COMSOL CONFERENCE 2017 BEIJING

Core-shell structure induced high displacement in piezoelectric ceramics

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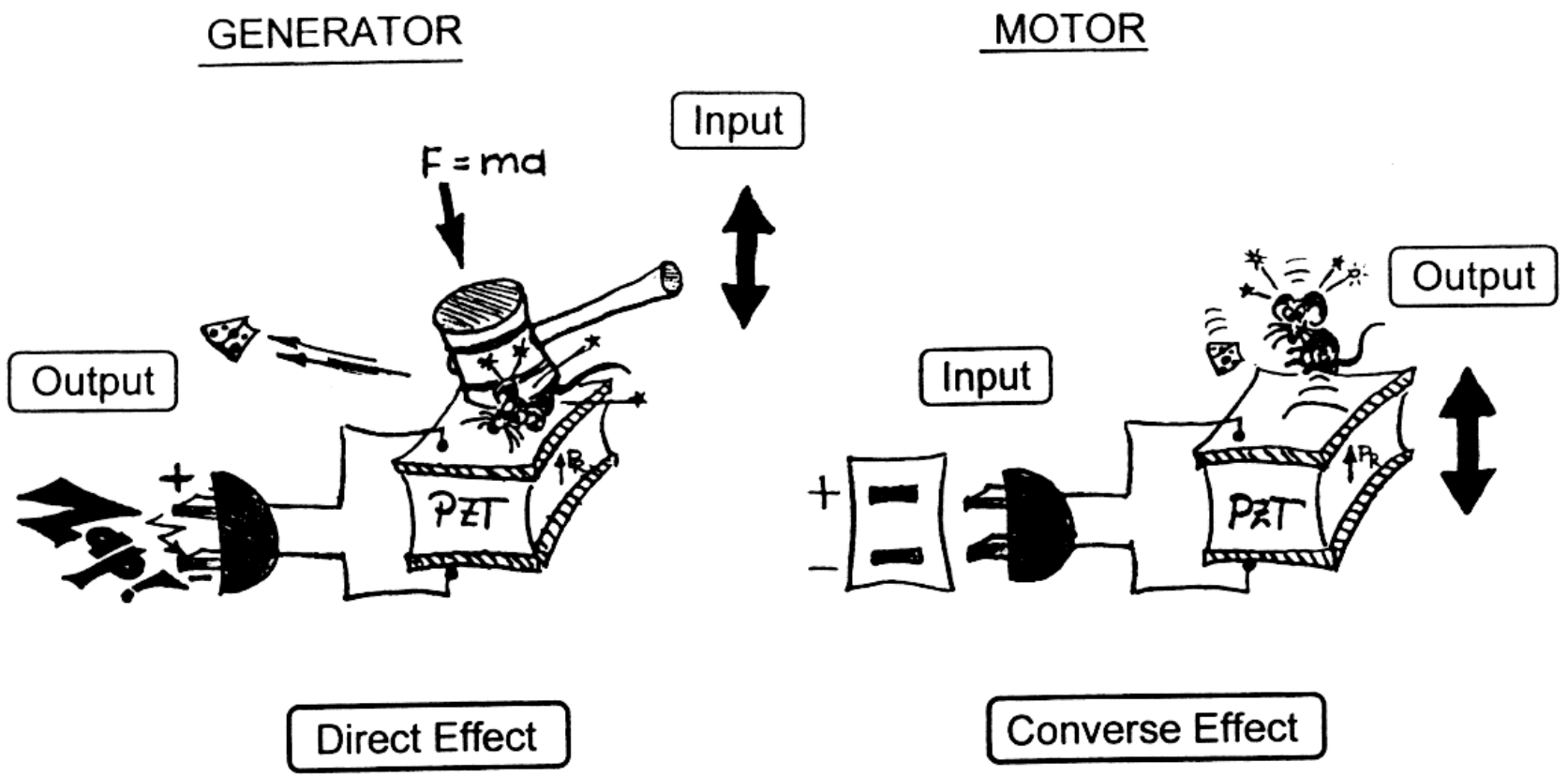
2017/11/2

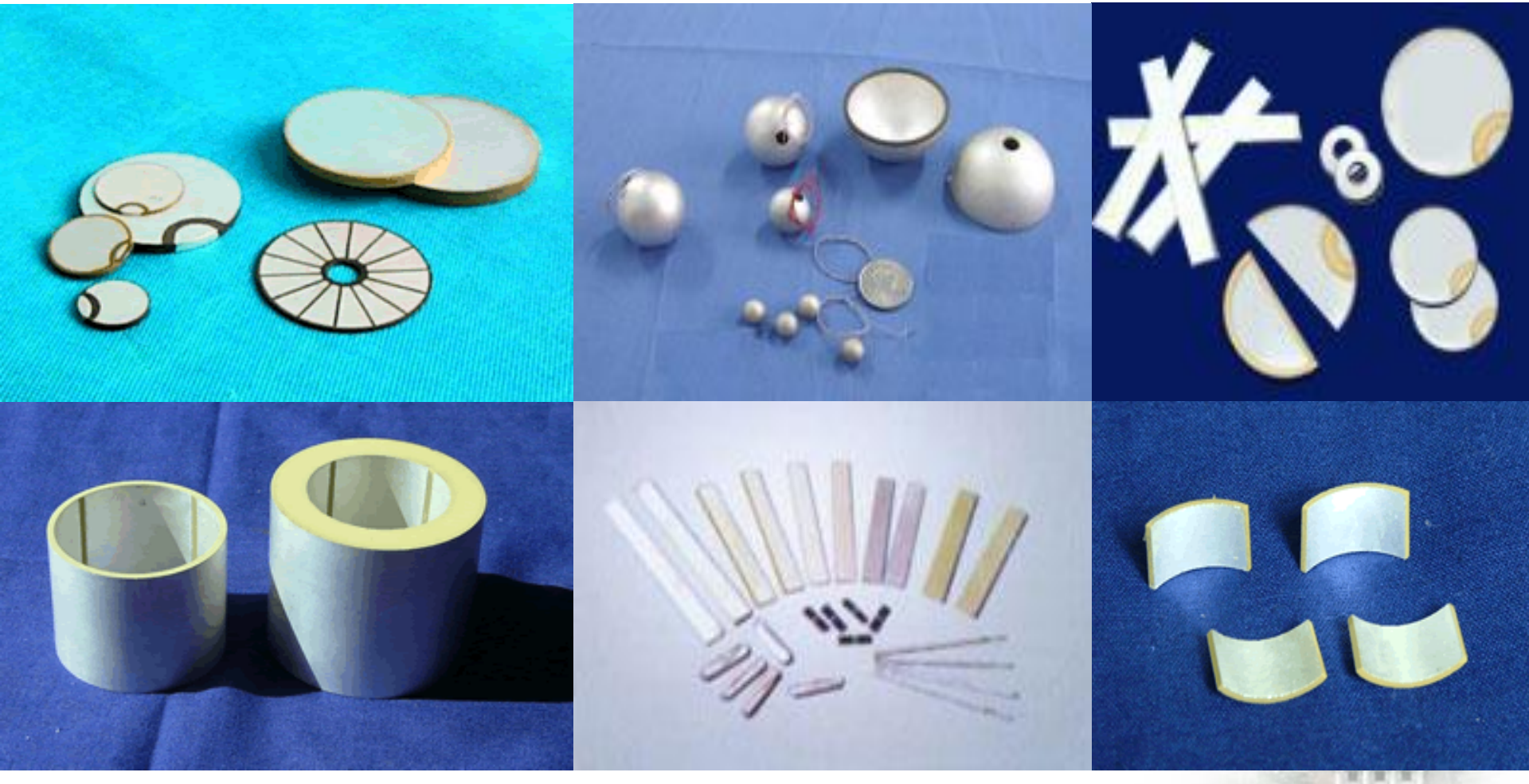
Introduction

piezoelectric effect



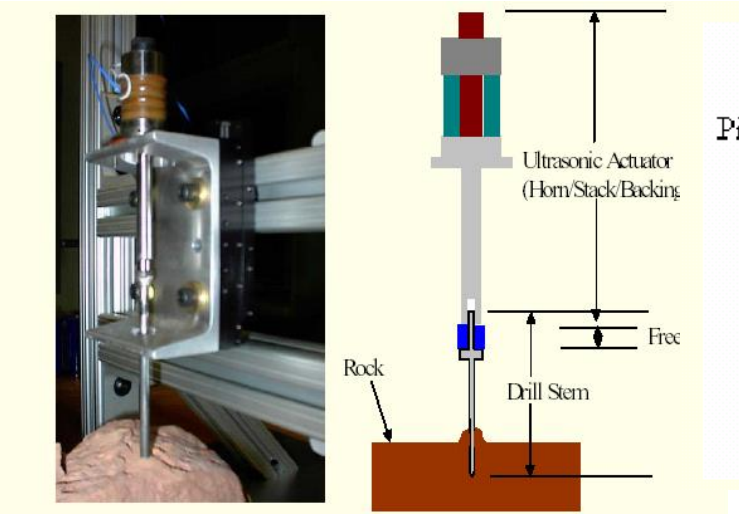
Introduction

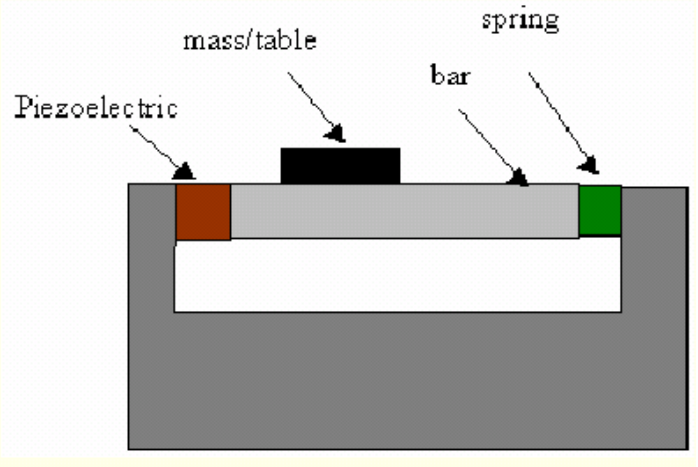
piezoelectric ceramics

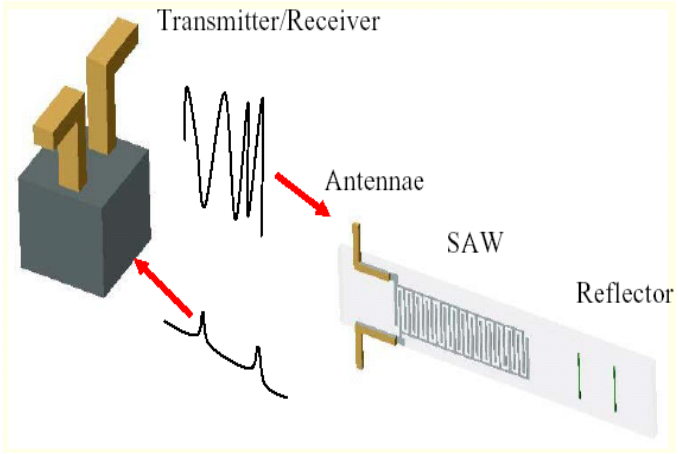


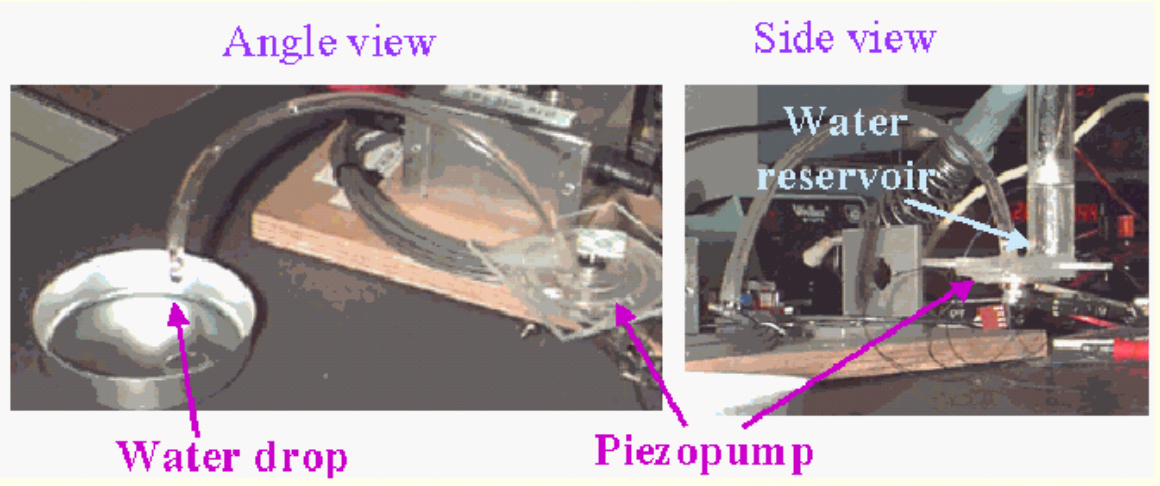
Introduction

piezoelectric applications



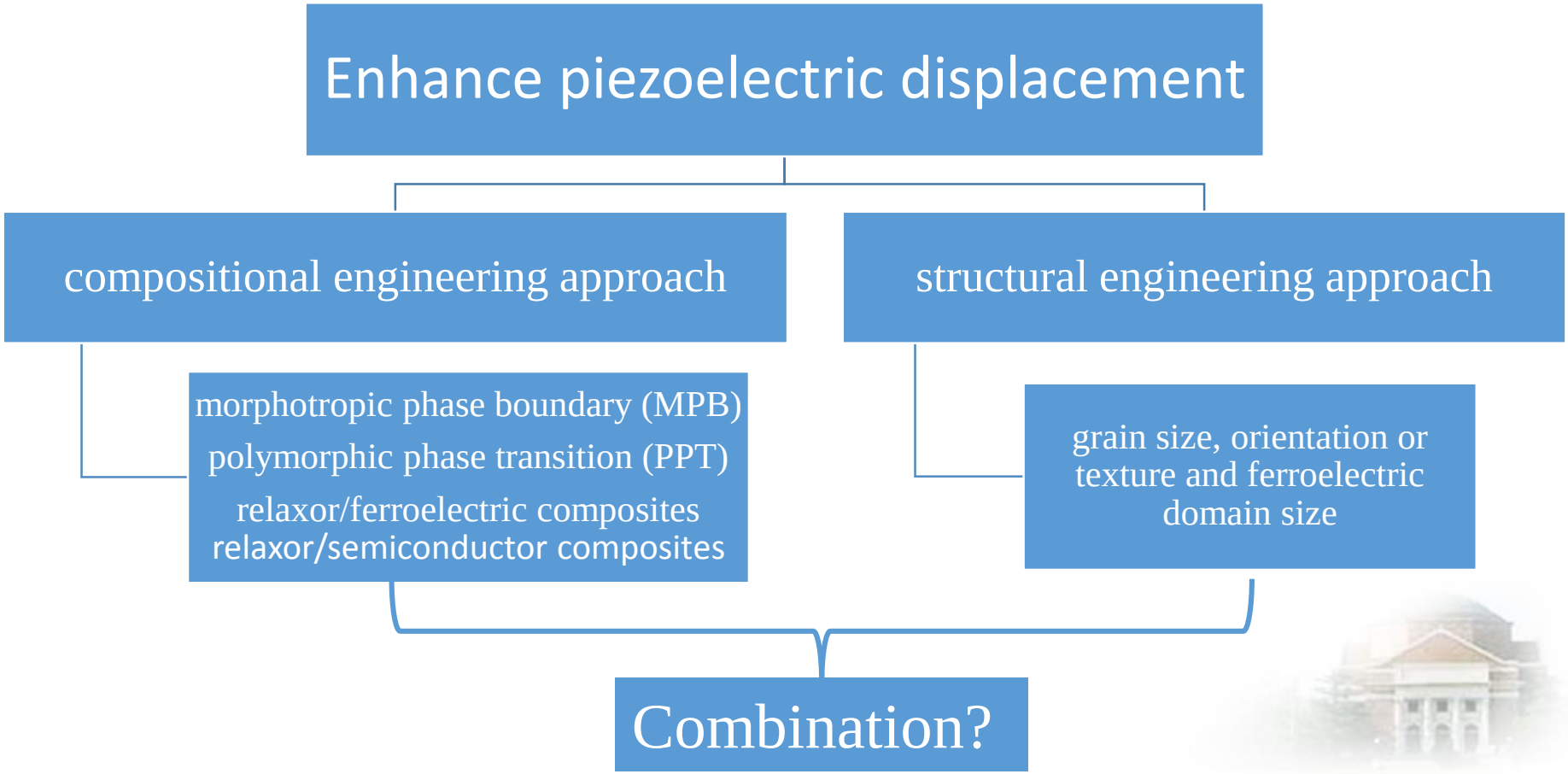






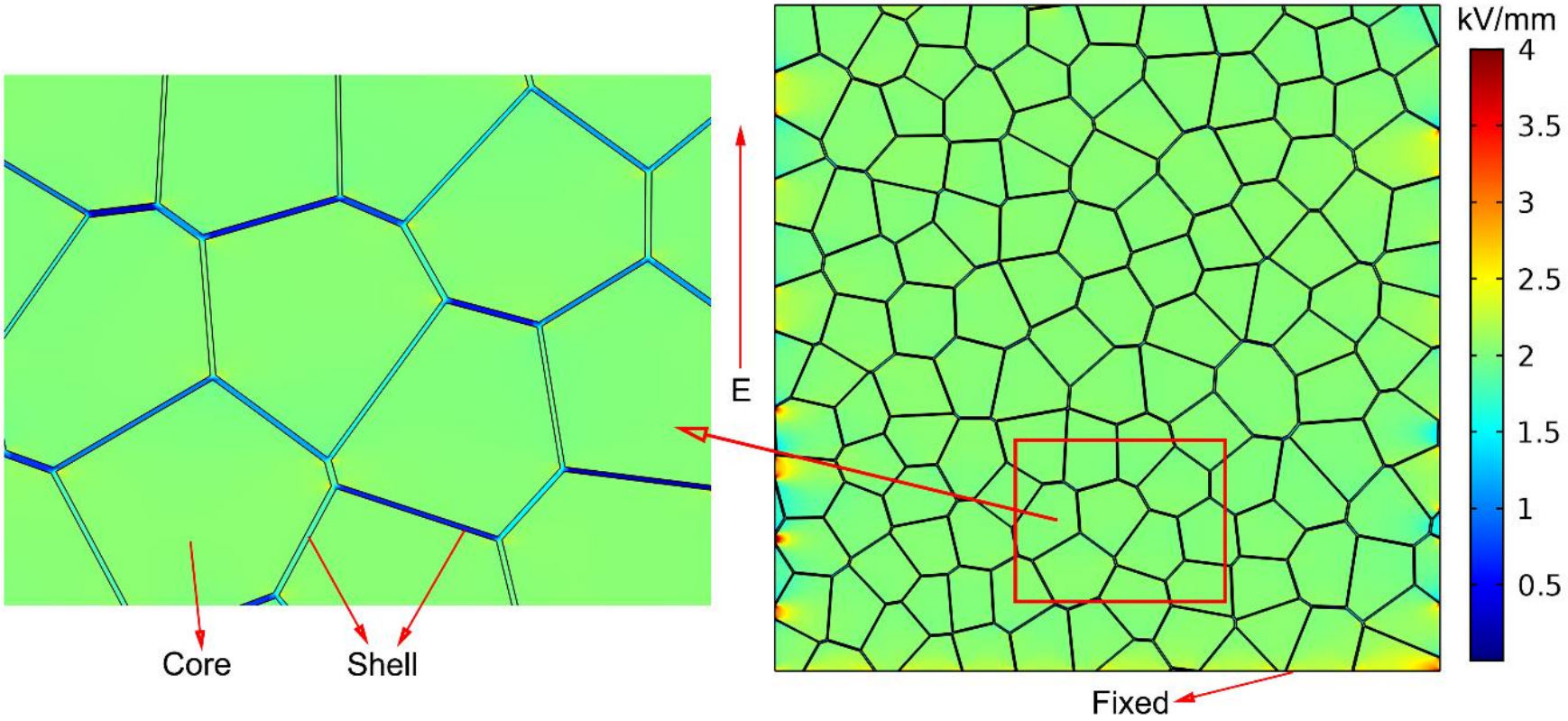
Introduction

In the particular application of piezoelectric actuators, the electrical input signal is transformed into displacement and mechanical force by piezoelectric ceramics. Such electromechanical coupling can be used in high accuracy control system like automotive fuel-injectors, precision positioning, ink-jet printing, micromotors, micropumps and many more.



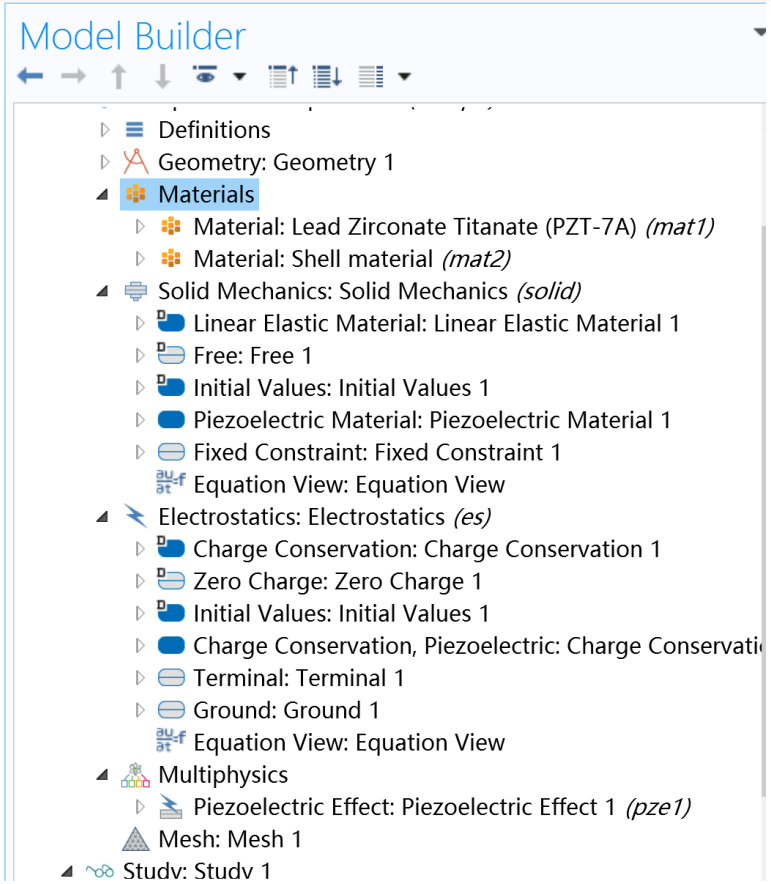
Introduction

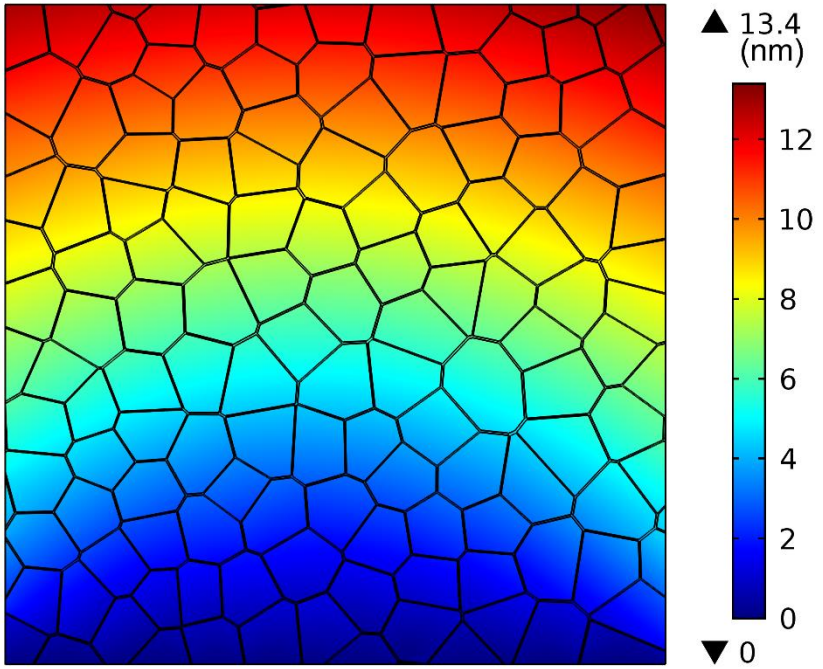
Core-shell structure



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



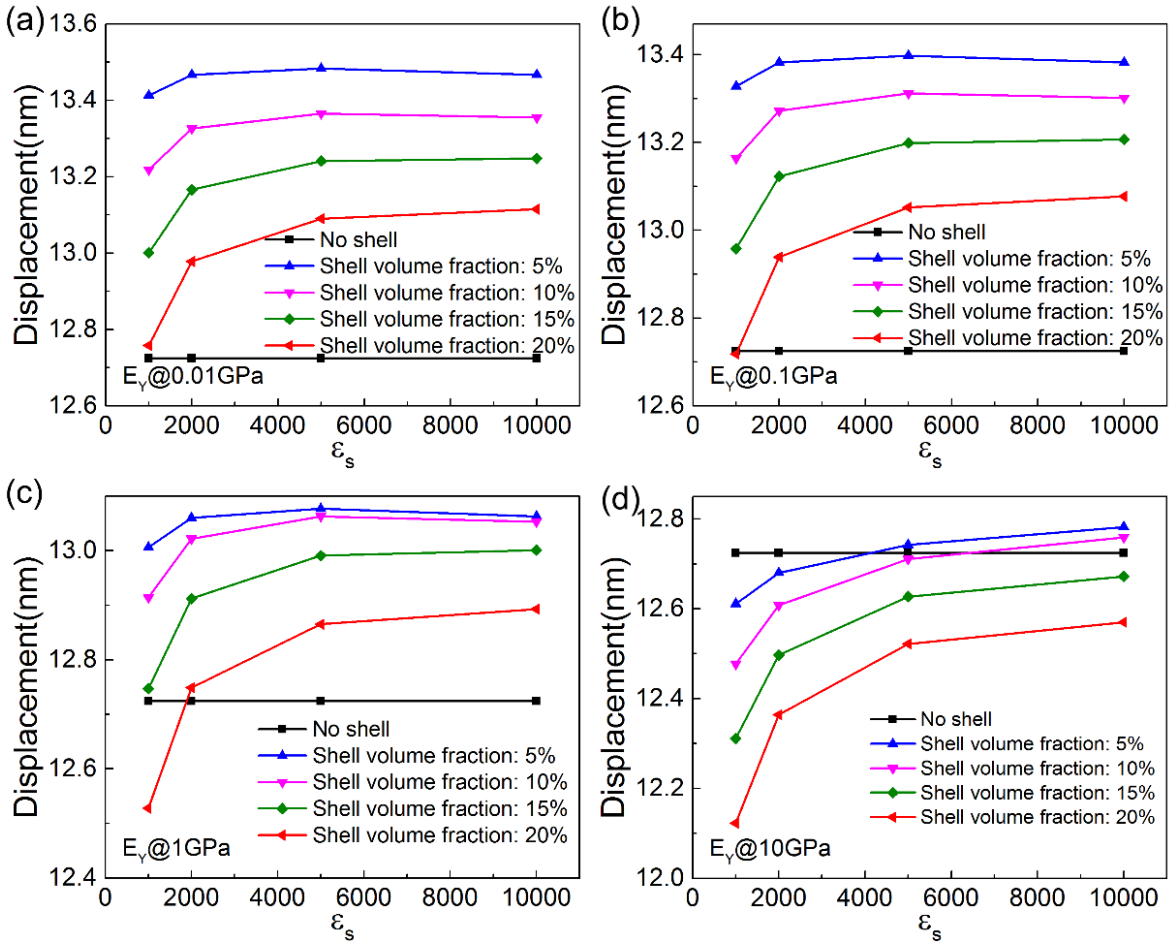


Shell volume fraction varying from 0 to 20%, dielectric permittivity varying from 1000 to 10000, Young's modulus varying from 0.01 to 10 GPa and applied electric field varying from 1 to 3 kV/mm.

Fig. 2. Displacement field distribution of piezoelectric composite under the applied electric field (E) of 2 kV/mm.

Results and Discussion

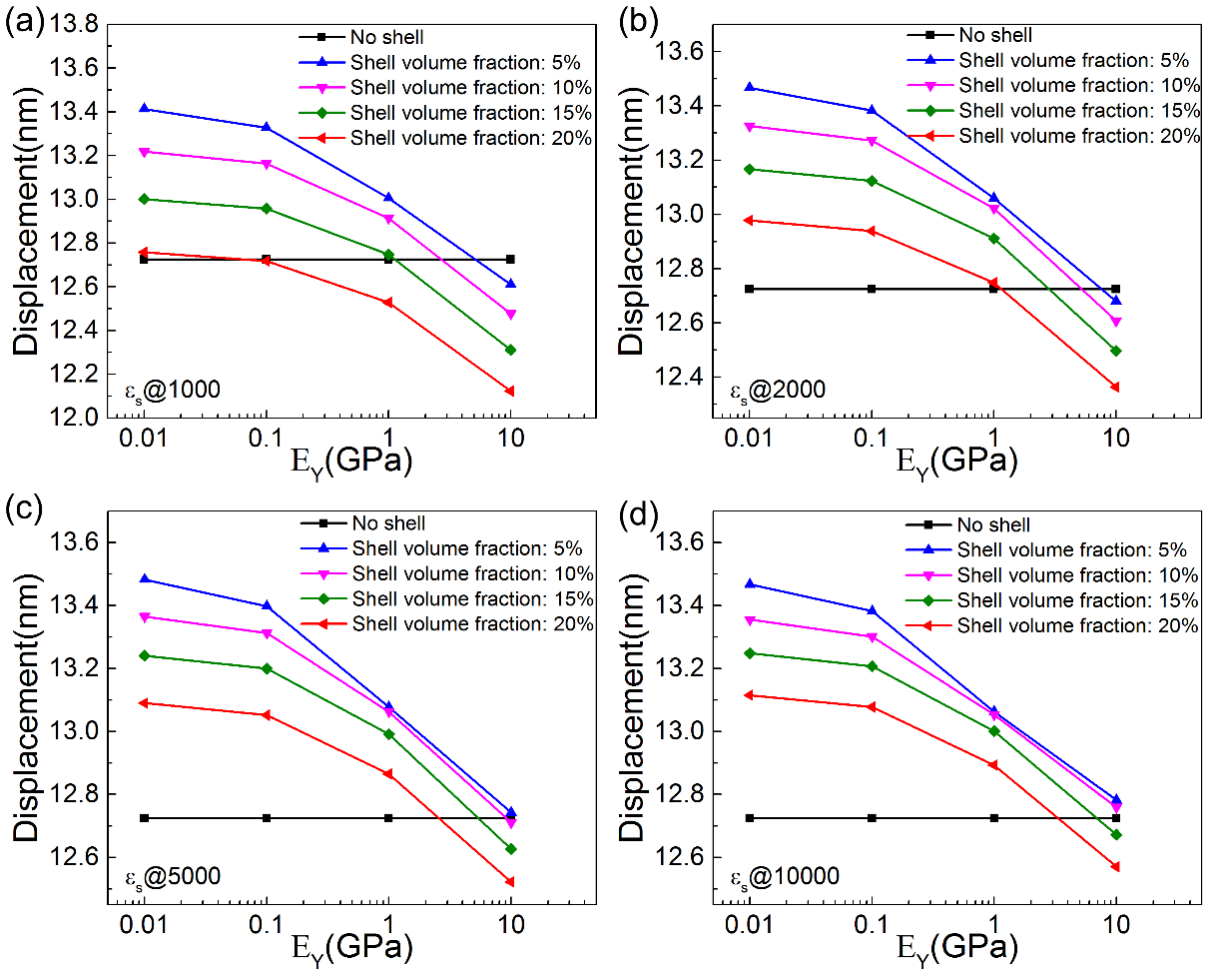
shell Young's modulus



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.

Results and Discussion

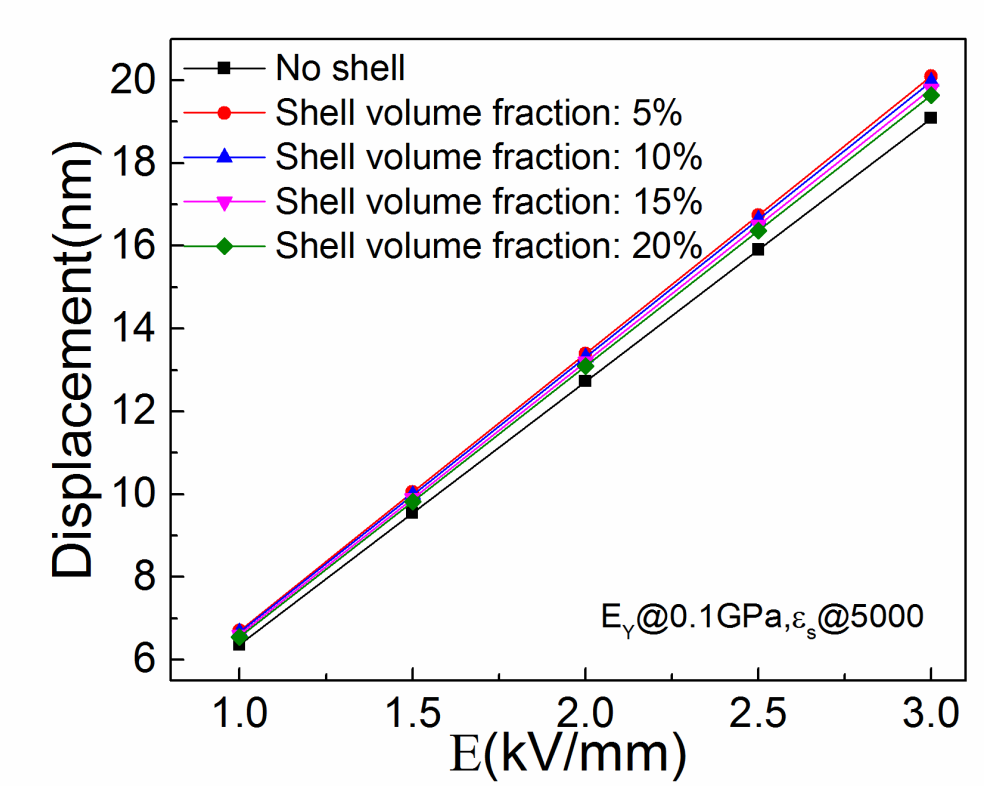
shell dielectric permittivity



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.

Results and Discussion

applied electric field



Maximum displacement as a function of the applied electric field (*E*) at various shell volume fractions.

Conclusion

A core-shell structured piezoelectric composite is proposed with the grain core typical ferroelectric material, while the shell "artificially created" material. The distribution of internal electric field and the displacement of these piezoelectric ceramic composites are successfully simulated through finite element method. 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. In conclusion, this novel core-shell structure design strategy in piezoelectric composite can achieve large piezoelectric displacement at a relatively low applied electric field, which is crucial for piezoelectric materials to be used as actuators.

Thanks !