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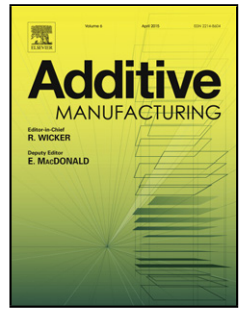

Title: An Overview of Functionally Graded Additive Manufacturing

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An Overview of Functionally Graded Additive Manufacturing

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Abstract
Functionally Graded Additive Manufacturing (FGAM) is a layer-by-layer fabrication process that involves gradationally varying the material organisation within a component to achieve an intended function. FGAM establishes a radical shift from contour modelling to performance modelling by having the performance-driven functionality built directly into the material. FGAM can strategically control the density and porosity of the composition or can combine distinct materials to produce a seamless monolithic structure. This paper presents a state-of-art conceptual understanding of FGAM, covering an overview of current techniques that can enable the production of FGAM parts as well as identify current technological limitations and challenges. The possible strategies for overcoming those barriers are presented and recommendations on future design opportunities are discussed.

Keywords
Additive Manufacturing; Functionally Graded Additive Manufacturing; Functionally Graded Materials; Variable-property Fabrication; Multi-material Printing.

1. Introduction and Definition

Functionally Graded Materials (FGMs) are a class of advanced materials characterised by spatial variation in composition across the volume, contributing to corresponding changes in material properties in line with the functional requirements [1]. The multi-functional status of a component is tailored through the material allocation at microstructure to meet an intended performance requirement. Microstructural gradation contributes a smooth transition between properties of the material [2].

Additive Manufacturing (AM) is a solid freeform manufacturing technology that enables the direct fabrication of fine detailed bespoke component by accurately place material at set positions within a design domain. Throughout the years, AM technologies have expanded from making one-off prototypes to the creation of full-scale end-use parts driven by improved manufacturability. The technological advancement of today's AM systems enables the use of FGM, leading to the term Functionally Graded Additive Manufacturing (FGAM) which is a layer-by-layer fabrication technique that involves gradationally varying the material organisation within a component to meet an intended function.

FGAM is a material-centric fabrication process that establishes a radical shift from contour modelling to performance modelling. The advancement of AM technologies makes it possible to strategically control the density and directionality of material deposition within a complex 3D distribution or to combine various materials to produce a seamless monolithic structure by changing deposition density and orientations [3]. The potential microstructural gradient compositions achievable by FGAM can be characterised into 3 types: (a) variable densification within a homogeneous composition; (b) heterogeneous composition through simultaneously combining two or more materials through a gradual transition; and (c) using a combination of variable densification within a heterogeneous composition.