Acoustic Characterization of a Photomask Cleaning System

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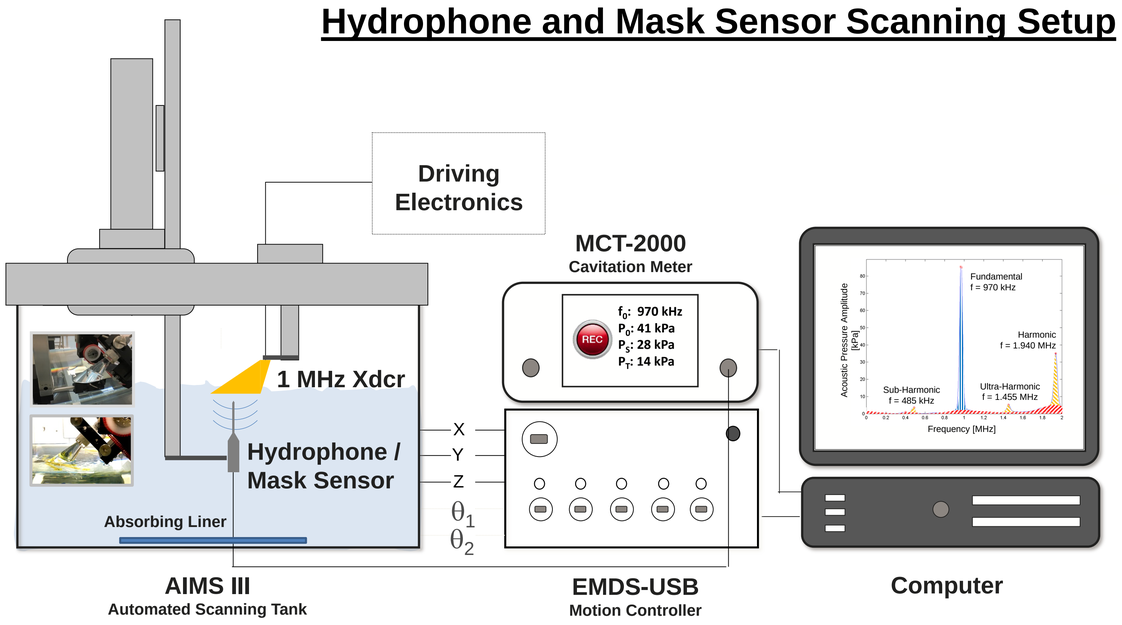
INTRODUCTION

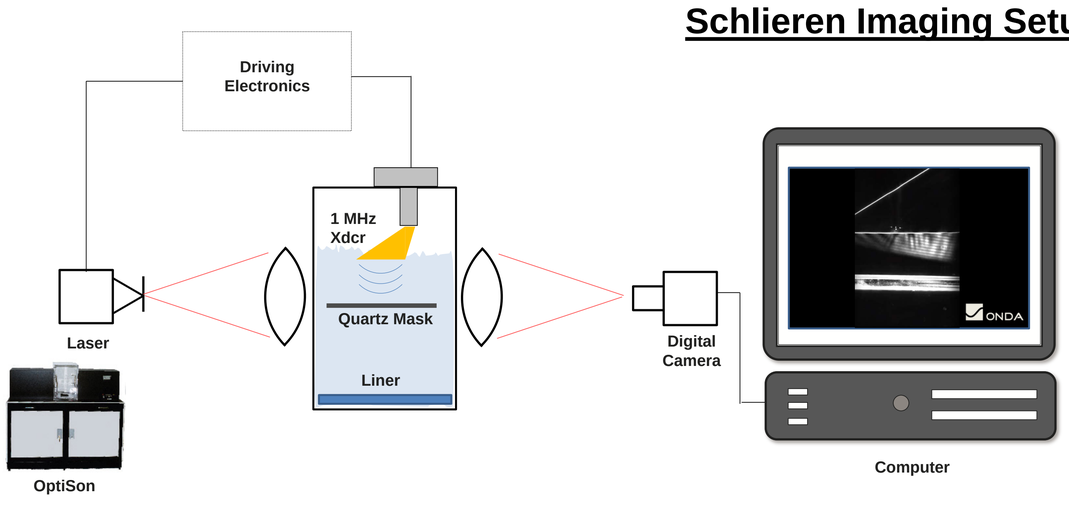
Although megasonic technology is widely used to clean photomasks, the acoustic performance is not well understood. Of all the process parameters that influence cleaning (e.g., temperature, flow, pH, gas concentration, mechanical translation, etc.) the characterization of the ultrasonic field remains elusive. The shift to EUV lithography processes elevates this issue further since the risk of yield loss is even higher in the absence of a pellicle. This study aims to achieve a deeper understanding of the complex acoustic behavior by presenting results from three independent measurement techniques.

METHODS

Hydrophone and Mask Sensor Scanning Setup

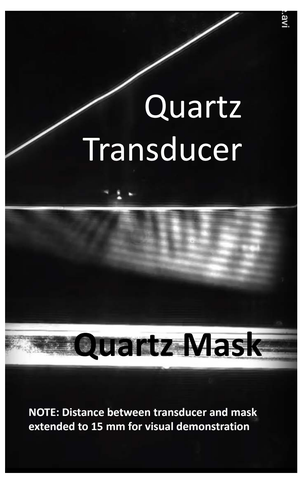


Schlieren Imaging Setup

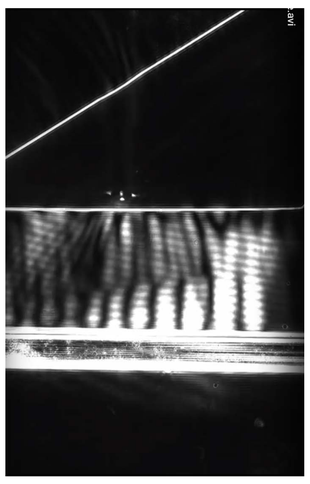


RESULTS & DISCUSSION

Schlieren Imaging (Access Full Video HERE)



Incident wave propagates at an offset angle from transducer

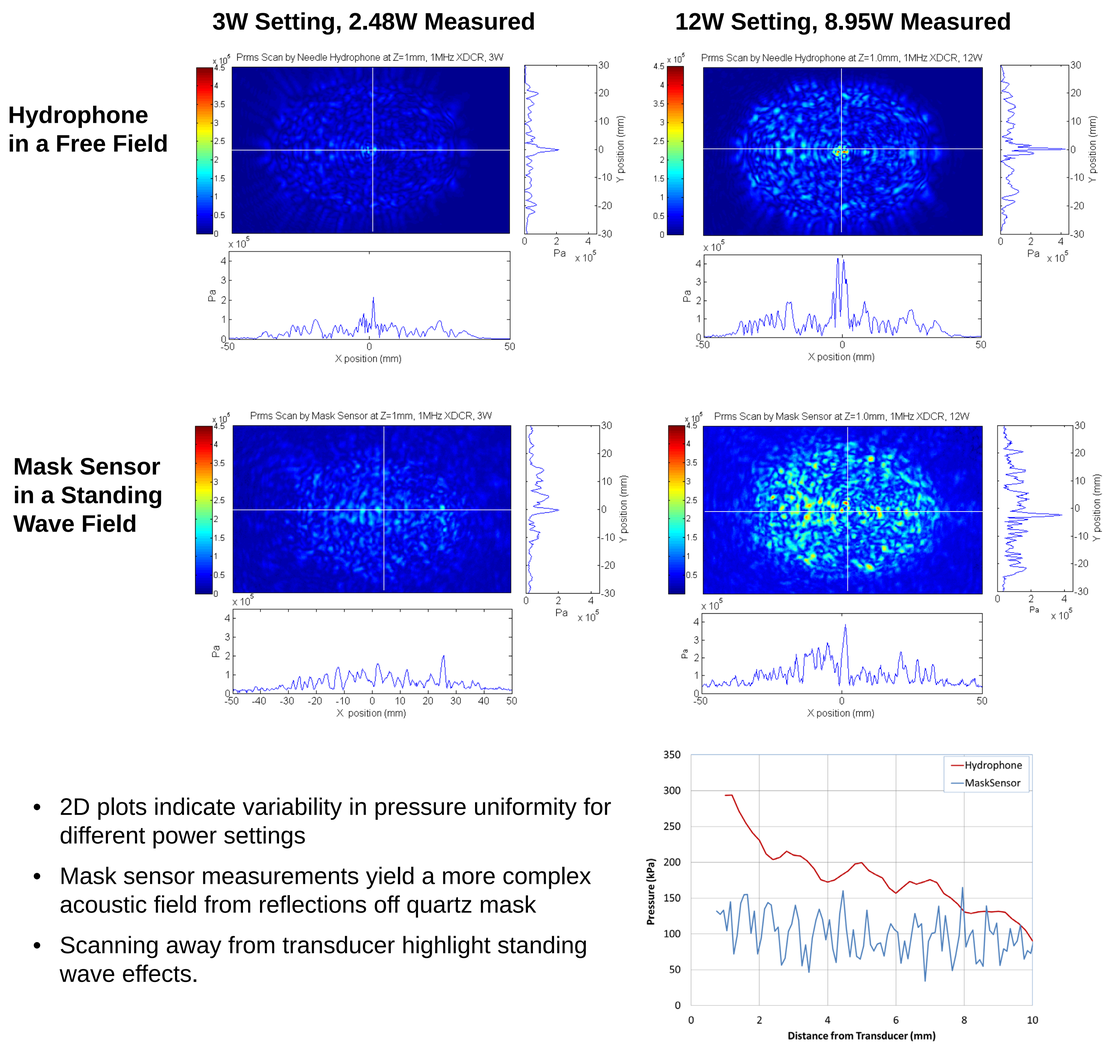


Incident wave disturbed by reflected wave from both top and bottom surface of quartz; some waves transmit through the quartz mask

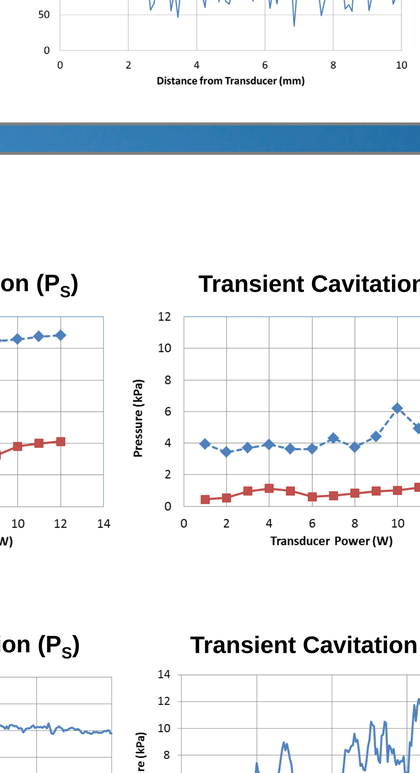
The resultant sound field reveal a complex pattern from multiple reflections

RESULTS & DISCUSSION

Total Pressure Uniformity

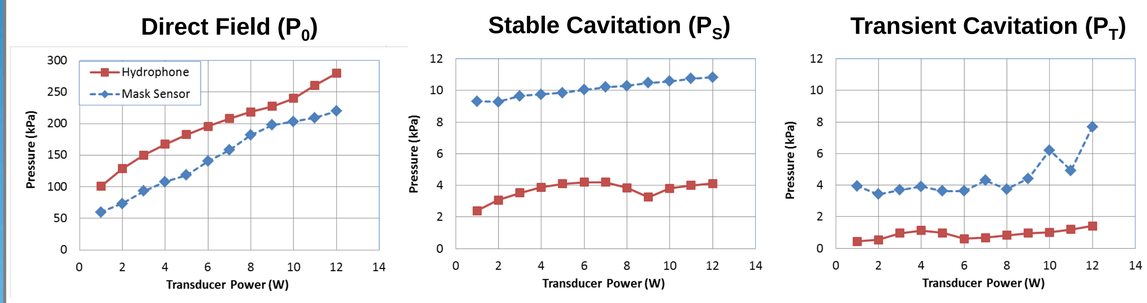


- 2D plots indicate variability in pressure uniformity for different power settings
- Mask sensor measurements yield a more complex acoustic field from reflections off quartz mask
- Scanning away from transducer highlight standing wave effects.

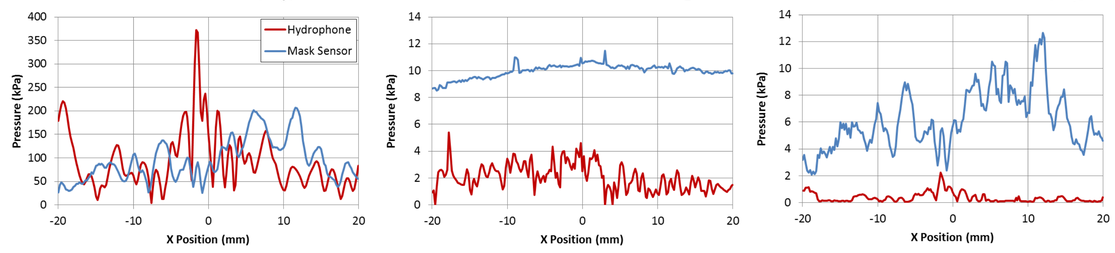


Direct Field and Cavitation Pressure

Cavitation vs. Power



Cavitation vs. Position



- Direct field pressure trend as expected with power, namely Power $\propto$ Pressure^2
- Low levels of stable and transient cavitation detected, even at high power levels
- Cavitation level increased with the presence of a photomask.

CONCLUSIONS

Different measurement techniques were used to better understand the acoustic performance of a megasonic photomask cleaning system. High spatial resolution maps characterized the acoustic field. Cavitation measurements indicated an absence of transient cavitation and low level stable cavitation. Schlieren imaging demonstrated the dynamic sweeping behavior on the mask surface. The culmination of these results help explain the novel cleaning performance.