Research Topic : **Shock Tube Pressure Amplification for LIP Nanoparticle Removal**
Duration : **1999-Present**
Sponsor(s) : **Intel Corp., SEMATECH, Praxair/Electronics, and CAMP**
Contact Person : **Dr. C. Cetinkaya, Assoc. Prof., cetin@clarkson.edu, (315) 268-6514**

**Synopsis of Research and Sponsored Projects**

Nanoscale substrate cleanliness is a critical requirement in nanotechnology and semiconductor applications. A novel particle removal technique based on Laser Induced Plasma (LIP) shockwaves has been introduced and evaluated for nanoparticle removal by the Photo-Acoustics Research Laboratory. An in-air and submerged method using shock tubes for amplifying the dynamic pressure of LIP shockwaves for removing sub-50 nm nanoparticles has been demonstrated.

Higher the LIP pressure generated, smaller the particles that can be removed. According to International Technology Roadmap for Semiconductors (ITRS) (2006 Update) the minimum front surface particle size that has to be cleaned from substrates, equivalent PSL nanosphere diameter ($d$), are $d \geq 65nm$ for 2009, $d \geq 45nm$ for 2012, and $d \geq 22nm$ for 2018.

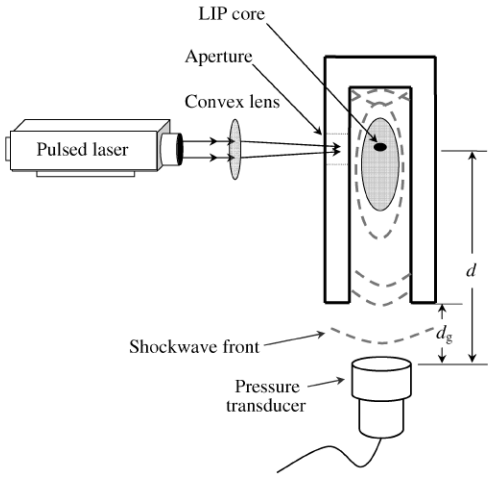


Fig. 1 In-Air Shock Tube

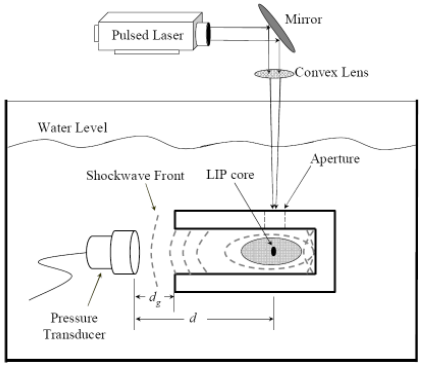


Fig. 2 Submerged Shock Tube

Constraining the expansion of the LIP core with a shock tube (Figs. 1 and 2) is a non-contact approach to increase pressure amplitude by an order of magnitude for removal of particles without damaging the substrate. The shock tube technique allows for higher pressures at distances significantly farther from the LIP core thus mitigating damage. The effects of sets of shock tubes to amplify the transient pressure of the LIP-generated shockwave fronts have been studied to evaluate their pressure amplification performances. Submerged shock tubes have resulted in highest transient pressure amplification with 6.48 MPa compared to 0.52 MPa for in-air shock tube (Fig. 3). Theoretically sub-10 nm PSL particle removal is predicted on silicon wafers utilizing submerged shock tubes.

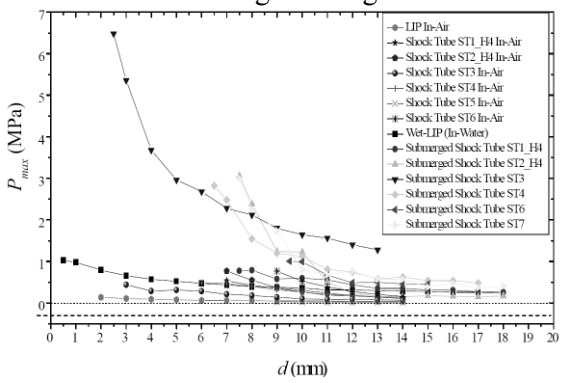


Fig. 3 Transient LIP Pressures with shock tubes

**Recent Publications**

**1.** T.J. Dunbar, M.D.M. Peri, I. Varghese, C. Cetinkaya, *Submerged Laser-induced Plasma amplification of shockwaves using shock tubes for nanoparticle removal*, J. Adhes. Sci. Technol 21(14), 1425-1437, 2007.

**2.** T. Dunbar, C. Cetinkaya, *Underwater Pressure Amplification of Laser-Induced Plasma Shockwaves for Particle Removal*, Appl. Phys. Lett., 91(5), 2007.

**3.** T. Dunbar, B. Maynard, D. A. Thomas, M. D. Murthy Peri, I. Varghese, C. Cetinkaya, *Pressure Amplification of Laser-Induced Plasma Shockwaves with Shock tubes for Nanoparticle Removal*, J. Adhes. Sci.. Technol, 21(1), 67-81, 2007.