glass by breaking the Si−O−Si bonds, formation of Si−OH groups, and release of $Si(OH)_4$ and silicate fragments. Condensation of Si−OH groups comes to the formation of the silica-rich layer on the glass surface. The silica-rich layer has high density of surface silanol groups (Si−OH), which are essential as nucleation centers for the precipitation of ACP. The formation of an amorphous calcium silicate and ACP is the result of electrostatic interactions between the Si−OH groups on the glass surface and the calcium and phosphate ions in a solution (Takadama et al., 2001). The ACP further increased its Ca/P atomic ratio, incorporating OH^- and small amounts of CO_3^{2-} anions from the solution, coming to the crystallization into HAP. The crystallization of ACP into crystalline HAP can be explained by the increase in its stability. Apatite minerals are the most thermodynamically stable and have a lower solubility in water than any other calcium phosphates (Dorozhkin, 2016; Raicevic et al., 2007). Cellular stages (6–12) are very complex and not fully clarified. These include biological processes, such as the action of macrophages, adsorption, desorption of proteins, growth factors, and collagen, which triggers proliferation and differentiation of cells and the creation of osteoblasts, thus encouraging bone growth on the surface glass (Ducheyne and Qiu, 1999). Osteoblast cells create an extracellular matrix, which mineralizes to form a nanocrystalline mineral and collagen on the surface of the glass implant, while the degradation and conversion of the glass continue over time (Ducheyne and Qiu, 1999; Hench and Polak, 2002).

Compared with a silicate glass, a bioactive borate glass is converted fully and faster to HAP in the SBF (Lepry and Nazhat, 2015; Huang et al., 2006; Yao et al., 2010; Manupriya et al., 2009; Abdelghany, 2013; Gu et al., 2011). A borate glass also showed a more rapid conversion to HAP compared to a phosphate glass (Abdelghany and Kamal, 2014). The conversion mechanism of borate glasses to HAP can be presented with a set of dissolution-precipitation reactions. Dissolution of a glass comes to a relatively rapid release of BO_3^{3-} and Na^+ ions, whereas the Ca^{2+} ions are slowly released and react with PO_4^{3-} and OH^- ions, from the phosphate solution, on the surface of the glass, leading to precipitation of an ACP layer that gradually crystallizes into HAP. HAP is initially formed on the outer glass surface remaining the same shape and size as the starting glass particles (Huang et al., 2006; Yao et al., 2010). The precipitated HAP is highly porous, providing for easy transport of the ionic solution through it. The continuation of the reaction leads to a thickening of the HAP layer from the surface of the glass inward. This process continues until the glass is completely converted to HAP. The conversion process could be controlled by diffusion of ions across the reacted layer, or by the reaction at the interface. The dissolution-precipitation reactions depend on both the physicochemical characteristics of glass and the leaching solution. The calcium content of the glass can be a major factor affecting the reaction rate of the conversion process (Manupriya et al., 2009; Abdelghany, 2013). An increase in the calcium content in binary calcium borate glasses causes an increase in the content of the BO_4 units, which decreases the rate of HAP formation on glass surfaces.