Ultracoustics
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Air-coupled wall thickness measurement for NDT applications

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October 2nd, 2023

Our technology possesses exceptionally high bandwidth and sensitivity, enabling a range of fascinating applications. One such application is the ability to conduct conventional non-destructive testing (NDT) inspections without the need for a couplant or physical contact. This method finds relevance in various scenarios, including weld inspections, determining pipe wall thickness, and ensuring semiconductor quality control. The advantage of employing an air-coupled approach is that it allows us to carry out tests in environments where contact mode is impractical, in addition to leaving no couplant residue behind.

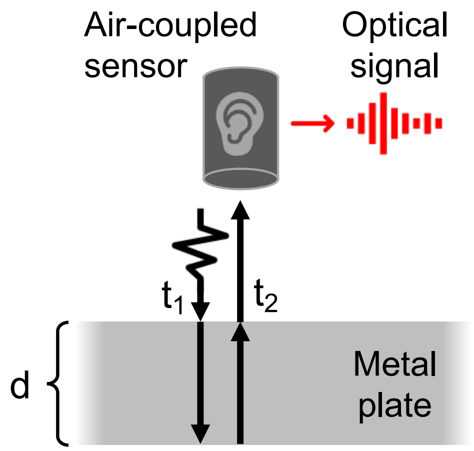

Fig. 1. A schematic showing how our air-coupled plate thicknesses are performed.

Figure 1 illustrates the working principle of an air-coupled non-destructive testing (NDT) measurement. Initially, a pulse is generated within a material using various methods, such as a spark, laser, or traditional piezoelectric crystal. As the pulse propagates through the material, it eventually reaches the end of a metal plate in the direction of travel. At this interface, a significant portion of the pulse energy reflects. The pulse then travels back towards the source. Any sound energy that does not reflect at the top interface upon its return journey travels to our sensor. Here, it couples into the optical system and is subsequently recorded. It's important to note that the attenuation at the air-steel interface is substantial, typically on the order of 87 dB, resulting in a highly inefficient process. Consequently, achieving very high sensitivity is crucial.

The equation provided below elucidates how the distance traveled by the sound wave (i.e., the thickness of the metal plate) can be determined using the round-trip time, assuming the speed of sound in the material is known.

$$v\ [m/s] = \frac{2 \cdot d\ [m]}{\Delta t\ [s]} \qquad (1)$$

$$\rightarrow d = \frac{v\ \cdot \Delta t}{2} = \frac{v}{2 \cdot \Delta \mathrm{f}} \qquad (2)$$

We have included a sample measurement in Figure 2 to illustrate how this process might look in your specific application. For this demonstration, we opted for the simplicity of using a conventional piezoelectric transducer in direct contact to generate a pulse, although the measurement setup would remain relatively consistent regardless of the excitation method.

Figure 2(a) depicts the experimental setup, with our sensor positioned approximately 1 cm away from the metal plate. Figure 2(b) displays a series of pulses recorded by our sensor. The remarkable thing here is that the piezoelectric transmitter is placed adjacent to our sensor rather in the direct line of sight. In addition to the prominent spikes, there are multiple lower amplitude features that contain the relevant information. To analyze this data, we employ a fast Fourier transform (FFT) to examine the frequency spectrum, as shown in Figure 2(c). By assessing the spacing between the prominent frequency fringes, we can extract the thickness of the metal plate using Eq. 2.

This technique can be extended to other materials and applications as well, so please do not hesitate to reach out if you have a specific application in mind.

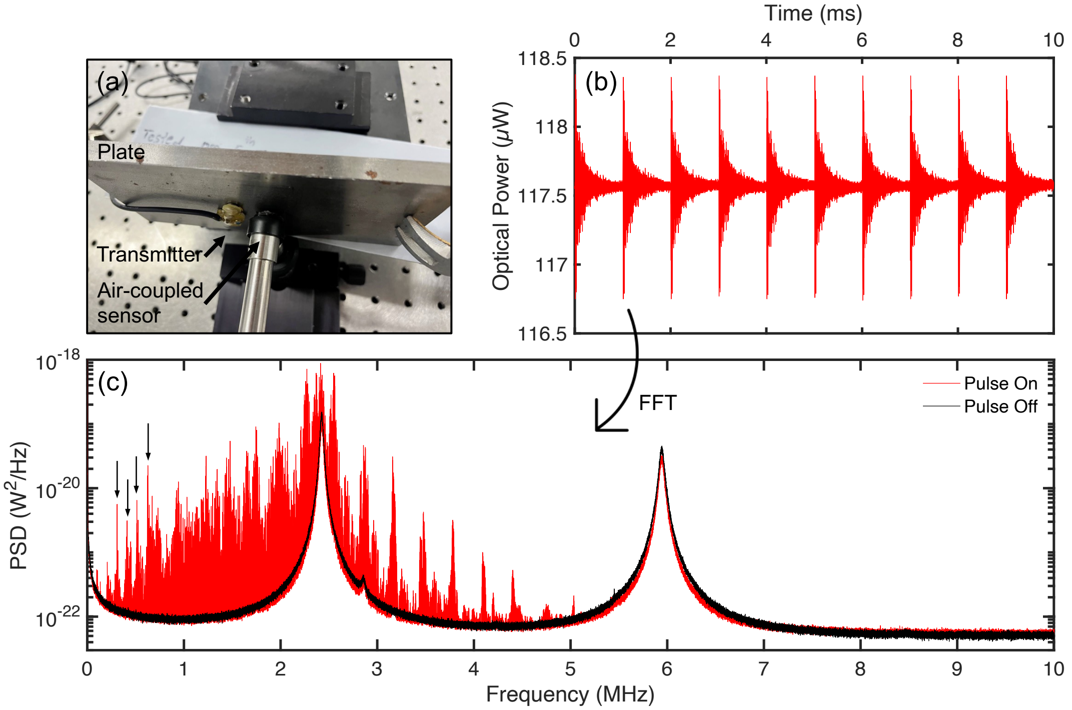

Fig. 2. Example data from an air-coupled plate thickness measurement. (a) An image of the experimental setup. (b) Raw data acquired from the measurement – a time trace of averaged pulses detected optically and received using a photodetector. (c) A fast Fourier transform (FFT) of the time domain data showing fringes (examples indicated with arrows) that can be used to extract the thickness of the metal plate.