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Typical dielectric elastomer structures: dynamics and application in structural vibration control

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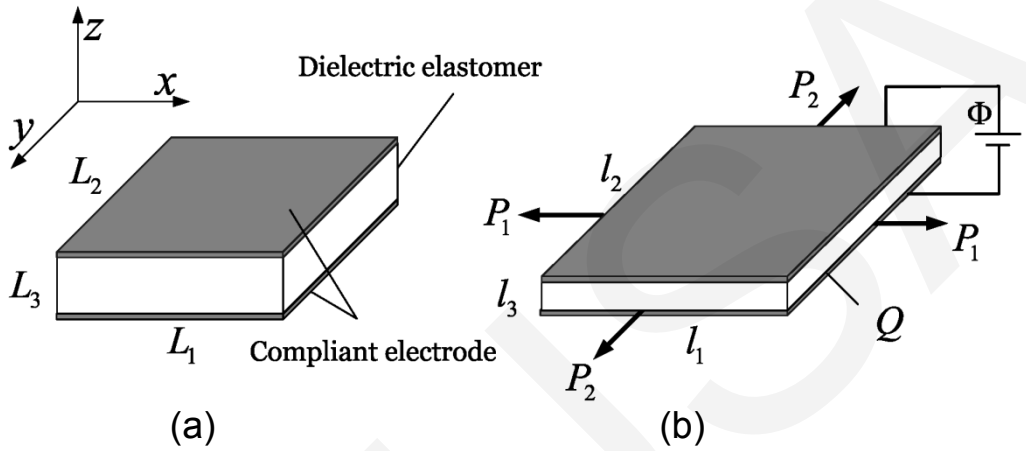
Dielectric Elastomer (DE) Structures

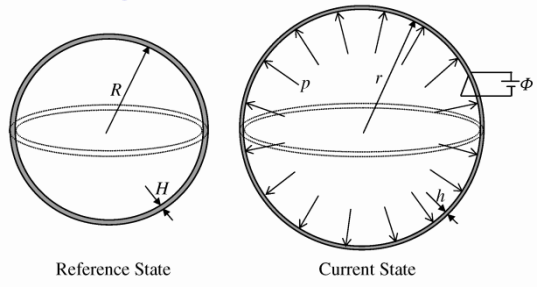


DE structure in the (a) un-deformed and (b) deformed states (reduces in thickness and expands in area)

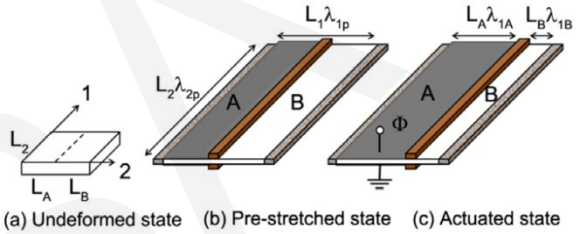
- **Prominent advantages: light weight, low compliance, high stretch ability, short response time, high energy density and so on.**
- **DE structure is mostly expected to work under dynamic excitation in many applications. DE structure can be used to constitute actuator and is suitable for application in vibration control.**

Dynamics of Typical DE Structures

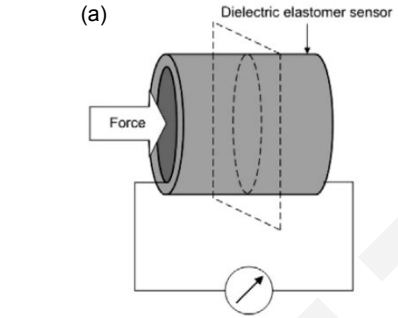
- Four typical structures according to their shapes

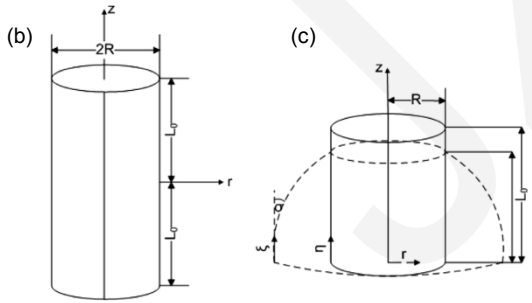


Spherical

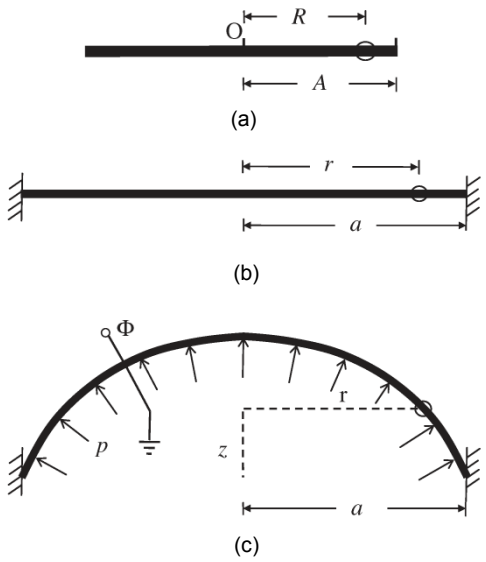


Rectangular





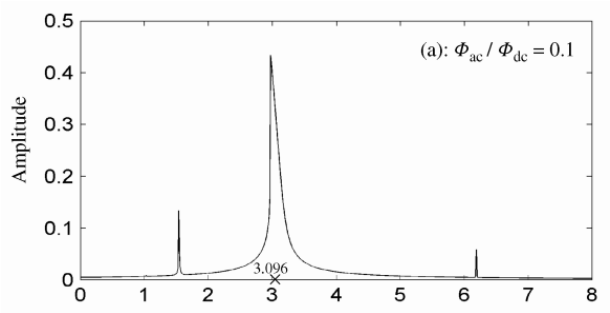
Tubular



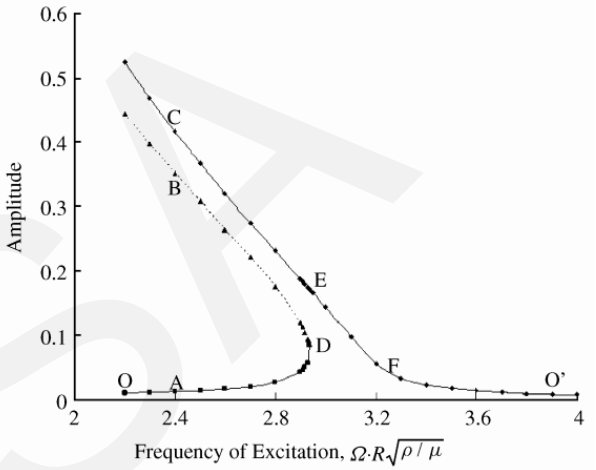
Circular

Dynamics of Typical DE Structures

Dynamical behavior



Resonance

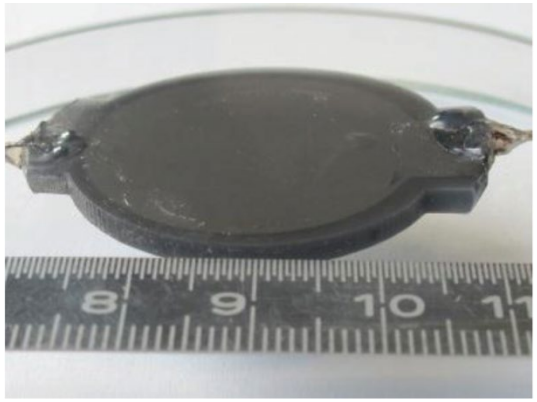


Jump

- Resonates at multiple values of excitation frequency, leading to super-harmonic, harmonic, and sub-harmonic responses.
- The oscillating amplitude may jump at certain value of excitation frequency.
- The natural frequency can be tuned by voltage and mechanical load.
- Bifurcation instability may occur.
- The imposed voltage and mechanical load may cause the DE structures failure.

Applications in Vibration Control

■Stack-type DE actuator



■Tubular-type DE actuator

- Stack-type DE actuator works in the contractile direction. Multi-layer stack design results in an increase in vertical direction with low electrical voltage.
- Tubular-type DE actuator works in expanding direction. Electrode corrugation design results in an increase of the force and stroke of unidirectional actuators.
- Feedforward and p-control algorithms are applied for the vibration control application of DE actuator. A significant reduction of vibration in certain frequency region is achieved.

Conclusions and Future Development

- All existing theoretical work on the dynamics of DE structures was confined to using low-dimensional models. However, bifurcation instability and asymmetry of practical DE structure may induce complex vibration. To accurately investigate the dynamical behavior of DE structure, high-order modal expansion must be taken into account.
- Moreover, in the existing work mechanical excitation and imposed voltage have been described by using deterministic functions. In practice, however, DE structure may be subject to random disturbance. Thus, the random responses of DE structure should be further investigated.

Conclusions and Future Development

- The control object, such as minimization of the responses of the main structure, can be obtained by elaborately designing the control term, i.e., the input voltage on the parallel electrodes. This subject, however, has not been covered by the existing literature and should be studied in future.