

Piezoelectric Materials Knowledge Evaluation Test

1. The piezoelectric effect is a result of a symmetric arrangement of atoms or ions in its material crystal structure.
 - a. True
 - b. False

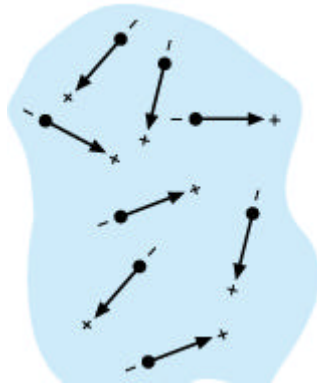
2. Piezoelectric materials are those that:
 - a. Experience a dimensional change when an electrical voltage is applied
 - b. Generate electricity when pressure is applied
 - c. Both a & b
 - d. Neither a nor b

3. Piezoelectric materials are made by the following process:
 - a. Annealing
 - b. Poling
 - c. Anti-poling
 - d. Binding
 - e. Both a & c

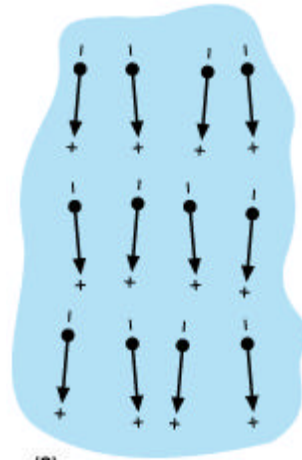
4. Which are steps required in making a piezoelectric material?
 - a. Heating the material above the Curie Temperature and cooling it with no electric field present
 - b. Heating the material above the Curie Temperature and cooling it with an electric field present
 - c. Cooling the material to the Curie Temperature while an electric field is maintained and then reheating it to room temperature
 - d. Cooling the material to the Curie Temperature with no electric field present and then reheating it to room temperature

5. Which picture represents the electric dipoles in the piezoelectric material after the poling process?

a.



b.



6. What occurs in materials to cause the piezoelectric effect?

- a. The crystal structure undergoes a phase change when it is subjected to an electric field.
- b. Aligned electric dipoles respond to produce a dimension change when subjected to a small electric field.
- c. Unaligned dipoles align themselves to produce a dimension change when subjected to a small electric field.
- d. None of the above

7. Open loop piezo actuators (also called ferroelectric actuators) exhibit hysteresis. The hysteresis is based on which of the following?

- a. Molecular friction
- b. Crystalline polarization effects
- c. Both of the above
- d. None of the above

8. Which of the following is true?

- a. The working temperature of the piezoelectric material is above its Curie temperature.
- b. Below the Curie temperature the dipoles can shift out of alignment when too strong a field is applied.
- c. If heated above the Curie temperature the dipoles will be aligned if no electric field is applied.
- d. Once a material is depoled it has the property of a dimensional response to an electric field.

9. The strain in a piezoelectric actuator is from:

- a. "free strain" (also called "piezoelectric strain")
- b. mechanical strain
- c. superposition of both the free strain and the mechanical strain
- d. None of the above

10. Free strain depends upon the following factors:

- a. load applied
- b. piezoelectric modulus
- c. applied electric field
- d. a & b
- e. b & c

11. Which of the following is true?

- a. Hard piezoelectric materials have a Curie temperature below 200°C and soft piezoelectric materials have a Curie temperature above 300°C.
- b. Hard piezoelectric materials are readily poled or depoled at room temperature with strong electric current and soft piezoelectric materials are not easily poled except at elevated temperatures.
- c. Both a & b are true
- d. Neither a nor b is true

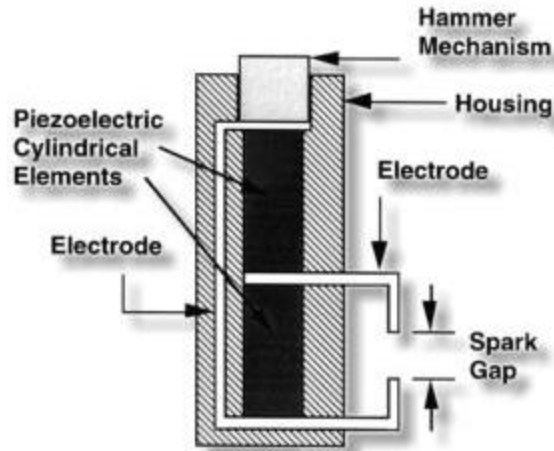
12. There are two modes of operation. Mode 1 is an expansion in the same direction as the electrical field and poling direction. Mode 2 is a contraction perpendicular to the electrical field and poling direction. Which of the following is true?
- The relative displacement in Mode 1 is larger than the relative displacement in Mode 2
 - The relative displacement in Mode 1 is smaller than the relative displacement in Mode 2
 - The relative displacement in Mode 1 is equal to the relative displacement in Mode 2
13. Which of the following is a false statement about piezoelectric actuation leading to bending deformation?
- Perfect bonding is *assumed* between the crystals and the structure at the interfaces.
 - The piezoelectric free strain must exceed in magnitude the maximum strain to be induced during actuation.
 - The strain and stress are continuous at the interfaces.
 - Strain within the crystals is obtained by superposition of the free strain and the strain in the driven structure.
14. The electric displacement for a piezoelectric material is NOT a factor of:
- Electric permittivity
 - Electric field
 - Stress
 - Piezoelectric coefficient
 - All of the above are factors
15. Which of the following is the name for a piezoelectric actuator that is made out of two thin plates of piezocrystals which are stacked in such a way that different applied voltages can generate deflections in different directions?
- Ceramic linearizer
 - Tubular
 - Metallographic stacks
 - Bimorph

16. In general, several piezoelectric actuators elements can be added together to increase the displacement or the force of the output.
- True
 - False
17. All of the following are current applications for piezoelectric materials. Which of the following does not require an electric voltage to be applied in order for the piezoelectric material to work.
- Changing the shape of telescope mirrors
 - To move an ink jet print head
 - As an impact sensor for crash detection
 - As a vibration damper
18. What is the piezoelectric material being used to do in the following application?
- “The piezoelectric materials were arranged in two stacks. These stacks are placed on top of another with a stress sensor between them. The top stack is made to vibrate at a specified frequency via application of an electric field. The stress sensor detects this vibration and sends the signal to a feedback loop. The feedback amplifier can either set the bottom stack vibrating in phase or exactly out of phase with the top stack. If the two stacks vibrate in phase, the device acts as a very compliant material. If the vibrations are out of phase, the device becomes stiff.”
- Electronic filter
 - Sensor
 - Vibration damper
 - None of the above
19. Piezoelectric materials have recently been put into some skis in order to reduce the vibrations and give the skier a smoother ride. First, vibrations in the piezoelectric material generate electrical signals in the card. These are interpreted by the control circuit, which in turn sends pulses of electrical energy into the piezoelectric material to change its stiffness and damp the vibrations.

What makes this a SMART system?

- The material serves as a sensor
- The material serves as an actuator
- The material serves as both an sensor and an actuator
- This is not a SMART system

20. In the following diagram illustrates how piezoelectric materials are used in one type of igniter.



In this example the hammer mechanism impacts the piezoelectric material. Which piezoelectric effect is the igniter utilizing?

- a. The material experiences a dimensional change when an electrical voltage is applied
- b. The material generates an electric voltage potential when pressure is applied
- c. Both of these are utilized in this example
- d. These are not piezoelectric effects

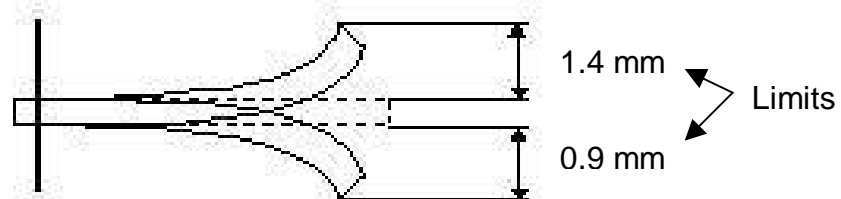
21. Aerospace Companies working on the Sidewinder missile now plan to fit piezoelectric elements in the fins that will make the fins twist in flight. They claim that the new design reduces aerodynamic drag on the fins by more than 90 per cent. The piezoelectric elements are attached in parallel strips to plates of fiberglass, and the plates flex when voltages are applied to the elements. At a voltage of 600 volts per millimeter of piezoelectric material, the plates will bend through 44 degrees per meter of plate and twist through 31 degrees.

Without knowing any other information about the system, the piezoelectric materials are being used primarily as:

- a. Actuator
- b. Electronic filter
- c. Sensor
- d. Vibration damper
- e. None of the above

22. Determine the maximum force that can be produced from a piezoelectric actuator if it is modeled as a simple beam spring.

Given:



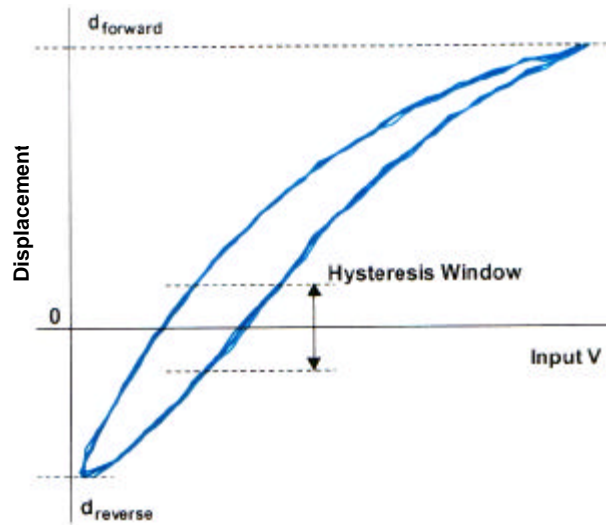
k = Spring Constant for piezoelectric material
 E = Youngs Modulus for piezoelectric material

- a. max force = k (1.4 mm)
- b. max force = k (0.9 mm)
- c. max force = k (2.3 mm)
- d. max force = E (1.4 mm)
- e. max force = E (2.3 mm)

23. A constant mechanical load is applied to the piezoelectric actuator in Problem 22. Provided the load does not exceed the maximum limits for the actuator, which of the following is true?

- a. Both the amount of deflection and the position of the end of the beam will remain unchanged.
- b. The amount of deflection will remain unchanged. However, the movement of the beam will be offset.
- c. The amount of deflection will increase.
- d. The amount of deflection will decrease.

24. As shown in the figure below, while a piezoelectric actuator exhibits hysteresis in its position (meaning it does not return to exactly the same position after being energized), the fully forward and fully reverse positions are not affected by hysteresis.



- a. True
b. False

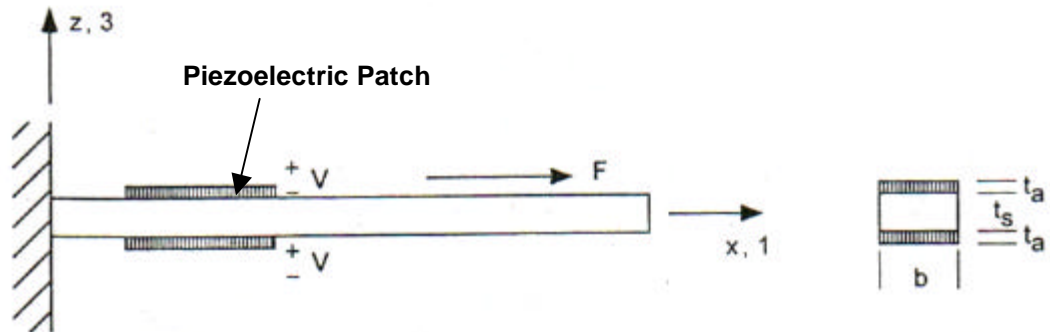
25. Two piezoelectric patches are attached to the flat bar as shown below. Assume that the movement can be modeled as axial motion of a rod.

Where:

ϵ_s = Strain in base Structure

ϵ_p = Piezoelectric Strain

ϵ_a = Strain in Piezoelectric Actuator



The strain of the bar with only mechanical loading ($V=0, F>0$) is:

$$e = \frac{F/b}{2E_a t_a + E_s t_s}$$

The strain of the bar with only actuator loading ($V>0, F=0$) is:

$$e = \frac{2E_a e_p t_a}{2E_a t_a + E_s t_s}$$

What is the strain on the bar with both mechanical and actuator loading?

- $e = \frac{F/b}{2E_a e_p t_a}$
- $e = \frac{2E_a e_p t_a}{F/b_s}$
- $e = \frac{F/b + 2E_a e_p t_a}{2E_a t_a + E_s t_s}$
- $e = \frac{F/b - 2E_a e_p t_a}{2E_a t_a + E_s t_s}$