Surface profile estimation and compensation for improved laser ultrasonic inspection of additive-manufactured components

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Laser ultrasonics provides a sensitive means to detect and characterize subsurface defects during inline inspection of additive-manufactured components. Data are collected by scanning the component build surface using laser-generated waves and a separate laser detection system. These data can be processed to form an image of pores and other defects within several millimeters below the surface. This inspection is preferably carried out on a layer-by-layer basis during component fabrication, to provide feedback for corrective measures or early scrapping. Inspection accuracy, however, is limited by surface topography. In this paper we address measuring and compensating for the effect of surface topography to improve defect-imaging accuracy. We demonstrate that the surface profile can be estimated directly from the laser ultrasonic measurement without any additional measurements. The generation laser beam is positioned at an oblique angle to the surface so that the distance between generation and detection beams varies with surface height. Since the head (skimming) wave and Rayleigh wave follow the surface, their arrival time variation can be used to infer the surface profile. The profile coordinates can then be used directly in the subsurface imaging algorithm. The concept is demonstrated to show significant improvement in image quality for both numerically modelled and experimental data.