There also exists another kind of hierarchical bioactive glass scaffolds based on mesoporous materials which have been intensively studied over the past decade. Although pores in the meso-range (2–50 nm) are too small to allow cells to enter the scaffold, mesopores can be very useful in imparting key added values to the material, such as the ability to encapsulate and then release biomolecules (e.g., drugs and growth factors) and therapeutic ions (Wu and Chang, 2014). Furthermore, the textural properties of mesoporous bioactive glasses (MBGs) play a key role in enhancing the apatite-forming ability of the material compared to melt-derived bioactive glasses (Arcos and Vallet-Regi, 2010). Some methods (e.g., sponge replication and additive manufacturing) have also been experimented with to produce hierarchical macro-mesoporous structures preserving the original mesoporosity of MBGs and permitting bone cell penetration, adhesion to the scaffold struts, growth, and proliferation that would lead to bone ingrowth and postoperative vascularization (Baino et al., 2016b). Therefore, these functionally graded scaffolds combine macroporosity for bone growth/oxygenation and mesoporosity to allow drug delivery of appropriate therapeutic biomolecules or ions. However, these scaffolds do not aim to mimic the gradients of porosity of bone or the porous/compositional transition between different tissues, but exploit the coexistence of pores at different scales to obtain a multifunctional effect.

16.3 MIMICKING THE TRABECULAR-CORTICAL BONE SYSTEM THROUGH PORE-GRADED GLASS-CERAMIC SCAFFOLDS: A CASE STUDY

We report some simple approaches based on polyethylene burn off and sponge replication to produce bioactive glass-derived materials with different pore features. Specifically, two major kinds of structures were fabricated: (i) homogeneously porous scaffolds with a trabecular structure similar to that of cancellous bone and (ii) bilayered scaffolds able to mimic the cancellous-cortical bone system by coupling a porous region with a thick compact coating.

16.3.1 Experimental

16.3.1.1 Materials

The scaffolds were prepared by using an experimental bioactive glass belonging to the $45SiO_2$-$3P_2O_5$-26CaO-7MgO-$15Na_2O$-$4K_2O$ (mol.%) system. The glass, referenced as CEL2, was prepared by a traditional melting-quenching process. The glass reagents (high-purity powders of SiO_2, $Ca_3(PO_4)_2$, $CaCO_3$, $(MgCO_3)_4{\cdot}Mg(OH)_2{\cdot}5H_2O$, Na_2CO_3, and K_2CO_3, all purchased from Sigma-Aldrich) were homogeneously mixed and heated in a platinum crucible to 1500°C (heating rate: 10°C min^{-1}) for 1 h in air; then the melt was quenched in cold water to obtain a "frit" that was ground by ball-milling and finally sieved to reach the desired particle size range.