

# Ultrasonic Phased Array Inspection of Wire Plus Arc Additive Manufactured (WAAM) Titanium Samples

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Ehsan Mohseni<sup>1</sup>, Yashar Javadi<sup>1</sup>, David Lines<sup>1</sup>, Randika Vithanage<sup>1</sup>, Euan Foster<sup>1</sup>, Zhen Qiu<sup>1</sup>, Rastislav Zimmermann<sup>1</sup>, Charles N. MacLeod<sup>1</sup>, Stephen G. Pierce<sup>1</sup>, Anthony Gachagan<sup>1</sup>, Gianrocco Marinelli<sup>2</sup>, Jialuo Ding<sup>2</sup>, Stewart Williams<sup>2</sup>

<sup>1</sup> *Centre for Ultrasonic Engineering (CUE), Department of Electronic & Electrical Engineering, University of Strathclyde, Glasgow G1 1XQ, UK, Ehsan.mohseni@strath.ac.uk*

<sup>2</sup> *Welding Engineering and Laser Processing Centre, Building 46, Cranfield University, Cranfield MK43 0AL, UK*

## Abstract

Recent developments in the application of the Wire + Arc Additive Manufacturing (WAAM) process for the production of titanium components have attracted the attention of many industrial sectors, such as aerospace and defence. The utilisation of those components within these sensible sectors increased the demand for advanced and efficient inspection procedures. In order to assess the quality and integrity of titanium components deposited via WAAM, conventional ultrasonic phased array inspections together with the more advanced imaging techniques, such as total focusing method (TFM), were deployed in this study. Four titanium linear structures were analysed in the study. In particular, the first two were built using parallel deposition and containing intentional deposition defects, such as lack of fusion (LoF) and keyhole (KH) defects, and the remaining two were deposited using oscillated deposition without intentional defects. The inspections were carried out in-contact both from the machined and the original surface of the WAAM walls using 5 MHz-64 elements, 10 MHz-128 elements, and 10 MHz-32 elements linear arrays (Figure 1(a)). Two different array controllers, FIToolbox (Diagnostic Sonar, UK) and LTPA (Peak NDT, UK), were used to excite the arrays and receive echoes. The calibration was performed on a  $\varnothing 2$  mm side-drilled hole in one of the walls. The results suggested that the best images were formed using a 5 MHz-64 elements array as demonstrated in Figures 1(b) and 1(c). Most of the intentional WAAM defects were detected in TFM images formed by a combination of arrays, stand-off wedges, phased array controllers, and TFM algorithms. Although, these defects cannot be sized properly without a calibration block made of the same material undergone the WAAM process, but the performance of phased array inspections found to be promising in inspection of titanium WAAM components.

**Keywords:** Additive Manufacturing; WAAM; Ultrasonic Phased Array; Total Focusing method (TFM); Intentional Defects.

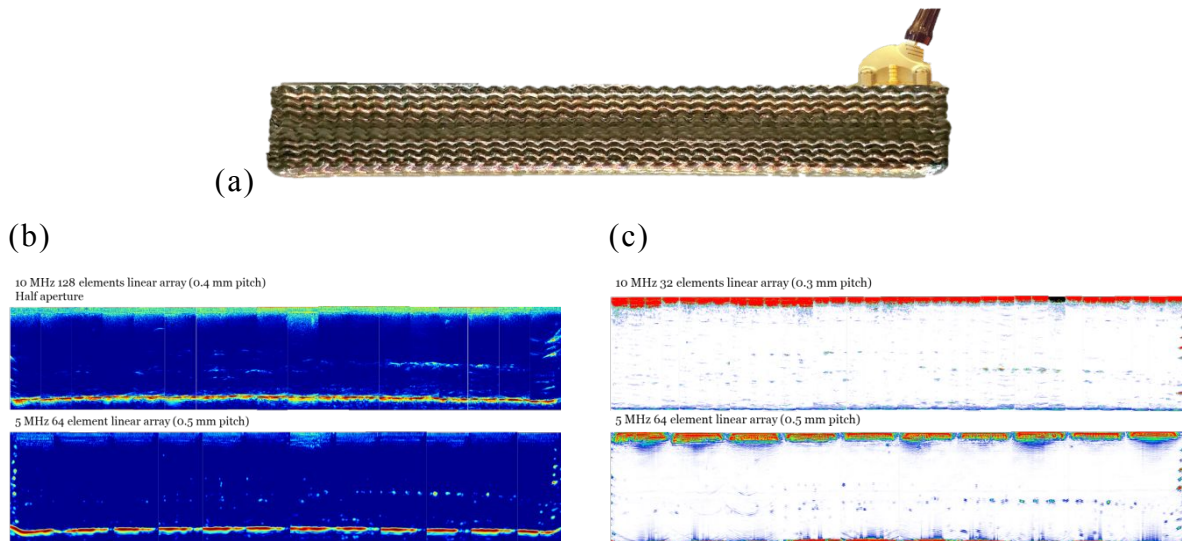


Figure 1: (a) In-contact inspection of a titanium WAAM wall onto the machined surface, TFM images of the titanium WAAM 10 MHz and 5 MHz inspections using (b) LTPA controller (Peak NDT, UK) + Bristol Brain TFM algorithm, and (c) FIToolbox (Diagnostic Sonar, UK) controller + FITStreamFRD TFM algorithm