Figure 1 (d), in the wavelength range of 280 to 400 nm, the SL intensity from Ar saturated water exhibits a maximum at a wavelength range (300 to 340 nm and 335 to 375 nm) characteristic of emission from excited hydroxyl radicals.

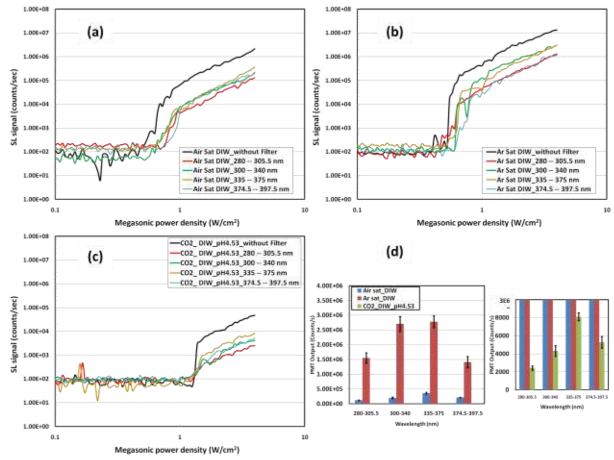

Figure 1: SL intensity from air (a), Ar (b) and CO_2 (c) containing DI water and comparison (d) at different wavelength ranges.

In air saturated solution such a maximum is also present but not very pronounced. In CO_2 containing water, the SL signal is very weak in the entire wavelength region investigated, indicating suppression of hydroxyl radical formation.

The results from air and Ar saturated DI water are consistent with results reported in the literature that were obtained using expensive spectrometers. The methodology reported in this work is simple, inexpensive and capable of capturing SL spectral features due to hydroxyl radicals.

References

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