scaffold is low, typically in the range reported for trabecular bone, which limits its use to the repair of low-load bone sites.

15.3.4 Solid Freeform Fabrication (SFF)

SFF, also referred to as rapid prototyping or additive manufacturing, is a term to describe a group of techniques that can be used to manufacture objects in a layer-by-layer fashion from a computer-aided design (CAD) file, without the use of traditional tools such as dies or molds. The technique can be used to build scaffolds whose structure follows a predesigned architecture modeled on a computer. In that way, the scaffold architecture can be controlled and optimized to achieve the desired mechanical response, accelerate the bone-regeneration process, and guide the formation of bone with the anatomic cortical-trabecular structure (Hollister, 2005). Several SFF techniques have been used for scaffold fabrication, including: three-dimensional printing (3DP), fused deposition modeling (FDM), ink-jet printing, stereolithography (SL), selective laser sintering (SLS), and robocasting (Hollister, 2005; Chu, 2005).

Scaffolds with controlled internal architecture and interconnectivity are made with SFF from a variety of biomaterials including biodegradable polymers (e.g., PLGA; PCL) and calcium phosphate materials (e.g., HA; TCP), as well as composites of these two classes of materials (e.g., PLGA/TCP) (Chu 2005; Sachlos and Czernuszka, 2003; Miranda et al., 2006, 2008; Russias et al., 2007; Franco et al., 2010). The fabrication of composite scaffolds containing bioactive glass (e.g., PLA/45S5 glass; PCL/45S5 glass) using a robocasting SFF technique has been reported (Russias et al., 2007), but there is little information on the production of bioactive glass scaffolds using SFF methods. Recently, scaffolds of apatite-mullite glass-ceramics, 13–93, and 6P53B glasses have been manufactured using freeze extrusion, SLS, and robocasting methods (Fu et al., 2011a; Goodridge et al., 2007; Huang et al., 2011). In the robocasting method, an aqueous paste of 6P53B bioactive glass powder is extruded through a fine nozzle in filamentary forms and deposited over the previous layer while maintaining the weight of the printed structures (Fu et al., 2011a). The technique enables precise manipulation of the three-dimensional architecture (Fig. 15.1D), and printing of lines as thin as 30 μm using micron-sized glass powders. The sintered glass scaffolds, with an anisotropic structure, show a compressive strength (136 MPa) comparable to human cortical bone, which indicates that these scaffolds have excellent potential for the repair and regeneration of load-bearing bone defects (Fu et al., 2011a).

15.3.5 Freeze Casting of Suspensions

The freeze-casting route involves rapid freezing of colloidally stable suspension of glass particles in a nonporous mold, and sublimation of the frozen solvent under cold temperatures in a vacuum. After drying, the porous constructs are