Metallic material grain structure characterization using ultrasonic arrays

NDT Problem

Defects in materials can arise both during manufacture and in-service. At the early stage of defect development, it is shown that the discontinuities on material grain boundaries are difficult to detect using conventional ultrasonic techniques because the amplitude of ultrasonic signals scattered from the discontinuity are weak and easily hidden by those from material grains. Even using advanced ultrasonic phased arrays with step-change techniques such as FMC and total focused method (TFM), the defect image is still difficult to identify from the speckle image of material grain structure. As an example, Fig. 1 (a) shows an image from a steel specimen surface using microstructure morphology and Fig. 1 (b) is a measured ultrasonic array image in which the material noise level is high and small defect detection difficult.

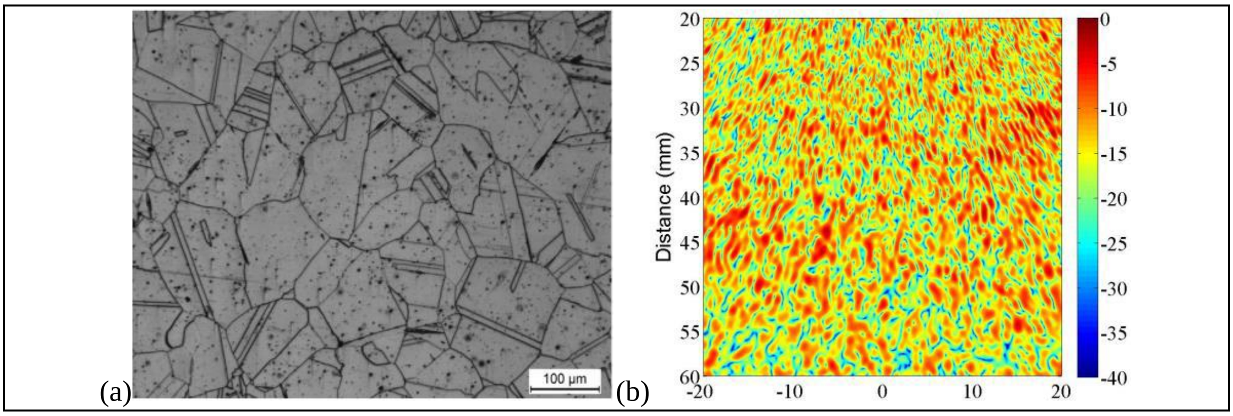

Fig. 1 An image from a steel specimen using (a) microstructure morphology and (b) ultrasonic array technique.

Aims

This project will be focused on material characterization using back scattering amplitude in full matrix capture (FMC) data to benefit:

1. Measuring material properties and texture.
2. Understanding coherent noise from microstructure to improve detection.

Objectives

The overall objective is to characterise metallic material grain structures using ultrasonic arrays. Specific points of timeliness and novelty in the proposed project include:

1. Development of an analytical wave back scattering model for the signals scattered from material grain structure and measured using ultrasonic arrays.
2. Model validation through FE simulation and experimental time-dependent spatial variance measurements on the metallic components.
3. Optimisation of the ultrasonic array configuration to map material grain size experimentally.
4. Explore an experimental protocol to assess metallic material grain size.

Current Progress

The current progress is in modelling the interaction of ultrasonic array signals with grain structures.

1. The wave pressure field estimation model of 1D linear array using Huygen's principle has been developed.

2. For 2D and 3D direct contact case, FOM (Figure of merit) can be successfully predicted from simulated data.
3. Synthetic noise signal is used to test the developed model.
4. Different types of distributions are used to get smaller relative error and decrease the computation time.