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A Glimpse into Megasonic Cleaning

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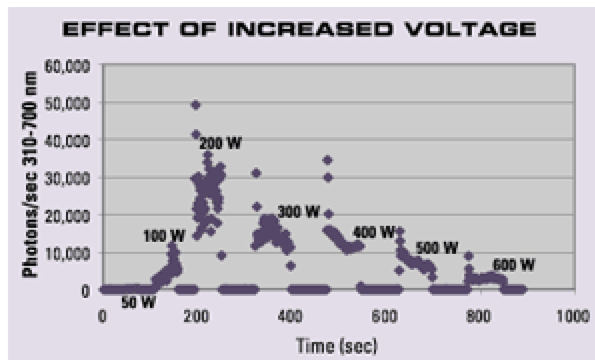
Semiconductor International

Megasonic cleaning is widely used for removing particles from wafer surfaces, but is it clearly understood? In general, there are two principal classes of mechanisms through which megasonic cleaners could accomplish cleaning: through a direct action of the sound field with the particle; and through indirect action, via acoustic cavitation. Most likely, particle removal from silicon wafer surfaces is associated with cavitation.

Until now, cavitation has been a difficult phenomenon to monitor; yet, its presence is essential to cleaning. Scientists at SEZ America Inc. (Mountain View, Calif.), in conjunction with the Center for Industrial and Medical Ultrasound at the Applied Physics Laboratory of the University of Washington (Seattle), developed a real-time, prototype cavitation probe to determine the temporal and spatial characteristics of the cavitation field. Experiments performed on a megasonic cleaner provided information on cavitation behavior, which unexpectedly resulted in a better understanding of megasonic cleaning. In fact, some assumptions were shown to be inaccurate. Detailed research and results were reported in the September 2002 issue of *The Journal of the Acoustical Society of America* .

Let's start with the common knowledge that a megasonic cleaner operates more effectively at high electrical powers. Yet, there are times when the system is not cleaning effectively and power is increased beyond the saturation level, which continues to reduce cleaning effectiveness. Results from the experiments demonstrate that, in fact, higher power (in excess of 300 W) does not deliver effective cleaning (Figure). The researchers found that this reduced effectiveness at high powers is not caused by limitations in the electrical or transduction systems, but is a cavitating fluid effect. Specifically, if there is too much cavitation, the increased volume fraction of gas in the liquid prevents the acoustic field from propagating.



Results show that increasing the power to the transducers beyond a saturation level has a deleterious effect on the amount of cavitation generated, as well as on cleaning efficiency. (Source: SEZ America)

Another experiment examined the sonoluminescence flux within the cleaner — pre-existing gas-filled nuclei are necessary for cavitation inception. When the liquid remained undisturbed for 10 min, and then engaged, the level of cavitation activity was quite low after an initial spike, and slowly showed decreasing activity over a 2 min period. If nucleation sites were continually supplied by bubbling air through the liquid both before and during cleaner operation, similar behavior was observed; however, the level of cavitation activity was more than 3× higher.

In the last experiment, the system remained undisturbed for several minutes, then both the cleaner and the bubbler were engaged. Results showed that the level of cavitation activity gradually increased from the lower value, observed without the bubbler; to the higher value, observed when the bubbler was active — indicating that it would be better to bubble gas through the megasonic cleaner while it is in a cleaning mode.

Finally, it is believed that, in sequential operation, there is no need to move the silicon wafers in the tank because cavitation activity is homogeneously distributed over the entire cleaning region. Again, results indicate a different scenario. When the cleaning region was examined during sequential operation, the transducers generated a band of cavitation activity, with regions between the transducers generating very little cavitation. This explains the existence of uncleaned bands on wafers.

This body of works explains some of the mysteries behind megasonics. Yet, it leaves more unanswered questions. Will megasonic cleaning fit into future roadmap requirements? And what is the significance of bubbling air through the liquid?