Overview of piezoelectric properties of 0-3 ceramic/polymer composites

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Abstract

As is known, composites based on ferroelectric ceramics (FCs) are developed for piezotechnical applications such as hydrophones, actuators, sensors, electromechanical transducers, elements of biomedical imaging devices, etc. In this review we analyze effective piezoelectric properties of FC/polymer composites with 0-3 connectivity. The main problem is to show how electromechanical properties and microgeometry of inclusions influence the piezoelectric activity and response of the 0-3 composites. In order to solve this problem, we consider the 0-3 composite that consists of aligned spheroidal FC inclusions and a polymer matrix. The shape of these inclusions is characterized by the aspect ratio, i.e., ratio of semiaxes of the spheroid. The effective properties of the composite are determined by using sets of electromechanical constants (EMCs) of its components. The sets of EMCs of the FC component are chosen among those determined for various perovskite-type compositions as follows: (i) EMCs calculated for lead titanate-based FCs in dependence on the remanent polarization; (ii) EMCs calculated for lead titanate - calcium titanate FCs in dependence on the molar concentration of components, and (iii) EMCs measured on soft FCs based on lead titanate - lead zirconate. Of particular interest are examples of non-monotonic behaviour of the piezoelectric coefficients of the 0-3 composite based on FCs from (i) - (iii). These parameters are calculated as functions of the volume concentration and the aspect ratio of the FC inclusions. In conclusions, we discuss and generalize reasons for this non-monotonic behaviour and some trends in improving the piezoelectric performance of the 0-3 FC/polymer composites.