Core-shell Structure Induced High Displacement In Piezoelectric Ceramics

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Introduction: Piezoelectric ceramics have been widely used in modern electronic industry such as actuators, sensors, generators, transducers and so on. In the particular application of piezoelectric actuators, the electrical input signal is transformed into displacement and mechanical force by piezoelectric ceramics. The piezoelectric displacement (or strain) plays a crucial role that determines the performance of piezoelectric actuators.

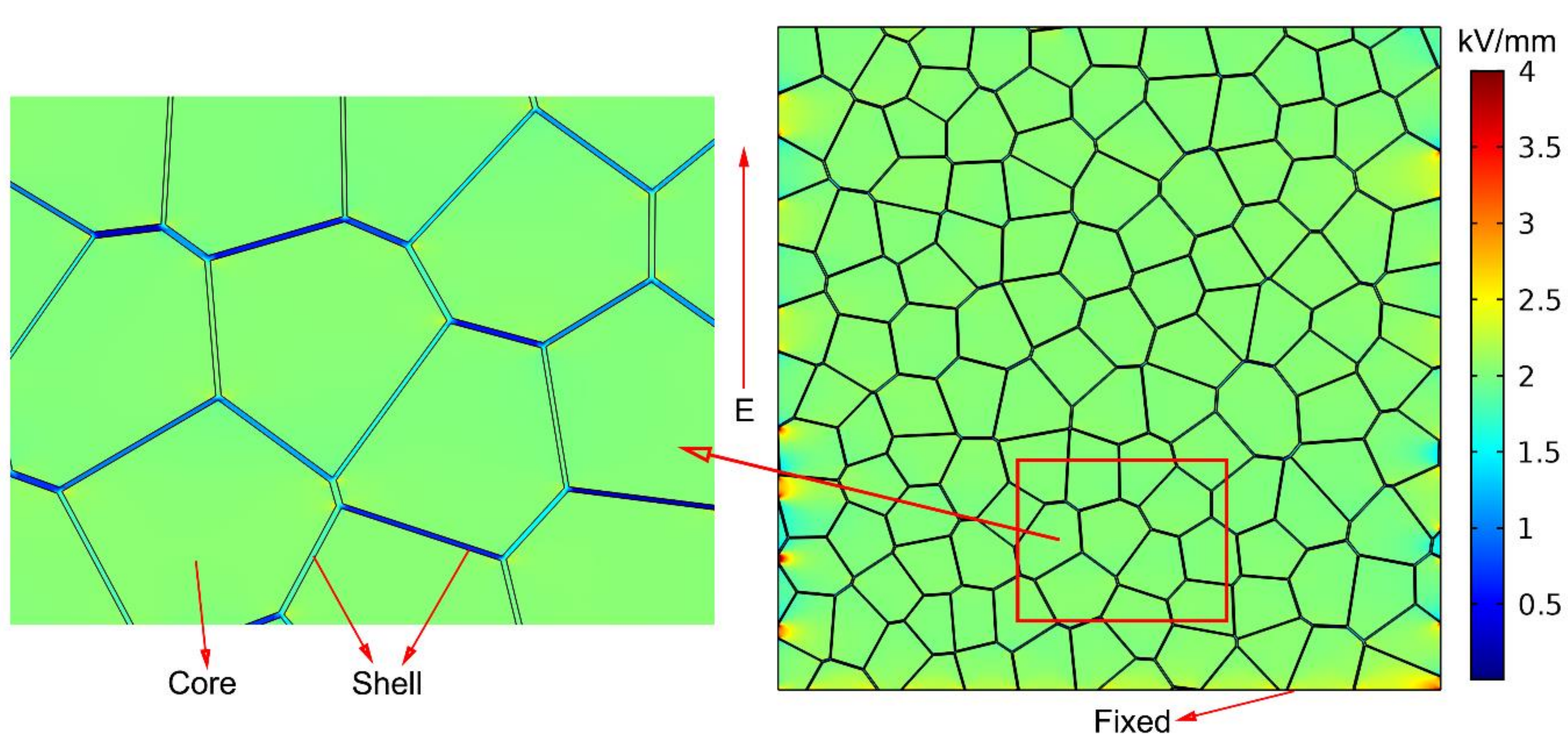

Fig. 1. Diagrams of core-shell structured piezoelectric composite and electric field distribution of composite under the applied electric field (E) of 2 kV/mm.

Modeling process : The core-shell structured microstructure of this selected region is generated through voronoi tessellation random construction routine as shown in Fig. 1. The most widely used piezoelectric ceramic lead zirconate titanate (PZT-7A) is taken as the example of grain core material. The displacement of piezoelectric composites is studied through Piezoelectric Device Interface under COMSOL Multiphysics.

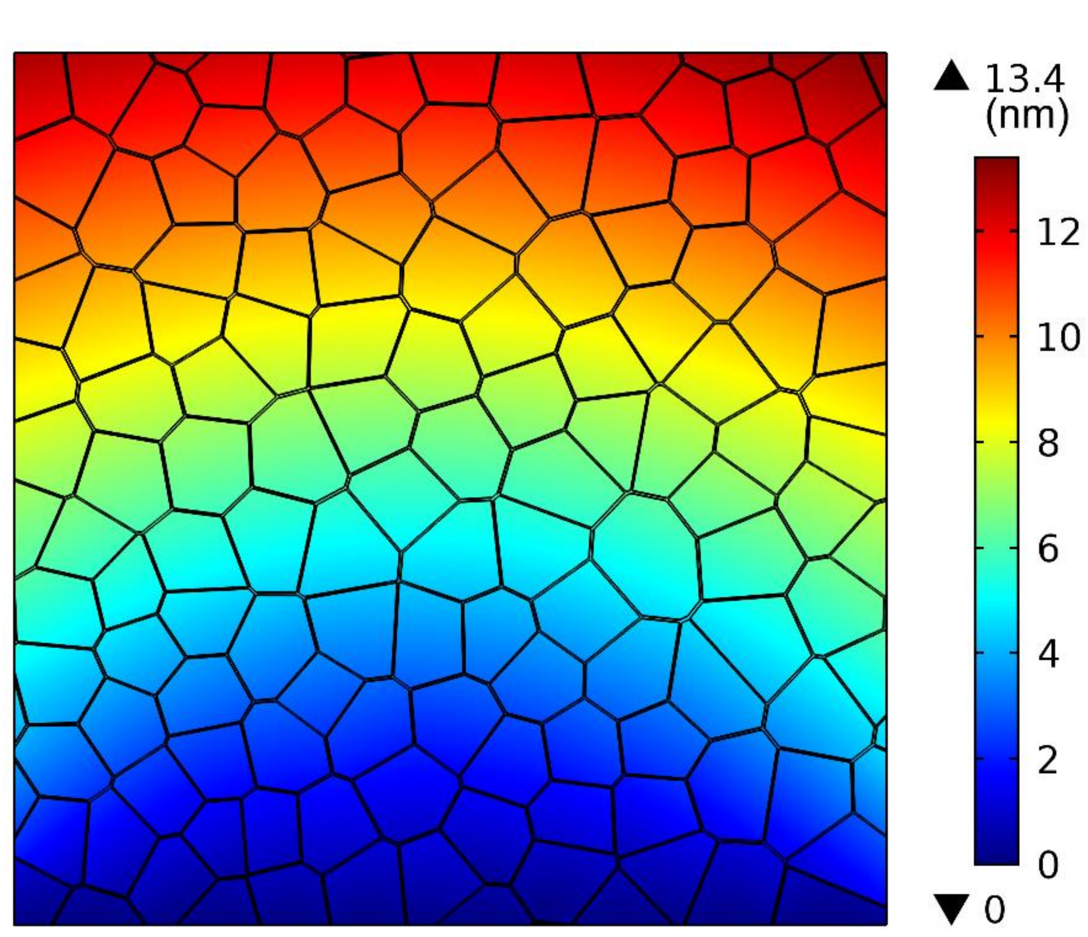

Fig. 2. Displacement field distribution of piezoelectric composite.

Results:

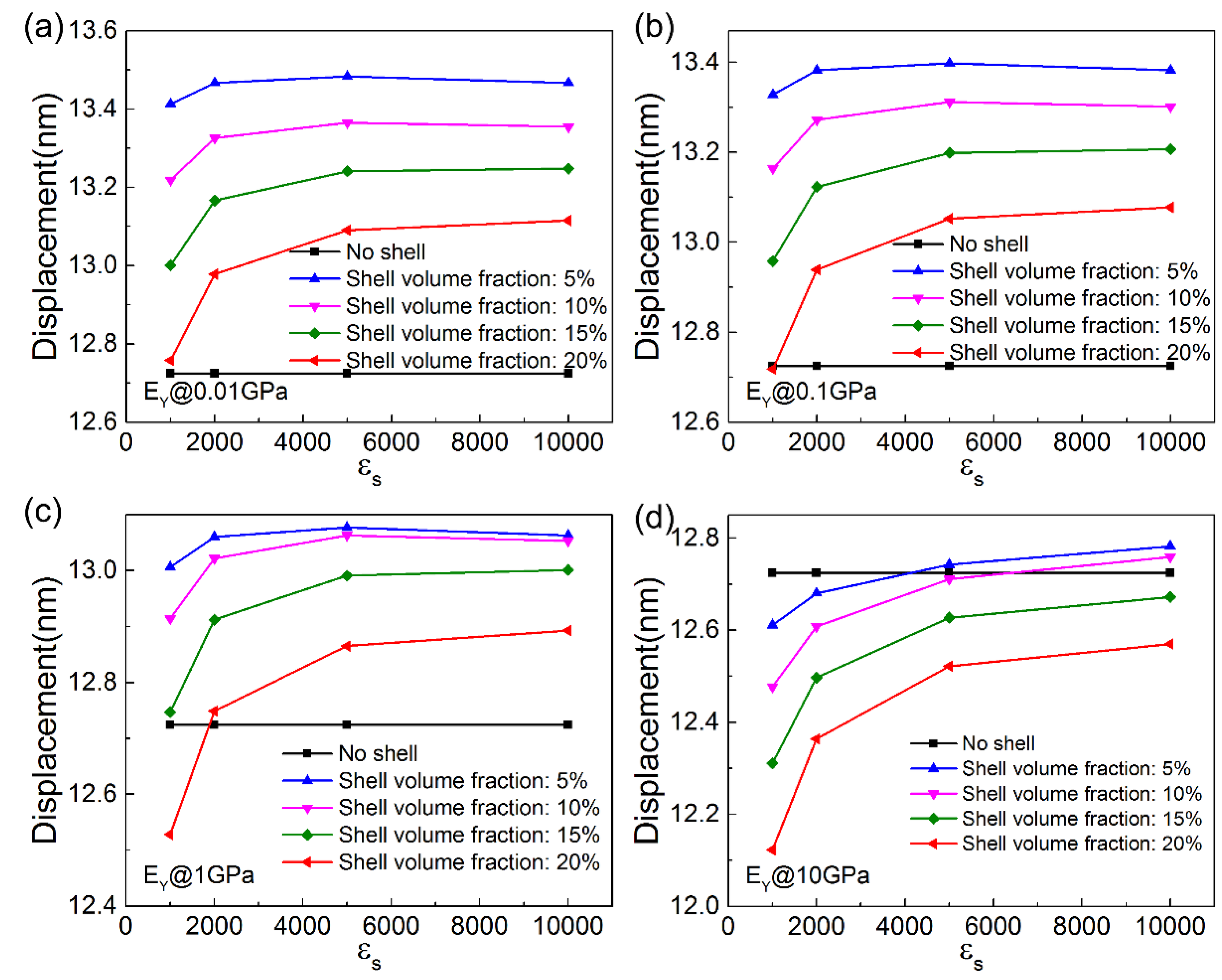

Fig. 3. Maximum displacement as a function of shell dielectric permittivity (ε_s) at various shell volume fractions with shell Young's modulus (E_Y) of: (a) 0.01GPa, (b) 0.1GPa, (c) 1GPa, (d) 10GPa.

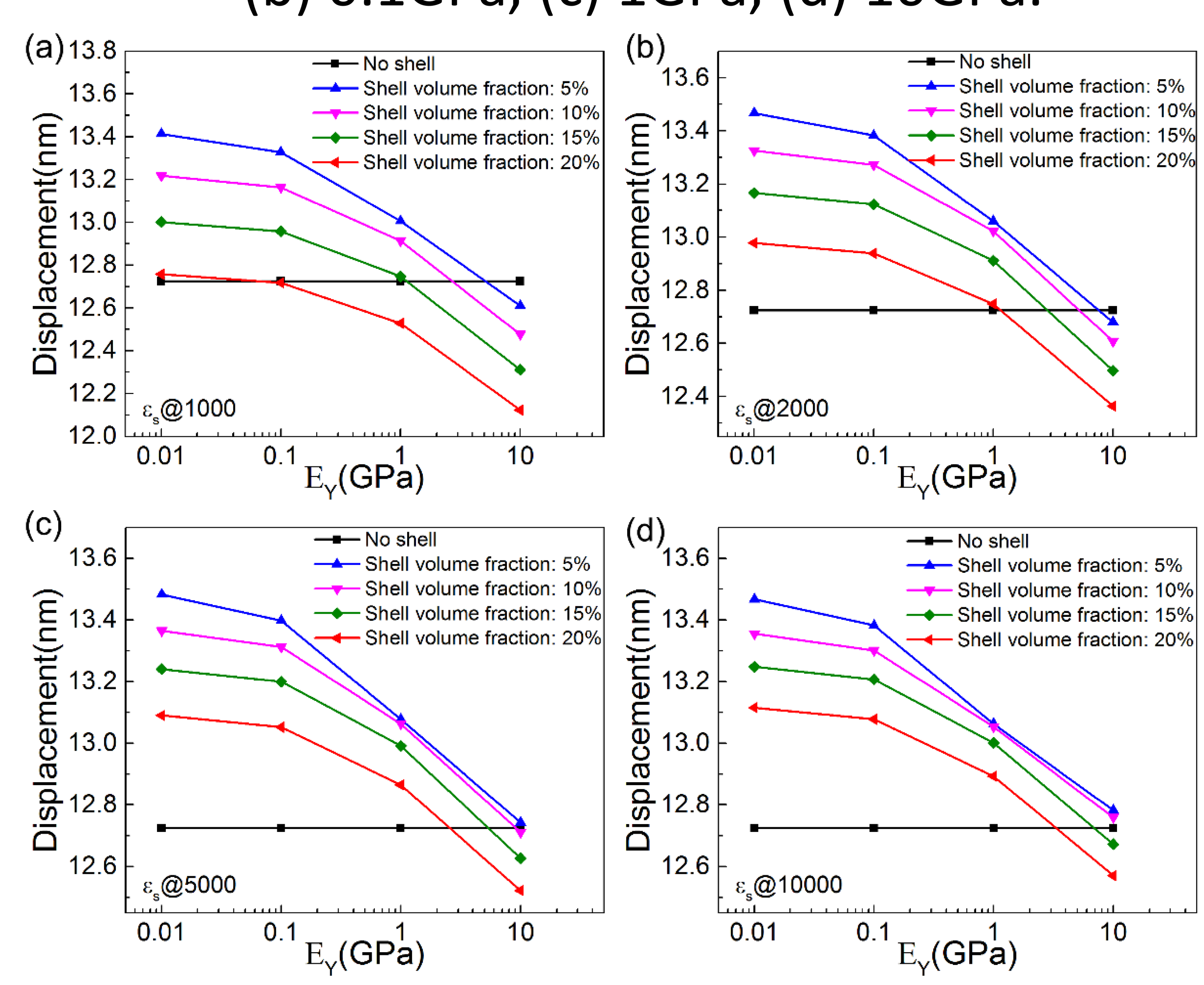

Fig. 4. Maximum displacement as a function of shell Young's modulus (E_Y) at various shell volume fractions with shell dielectric permittivity (ε_s) of: (a) 1000, (b) 2000, (c) 5000, (d) 10000.

Conclusion: It can be summarized that the displacement of piezoelectric composites can be enhanced by adopting smaller shell volume fraction, or by increasing the shell permittivity or decreasing shell Young's modulus. The mechanism of core-shell structure enhanced high displacement in piezoelectric ceramic composites is discussed deeply.

References:

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