Chapter 8
An Overview of 3D-Printed Smart Polymers and Composites

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ABSTRACT

This chapter highlights recent developments and provides an overview of the rapid application of fused deposition modelling (FDM) for polymeric smart and composites. The review is divided into sections that describe the processing conditions and characteristics of FDM components made of polymer and its composites as well as shape memory polymers/composites. The chapter covers a wide range of applications, including PVDF structures and components. While FDM adoption has been rapid in this field, more coordinated efforts in the areas of smart polymer feedstock synthesis, process tuning, and testing are required. This chapter provides an overview of 3D printed smart polymer materials and composites as well as their properties, performance, and potential applications. Additionally, this chapter discusses the motivation for future 3D printing research.

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INTRODUCTION

The emergence of 3D printing has simultaneously given rise to a new generation of enthusiasts and transformed it into a pervasive technique with several applications in a variety of fields. This encompasses the aircraft, automobile, bio-medical, consumer goods, agriculture, clothing, architecture, modeling, metalworking, defense, and pharmaceutical sectors among others (Gibson et al., 2014, F C Godoi et al., 2018, A. Paolini et al., 2019, L.E. Murr et al., 2016). The innovative emergence and permeation of 3D-printing into residences, low to higher-level educational institutes, and the private organizations in the past ten years has not been achieved overnight for an advanced technology that once demands extensive machinery which was for a longer period considered an instrument for replicating by the design team, performers, and engineers. A series of circumstances came together to make this ascent feasible in part.

Since 2010, numerous innovative makers (including Ultimakers, Markforgeds, XYZprintingss, Zortax, FlashForges, RepRaps, etc.) have had the flexibility to create reasonably priced 3D printers thanks to the exhalation of a ground-breaking invention regarding the technical expertise of fused deposition modeling (a subset of 3D-printing). This is one of the obvious forces behind the 3d-printing transformation into a common technology (T.D. Ngo et al., 2018). The innovation is, however, determined to continue gathering traction as we enter the new decade, according to recent findings. This is because there are numerous additional enabling variables. is a non-exhaustive summary of these characteristics contains (U.M. Dilberoglu et al., 2017, N.A. Gershenfeld, 2005, B. Berman, 2012, J.-Y. Lee et al., 2017, K.B. Mustapha et al., 2019)

- Industry 4.0 and digitalisation are both boosting the demand for embedded smart materials, opening the door for the quick creation of agile production hubs, and making it easier to integrate smart manufacturing systems.
- A wider variety of materials (polymer, metallic, ceramic, wood, composite materials, etc.) are now available for 3D printing techniques, making it more affordable than conventional production methods when working with difficult geometries.
- Enablement of component customisation for low to medium scale manufacture of printed electronic components multi-material parts than others.
- Rapid iterations of product files and administration enabled by seamless interface with design systems, which speeds up innovations.
- Reductions in tool expenditures.
- Manufacturing of compact and integrated systems into a single step.
- Lowering the risk associated with inventories and eliminating waste.

What 3D printing represents has been described by numerous researchers. 3D printing M was formally defined as a "solid freeform production technology for the straightforward automated manufacturing of customised goods and components in very small to moderate-sized batches without relying on particular molds and tooling" by (M. Monzon et al., 2015) in their definition. Although there are many additional definitions of the technologies, it generally entails the slicing-by-slicing manufacture of actual parts from computer-aided design virtual objects that are transformed by a particular 3D printing machine. This has become now well accepted that there are multiple approaches to achieving this continuous layer-by-layer part production. So, 3D printing has been defined as a catch-all phrase that, in accordance with