Analysis of Reflected Laser Signal Disruption via Transparent Irregular Surfaces

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Introduction

- Laser microphones are surveillance devices that use projected laser beams to detect sound. A laser beam can be directed at a window or an object inside a room, reflected off of it, and returned to a receiver such as a light sensor (Hewitt et. al., 2007) (Fig. 1 and 2)
- Windows and certain objects vibrate according to the sound waves in a room, for example, when people talk, therefore, the differences in the amount of light according to the displacement of the laser by the sound waves, can be converted back into sound waves to eavesdrop (Wang et. al., 2009).
- If the laser being used is invisible to human beings (UV), then a person(s) in the room could be completely unaware that they are being eavesdropped on. The laser microphone can be potentially hazardous to the military as well as government agencies such as the FBI. By creating a defense against this dangerous spyware, these potential risks could be resolved.
- The KGB, the main security agency for the Soviet Union used laser microphones to spy on the British, French, and US embassies in Moscow (http://www.lucidscience.com/pro-laser%20spy%20device-18.aspx). In addition, the GCHQ, a British intelligence agency, feared that if Russian or Chinese agents were unsuccessful in penetrating the Guardian's computer systems, they might try to listen to journalists discussing the secretive files by using a laser microphone (Bryant 2013).
- Goal: To develop methods of reducing the viability of a modulated laser signal through transparent material while maintaining light transmittance.
- Hypothesis: If the reflected laser signal being modulated by vibration is scattered by a transparent irregular treatment, then the frequency or amplitude of the signal received will be altered.

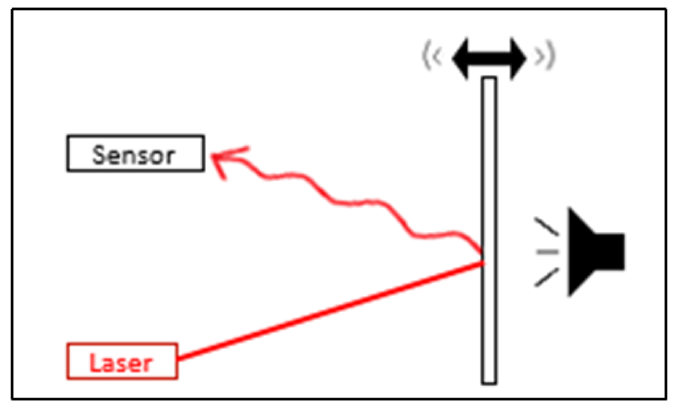

Fig. 1: Modulation of a laser based on vibrations of a window due to sound

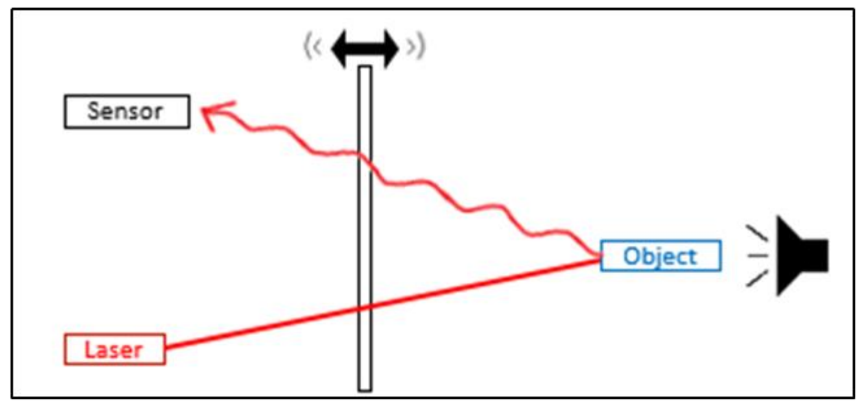

Fig. 2: Modulation of a laser based on vibrations of an inside object due to sound

Fig 3: Laser microphone constructed using a transparency as the reflectant and a photovoltaic cell.

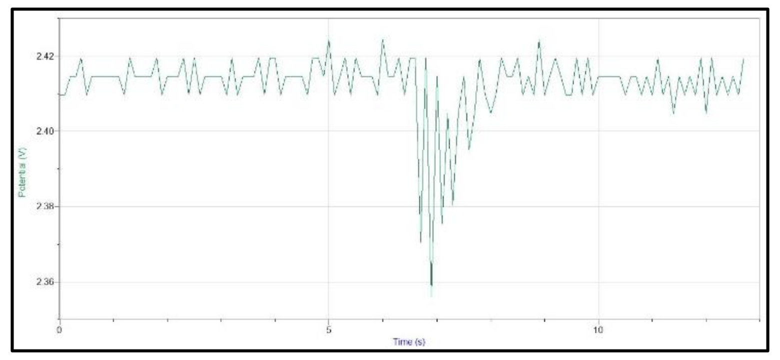

Fig 4: Laser microphone reflecting off a window as a word is spoken.

Methods

Phase I

- An Alpec Class IIIA <5mW HeNe Red Laser was directed through untreated(control) and treated(experimental) Apollo transparency films, onto a second transparency, connected and making contact with a piezoelectric disk, which was be modulated by a function generator at a frequency of about 1.0 Hz. The reflection of the modulated laser signal off the transparency was directed at a Vernier light sensor, connected to a Vernier data logger (Fig. 7).

Phase II

- A red laser will be directed through an untreated(control) and treated(experimental) transparency films, onto a second transparency. The reflection off the transparency will be directed through a spatial filter. This scattered signal (experimental) will be directed through a lens to condense the scatter and will be received by a Vernier light sensor, connected to a Vernier data logger (Fig. 10).

Phase III

- Light transmission trials: A 120V AC 450 Lumen LED was directed through each glass slide treatment at a 5cm distance (Table 1). The light output was measured with a Vernier light sensor (Fig. 13)

Phase IV

- Image quality trials: Each treatment was placed against a camera lens. Photographs of a printed word were taken at progressing distances.

Methods

Table 1: Composition of treatments on glass

Treatment	Method of Composition
Silicone Polymer	A transparency film coated with a thin layer of silicone polymer (Fig 6).
Nanoparticle-Epoxy Resin (2.68mm)	A thick mixture of silica nanoparticles and epoxy resin placed between two glass slides (Fig. 5).
Nanoparticle-Epoxy Resin (.171mm)	A thin mixture of silica nanoparticles and epoxy resin placed between two glass slides (Fig. 5).

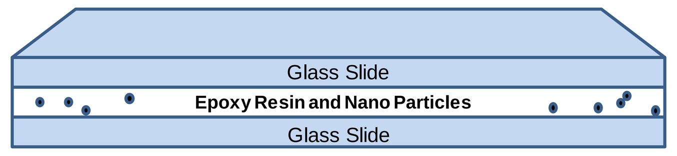

Fig. 5: Nanoparticle and epoxy resin

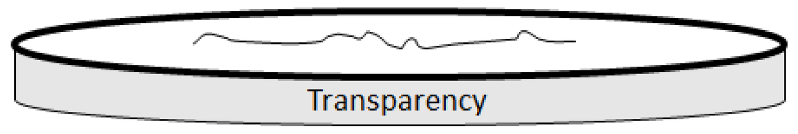

Fig. 6: Silicone polymer

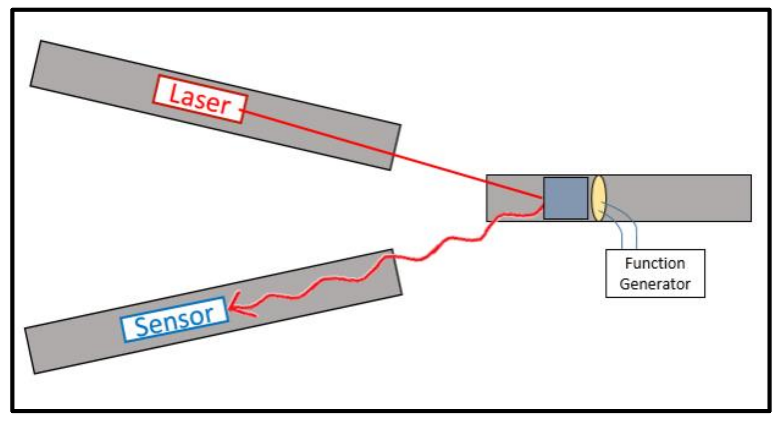

Fig. 7: : Irregular surfaces of treatments were tested for their ability to facilitate disruption of a modulated laser signal via specular reflection.

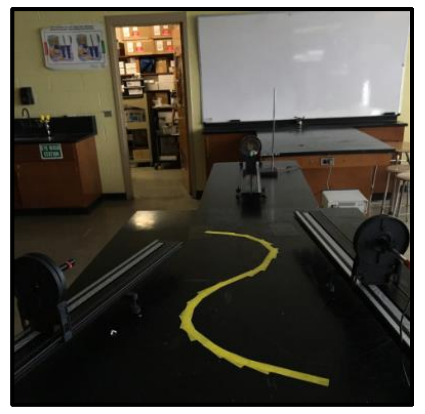

Fig. 8: Trial setup with reflected laser, piezo, light sensor, and data logger.

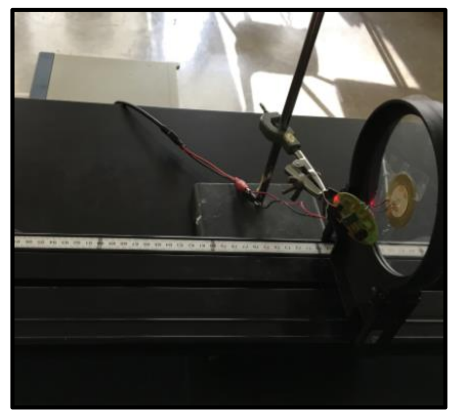

Fig. 9: Piezo modulation by function generator.

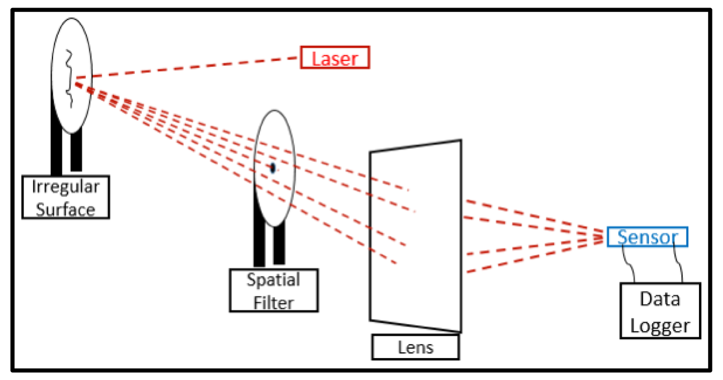

Fig. 10: Irregular surfaces of treatments were tested for their ability to produce scatter

Fig. 11: Trial setup with reflected laser, spatial filter, lens, light sensor, and data logger.

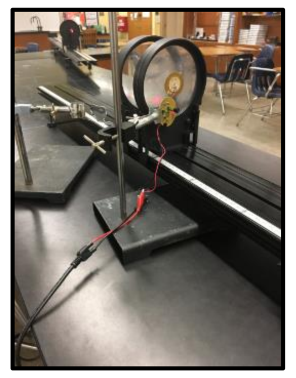

Fig. 12: Spatial filter configuration.

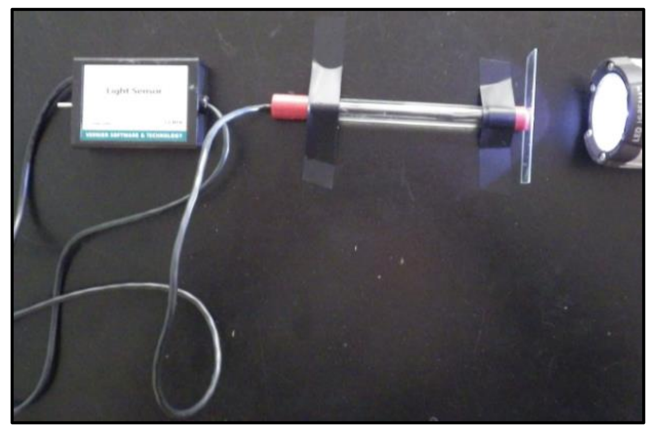

Fig. 13: Light transmittance test using a light source and Vernier light sensor

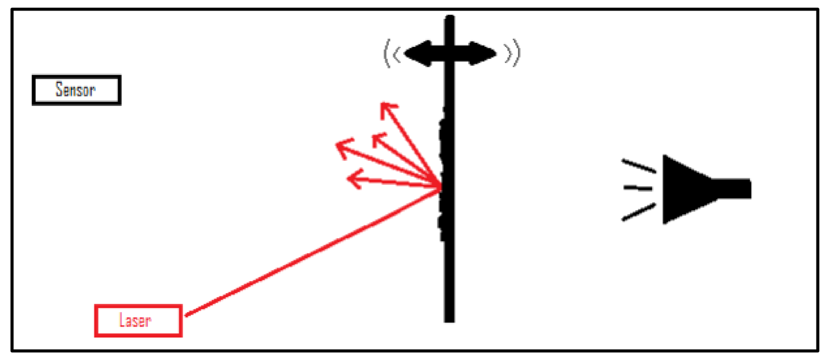

Fig. 14: Scattering or diffuse reflection of the laser beam due to a transparent irregular surface.

Results

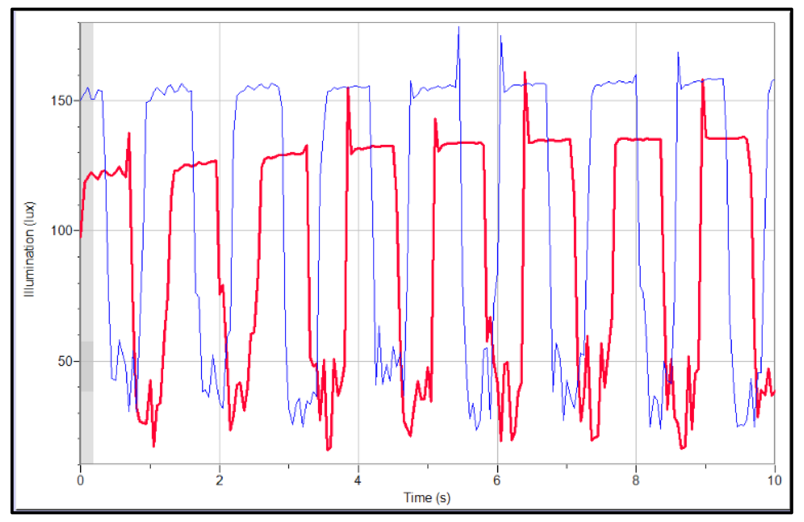

Fig. 15: Nanoparticle-Epoxy Resin (0.171mm) treatment ($p<0.0001$).

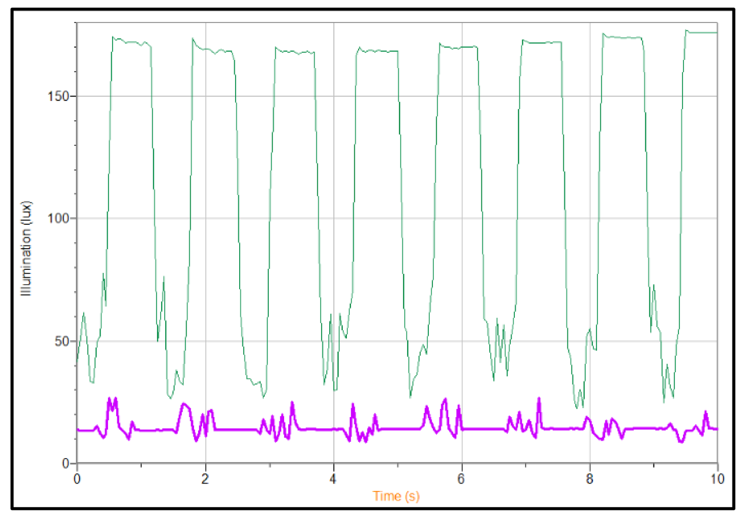

Fig. 16: Nanoparticle-Epoxy Resin (2.68mm) treatment ($p<0.0001$).

Results

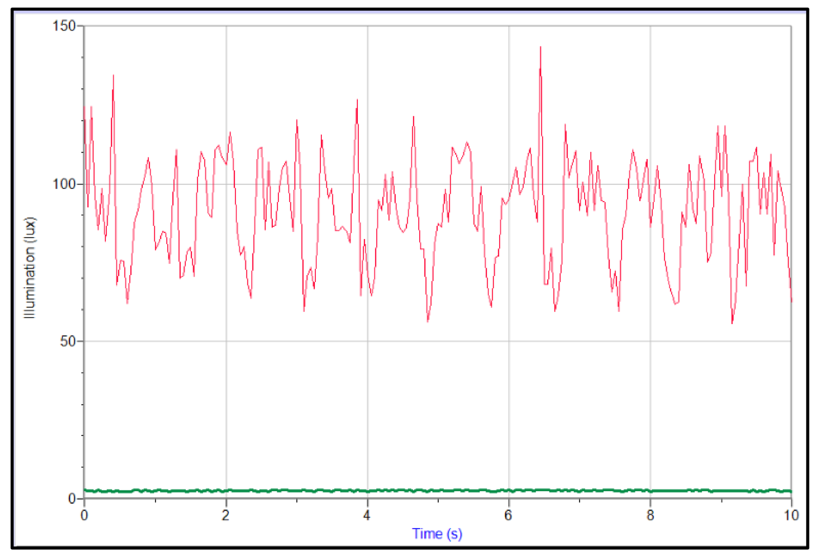

Fig. 17: Silicone polymer (0.171mm) treatment ($p<0.0001$).

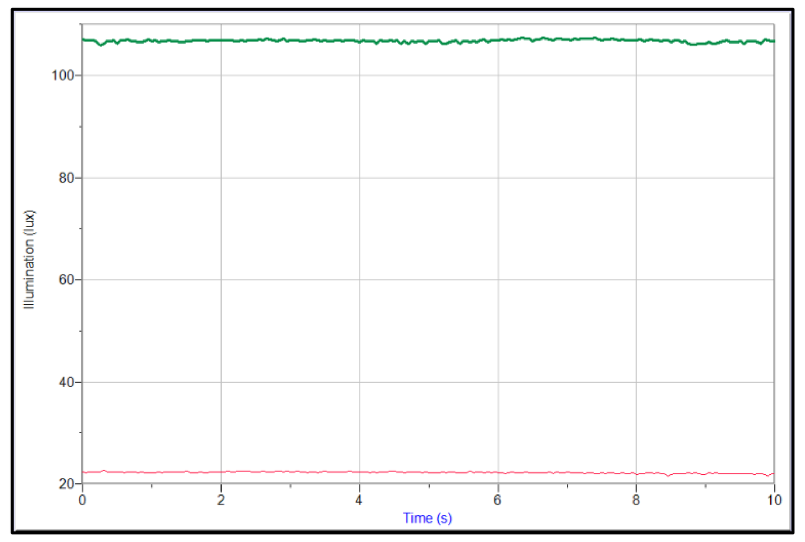

Fig. 18: Silicone Polymer treatment with spatial filter ($p < 0.0001$): 79.1% signal scatter.

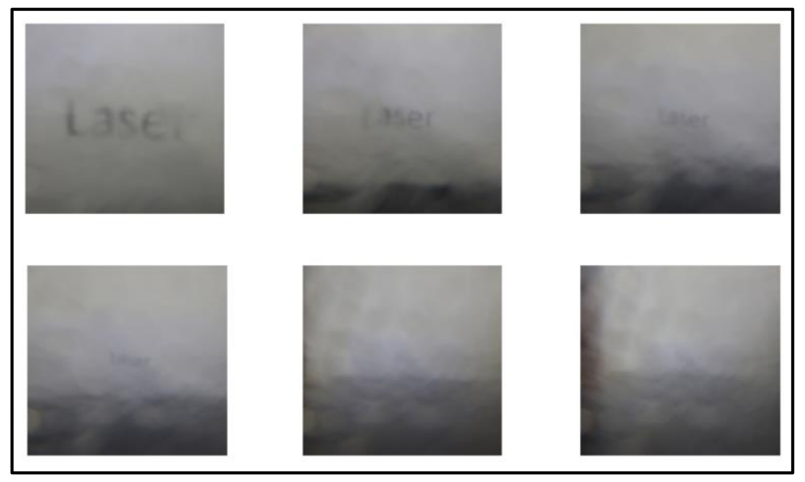

Fig. 19: Image quality through silicone polymer treatment at various distances.

Fig. 20: Image quality through nanoparticle-epoxy resin treatment (2.68mm) at various distances.

Table 2: Quantifying image quality through silicone polymer treatment.

Distance	5 cm	10 cm	15 cm	20 cm	40 cm	50 cm
Contrast	1.11 lux	1.06 lux	1.05 lux	1.02 lux	1.02 lux	1.01 lux

Table 3: Quantifying image quality through nanoparticle-epoxy resin treatment (2.68mm).

Distance	5 cm	10 cm	15 cm	20 cm	40 cm	50 cm
Contrast	2.43 lux	2.37 lux	1.93 lux	1.90 lux	1.67 lux	1.49 lux

Table 4: Reduction in light for each treatment.

Treatment	Light Reduction
Silicone Polymer	0%
Nanoparticle-Epoxy Resin (.171mm)	8%
Nanoparticle-Epoxy Resin (2.68mm)	10%

Discussion

- All treatments significantly reduced the signal output
- Nanoparticle treatment enabled quality control and had ideal image quality
- Silicone polymer was most effective in diminishing the laser microphone signal
- These results suggest that treatments producing specular reflection of laser light are able to weaken a modulated laser signal without causing a large reduction in light transmission.

Future Studies:

- Explore the minimum amounts of treatment needed to disrupt the signal.
- Explore materials that allow good image quality and cause disruption of light

Literature Citations

Bryant, Chris. "Q&A: Laser Microphone Surveillance." *The World*. N.p., n.d. Web. 09 Mar. 2016. <http://blogs.ft.com/the-world/2013/08/qa-laser-microphone-surveillance/>.

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Wang, Chen-Chia, Sudhir Trivedi, Feng Jin, V. Swaminathan, Ponciano Rodriguez, and Narasimha S. Prasad. "High Sensitivity Pulsed Laser Vibrometer and Its Application as a Laser Microphone." AIP Scitation. American Institute of Physics, n.d. Web. 6 Feb. 2016.<http://scitation.aip.org/content/aip/journal/apl/94/5/10.1063/1.3078520>.