Transparent Irregular Surfaces as Sound-Modulated Laser Transmittance Countermeasures

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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 secret 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 modulated laser is scattered by a transparent irregular treatment, then the frequency or amplitude of the signal received will be altered.

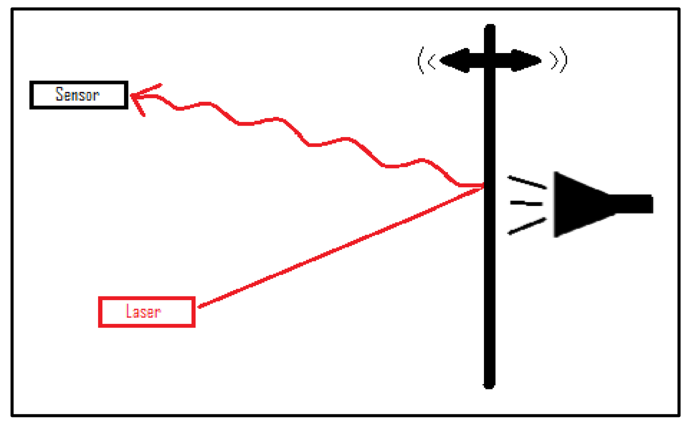

Fig. 1: Modulation of a laser based on vibrations of a window due to sound

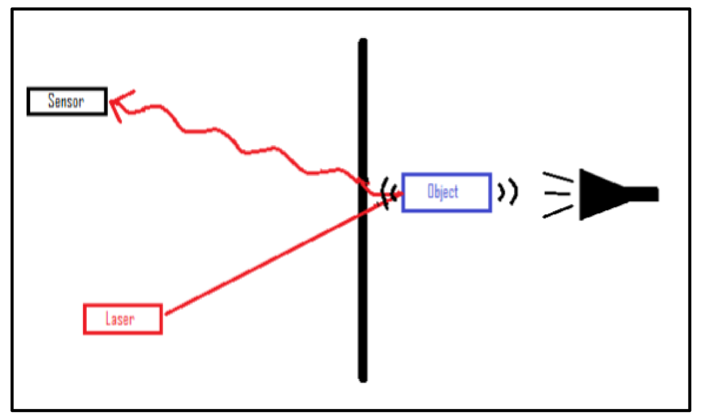

Fig. 2: Modulation of a laser based on vibrations of an inside object due to sound

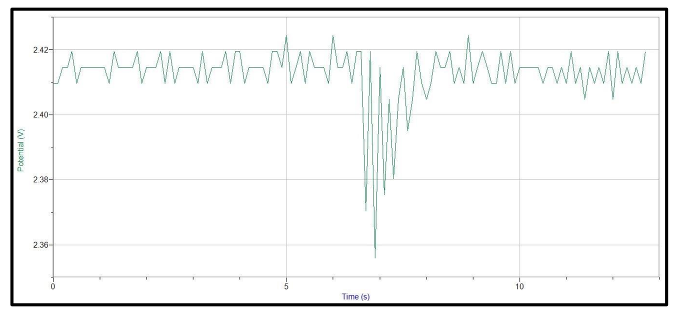

Fig 3: Laser microphone reflecting off a window as a word is spoken.

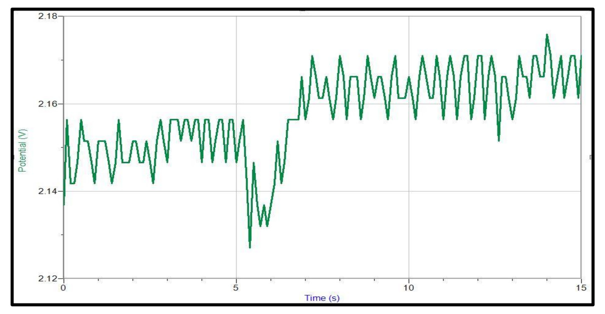

Fig 4: Laser microphone reflecting off an object as a word is spoken.

Methods

- Control trials: An Alpec Class IIIA <5mW HeNe Red Laser, modulated at a frequency of about 0.5 Hz (Fig. 14), was directed towards a photovoltaic cell (Fig. 15) through an untreated glass slide at a distance of 2.5m and 10m. As the beam was modulated according to the frequency of the function generator the graph on the Vernier data logger showed corresponding dips in voltage.
- Experimental trials: The laser, modulated at a 0.5 Hz frequency, was transmitted through various treated glass slides at the photovoltaic cell at a distance of 2.5m and 10m. As the beam was modulated according to the frequency of the function generator, each treatment was placed between the laser and photovoltaic cell to test which treatments were capable of diminishing or thwarting the modulated signal.
- Light transmission trials: A 120V AC 450 Lumen LED was directed though each glass slide treatment at a 5cm distance (Table 1). The light output was measured with a Vernier light sensor (Fig. 17)

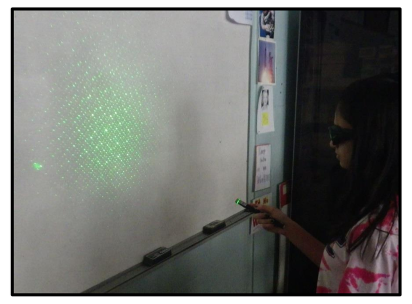

Fig. 5: The effect diffraction grading produces on lasers.

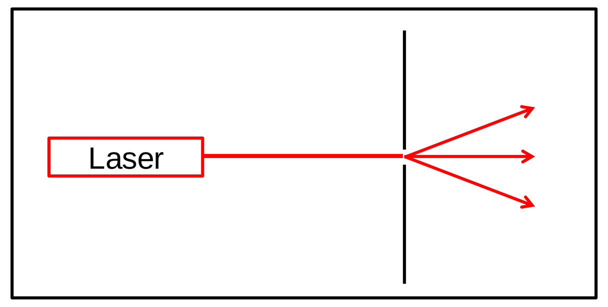

Fig. 6: Diffraction grating splitting a laser beam.

Methods (cont.)

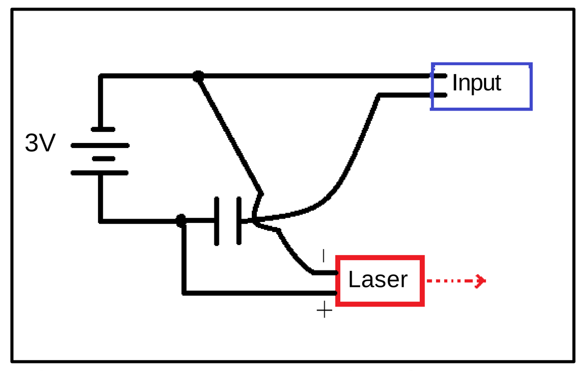

Fig. 7: Laser modulator utilized for functional auditory test.

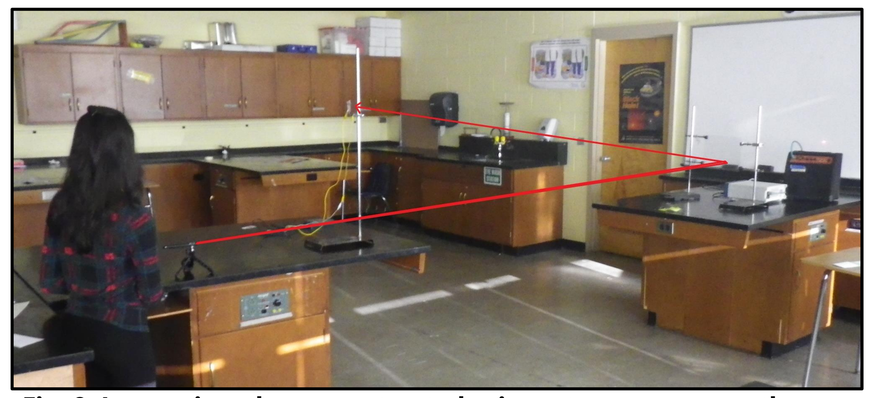

Fig. 8: Laser microphone constructed using a transparency as the reflectant , a function generator, and a photovoltaic cell.

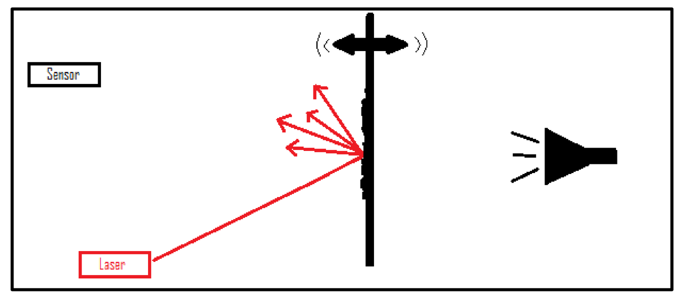

Fig. 9: Scattering or diffuse reflection of the laser beam due to a transparent irregular surface.

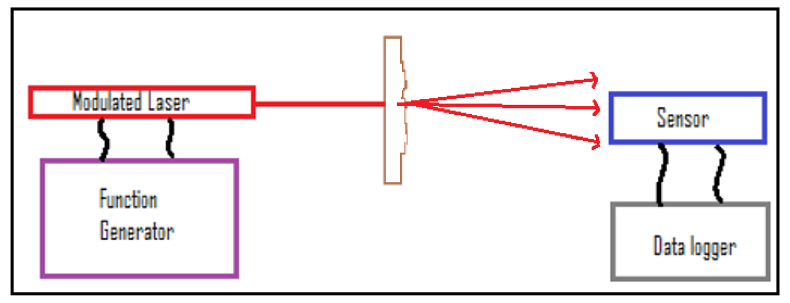

Fig. 10: Irregular surface of treatments were tested for their ability to facilitate disruption of a modulated laser signal via specular reflection.

Treatment	Method of Composition
Sodium Silicate Specular	A glass slide coated with slight amount of sodium silicate, a viscous transparent gel that cures irregularly (Fig. 11) .
Sodium Silicate Pattern	Sodium silicate was spread on a translucent paper towel placed on a glass slide (Fig. 11)
Sodium Silicate Flat	A glass slide layered with a thicker amount of sodium silicate (Fig. 12).
Diffraction Grating	Thin sheet of diffraction grating, which splits and diffracts light into several different directions (Fig. 12).
Silicone Polymer	A glass slide coated with a thin layer of silicone polymer, a rubber-like material (Fig. 13)
Polarized Film	Thin square of polarized film, a glass substrate on which a special optical coating is applied (Fig. 13)

Table 1: Composition of treatments on glass slides

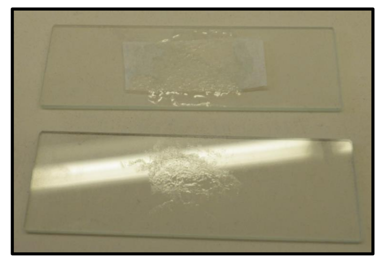

Fig. 11: Top: Sodium Silicate Pattern Bottom: Sodium Silicate Specular

Fig. 12: Top: Silicone Polymer Bottom: Sodium Silicate Flat

Fig. 13: Top: Polarized Film Bottom: Diffraction Grating

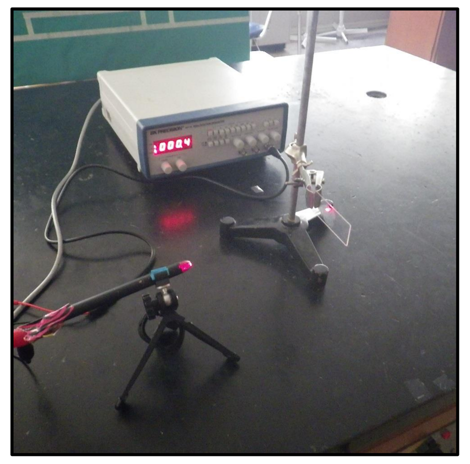

Fig. 14: Laser modulation by a function generator

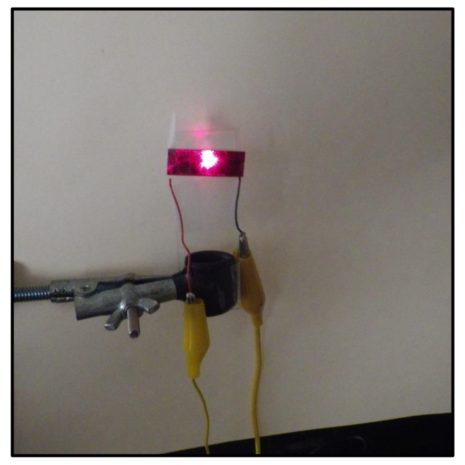

Fig. 15: Laser beam directed at a photovoltaic cell.

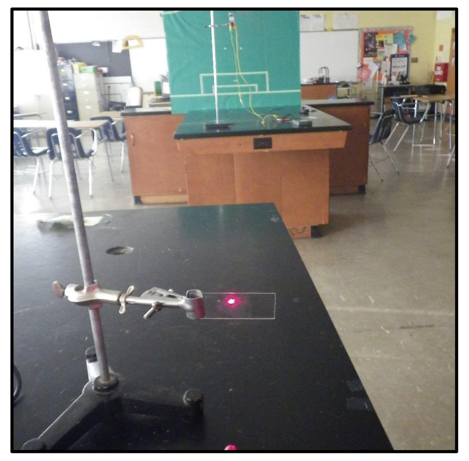

Fig. 16: Trial setup with modulated laser, photovoltaic cell, and data logger

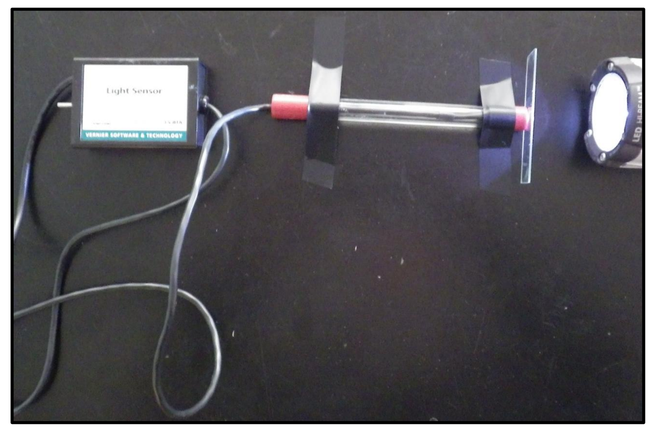

Fig. 17: Light transmittance test using a light source and Vernier light sensor.

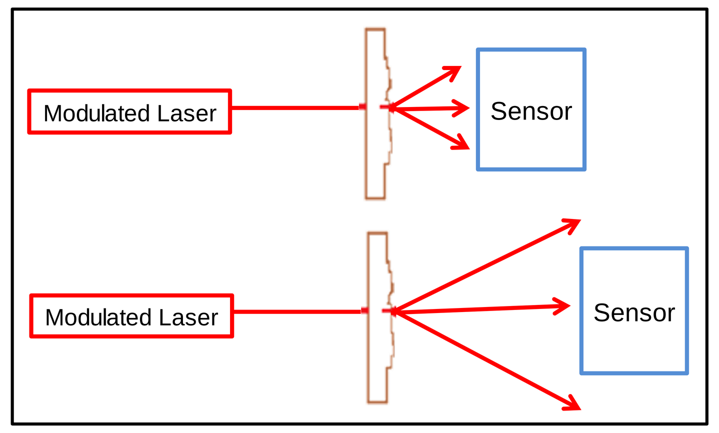

Fig. 18: The effect of distance on signal strength with internal reflection

Results

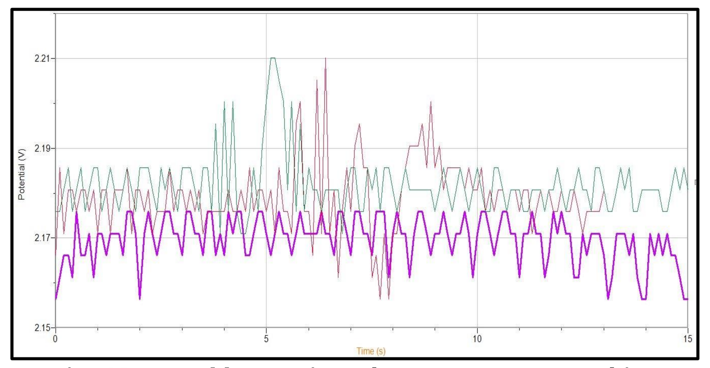

Fig. 19: A real laser microphone was set up and its modulated signal thwarted by silicone polymer.

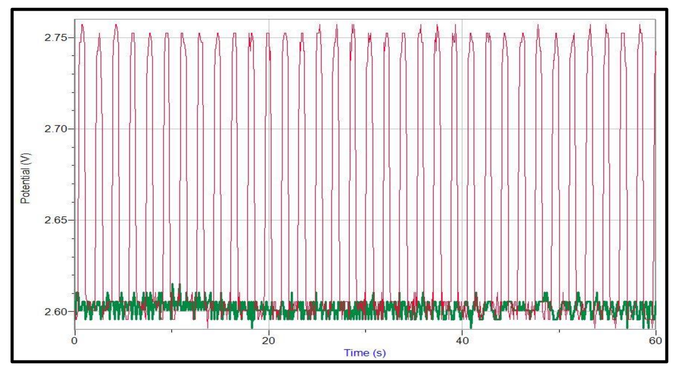

Fig. 20: Silicone Polymer treatment at 10m ($p < 0.0001$)

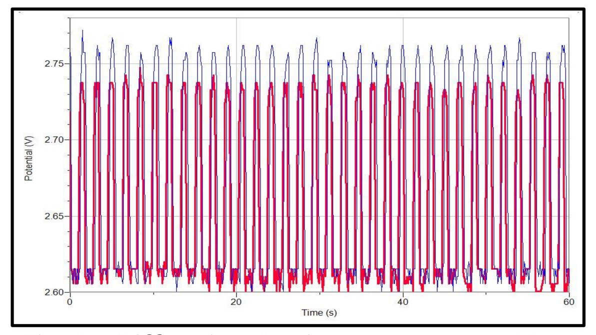

Fig. 21: Diffraction Grating treatment at 10m ($p < 0.0001$)

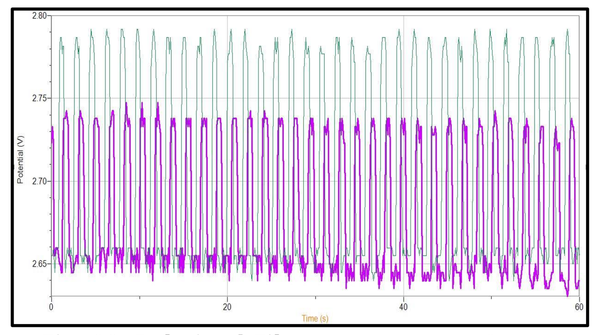

Fig. 22: Polarized Film treatment at 10m ($p < 0.0001$)

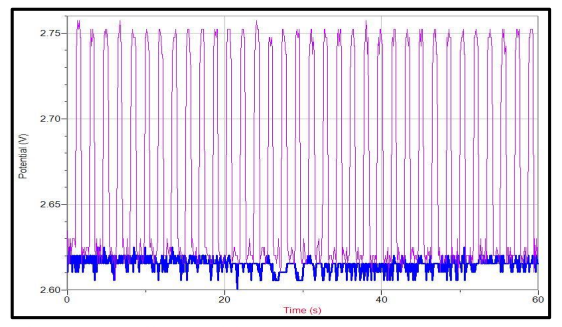

Fig. 23: Sodium Silicate Pattern treatment at 10m ($p < 0.0001$)

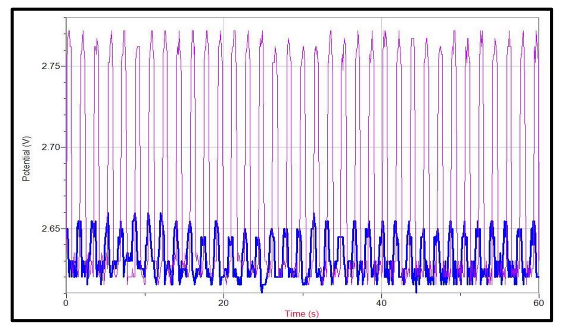

Fig. 24: Specular Silicate treatment at 10m ($p < 0.0001$)

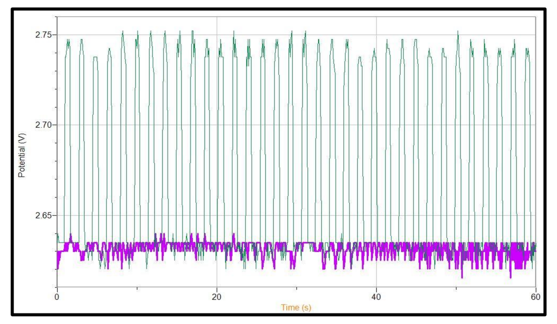

Fig. 25: Sodium Silicate Flat treatment at 10m ($p < 0.0001$)

Treatment	Reduction in Light
Sodium Silicate Specular	0%
Sodium Silicate Pattern	24.6%
Sodium Silicate Flat	0%
Diffraction Grating	7.3%
Silicone Polymer	0 %
Polarized Film	56.4%

Table 2: Reduction in light for each treatment

Discussion

- All treatments significantly reduced the signal output, however the silicone polymer treatment was most effective.
- Sodium silicate specular, sodium silicate flat and silicone polymer were most successful in maintaining light transmittance at 0% light reduction, while diffraction grating (7.3%), sodium silicate pattern (24.6 %), and polarized film (56.4 %) had poorer results (Table 2).
- Sodium silicate had the ideal combination of a 0% reduction in light and a relatively high disruption of the modulated laser signal (Fig. 20).
- These results suggest that treatments producing diffuse reflection of laser light are able to weaken a modulated laser signal without causing a large reduction in light transmission.

Future Studies:

- Evaluate image quality through the successful treatments and explore the minimum amounts of treatment needed to disrupt the signal.
- Explore reflective nanoparticle addition to sodium silicate or epoxy resin to simplify quality control and offer better repeatability as opposed to utilizing irregular surfaces (Fantell and Dmitus 2015)(Fig. 26).

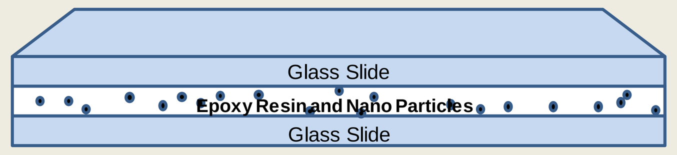

Fig. 26: Nanoparticle and epoxy resin treatment

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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