5th International Workshop on Laser-Ultrasound for Metals
May 5-6, 2022
Gif-sur-Yvette, France

Surface acoustic wave suppression for ultrasonic imaging of near-surface defects using laser induced phased arrays

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Laser ultrasound (LU) offers a remote and non-contact mode of operation that makes it deployable for complex geometries, hostile environments, and places of restricted access. The disadvantage of LU is that it generates ultrasound with a low signal-to-noise ratio (SNR). To overcome the disadvantage of the low SNR, laser induced phased arrays (LIPAs) have been developed. Contrary to conventional transducer-based arrays, LIPAs use one laser for generation and a second laser for detection. A signal is captured for each combination of generation and detection laser position by scanning the generation and detection laser, following the paradigm of the Full Matrix Capture (FMC). In this work, LIPAs are synthesized in the non-destructive thermoelastic regime using a 7 ns pulsed 1064 nm laser and a 532 nm continuous wave laser to image side-drilled holes inside a metal sample. The acquired FMC data is post-processed using an imaging algorithm known as the Total Focusing Method (TFM). TFM is implemented by targeting one or more wave modes (i.e., longitudinal or transverse). However, the images generated contain a contribution from another wave mode called the surface acoustic wave (SAW). In LU, SAW is the strongest wave mode generated, and as a consequence, a region of the image generated is saturated by the SAW arrival (SAW crosstalk). The SAW crosstalk region extends into the sample starting at the scan surface and hence masks any features/defects within this region. It is crucial to detect defects closer to the scan surface for applications such as additive manufacturing and welding, where the manufacturing process is monitored to identify and then rectify the defects formed on the surface or near the surface. This study explores various signal processing techniques to suppress/remove the SAW wave mode from the ultrasonic data captured using LIPA for successful imaging of subsurface defects. The mode suppression is achieved by targeting the unique characteristics of the SAW, such as its velocity, amplitude, and phase. Different methods of wave suppression are compared, and relative merits are discussed.