



FIG. 15.4 Flexural strength of bioactive glass scaffolds grouped on the basis of their structures. Purple: isotropic scaffolds; green: anisotropic scaffolds; pink: periodic scaffolds (Fu et al., 2013).

of the glass composition, coupled with improved control of the pore architecture using methods such as unidirectional freezing of suspensions and SFF, has resulted in the creation of scaffolds with the requisite combination of strength and porosity.

15.4.2 Fracture Toughness and Reliability

As described above, bioactive glass scaffolds can be created with the desired compressive strength for the repair of load-bearing bone defects. However, their use in these applications may be limited by their intrinsic brittleness or low resistance to crack propagation. Commonly, the resistance of a material to crack propagation is measured in terms of an engineering parameter called the fracture toughness, denoted by K_{Ic} . The K_{Ic} values for ceramics and glass are inherently low (typically $K_{Ic}=0.5\text{--}5\text{ MPa m}^{1/2}$ for ceramics and $0.5\text{--}1\text{ MPa m}^{1/2}$ for glass). Owing to their low fracture toughness, ceramics and glass are very sensitive to the presence of small defects and flaws ($\sim 10\text{ }\mu\text{m}$) and they can fail catastrophically when subjected to tensile or flexural stresses far lower than their compressive strength (Davidge, 1979; Sakai and Bradt, 1993). While the fracture of brittle ceramics has been widely studied (Reis, 2008; Brezny and Green, 1989; Gibson and Ashby, 1997), there has been little effort to apply this knowledge to quantifying “brittle behavior” or toughness of porous bioactive glass scaffolds. Brittle behavior is often quantified using one or more of the following parameters: fracture toughness, Weibull modulus, and work of fracture.

Standard test methods for measuring the fracture toughness of brittle materials are specified by the American Society for Testing and Materials (ASTM)