Introduction to Piezoelectric Actuators
– Professor's Misconceptions Top 10 –

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Actuator applications of piezoelectrics started in late 1970s, and enormous investment was installed on practical developments during '80s, aiming at consumer applications such as precision positioners with high strain materials, multilayer device designing and mass-fabrication processes for portable electronic devices, ultrasonic motors for micro-robotics and smart structures. After the slump due to the worldwide economic recession in late '90s, we are now facing a sort of "Renaissance" of piezoelectric actuators according to the social environmental changes.

In order to stimulate young researchers in this area, I dare to create this teaching material, "Professor's Misconceptions Top 10". The "piezoelectric actuator" is a really interdisciplinary area, to which materials, electrical and mechanical engineers are primarily approaching. Because of narrow knowledge of young professors, they occasionally instruct the students with a sort of misconceptions. During my 40 year experiences in this world as both academic authority and industrial executive, I accumulated various professors' misconceptions. This paper reviews the top 10 among these. Initially try the following ***True/False tests*** (All are actually False). If you do not find any "False", you are a serious patient, and you should take this tutorial course as a prescription.

1) Electrostriction is caused by a slight displacement of ions in the crystal lattice under field. This displacement will accumulate throughout the bulk and result in an overall strain along the field. (cited from a famous encyclopedia).
2) When 1 J electric energy is input to a piezoelectric with an electromechanical coupling factor k, we can expect k^2 J mechanical energy converted in this piezo-material. Thus, we can conclude that the efficiency of this device is k^2 %. (cited from a journal paper on Mechanical Engineering)
3) By applying 1 J electric energy on a piezoelectric with an electromechanical coupling factor k, we accumulated k^2 J mechanical energy in this piezo-material. Thus, this actuator can work mechanically up to k^2 J to the outside.
4) Elastic compliances & sound velocity are the material's constants in a piezoelectric. Thus, the resonance frequencies are merely determined by the sample size.
5) PZT with the high electromechanical coupling factor k is the best piezoelectric material for heart beat monitoring sensors. (during a conversation with an electrical engineering professor)
6) When the piezo-actuator generates unwelcomed vibration ringing in the mechanical system, the best way is to install a suitable mechanical damper in the system. (during a conversation with a mechanical engineer)
7) The resonance mode is only the mechanical resonance, while the antiresonance mode is not a mechanical resonance. (during a conversation with a materials professor)
8) The resonance mode is the best efficient driving condition of the piezoelectric transducer.
9) Improving the performance is the best way for seeking the "Best-Selling" device. (most of the professors)
10) The device developer should focus merely on the "component" development by purchasing the driving circuit from the outside for reducing the development period.

In order to provide a long-term research strategies, the author present the application trends in the 21st century. Global regulations are strongly called on ecological and human health care issues, and the government-initiated technology (i.e., "*politico-engineering*") has become essential. Because of significantly high energy efficiency of piezoelectrics in comparison with other actuators such as chemical engines and electromagnetic components, piezoelectric actuators have been re-focused recently in the sustainable society (i.e., "Renaissance" in piezoelectric actuators). Crisis technology applications such as earthquake detection, infrastructure monitoring, virus inspection as well as sophisticated warfare will be expanding in the market. Designing principles of ultrasonic motors, piezoelectric transformers and energy harvesting systems are briefly introduced during this presentation.