The Role of Nanomaterials in the Evolution of Additive Manufacturing

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Abstract— Additive manufacturing (AM), also known as 3D printing, builds parts layer by layer from digital models. In recent years, the use of nanomaterial structures with features between 1 and 100 nanometers has significantly advanced this technology. Nanomaterials such as carbon nanotubes (CNTs), graphene, metal and ceramic nanoparticles, and Nano clays offer mechanical, thermal, electrical, and chemical properties that traditional materials do not offer. On their incorporation into AM feedstocks, these nanomaterials can enhance printed parts by achieving greater strength, stiffness as well as durability and by imparting new functionalities such as electrical conductivity, thermal management or even being able to live. This review outlines the benefits of nanomaterials on various AM processes, such as Fused Deposition Modeling (FDM) and Stereolithography (SLA) and Powder Bed Fusion (PBF). It points out that recent years bring strong nanocomposite filaments, nano-reinforced resins, and nano-coated metallic powders (graphene), which increase part density and performance. Other applications and use in practice are also mentioned, including lightweight structural components in the aerospace industry, personalized implants in the field of medicine, electronic printing in wearable electronics, and intelligent components in constructions. The most crucial limitations such as nanoparticle dispersion, printers' compatibility, cost, and safety regulations are solved. Lastly, some future avenues including smart nanocomposites, multi-material printing, bio-based fillers, and process optimization using AI are discussed. This paper intends to offer a brief and definitive survey to the researchers and engineers that would like to familiarize themselves with the synergy between nanotechnology and additive manufacturing.

Keywords— Additive Manufacturing (AM), Nanomaterials, 3D Printing, Nanocomposites, Fused Deposition Modeling (FDM), Stereolithography (SLA), Powder Bed Fusion (PBF)