

Advanced Electroactive Actuator based Modified Terpolymer for Intelligent Astronomical and Medical Applications

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Electroactive polymers (EAPs) have currently attracted a great deal of interest in actuator devices thanks to their high flexibility, easy control, simple integration, and possible to be 3D printed. Such materials seem to be very promising in additive manufacturing whose recent advances become far more widespread and it offers exciting opportunities for future development, particularly in high potential applications like a deformable mirror for astronomy optical communication in Figure (1A), smart remote sensing system, smart medical instruments, etc. However, enhancement in actuation performance is still in progress for achieving large deformation and load exertion, which is the main reason that limits the current EAPs widely used in actuator industries.

In this work, terpolymer (P[VDF-TrFE-CFE]) is investigated as EAP by the reason of its outstanding electromechanical coupling properties [1]. In order to improve the electromechanical coupling, the plasticizer Diisononyl phthalate (DINP) was incorporated into the terpolymer matrix, leading to decrease Young's modulus and increase dielectric permittivity, simultaneously. It was demonstrated that excellent transversal strain, as well as energy density, has been achieved under relatively low electric field, as opposed to the classical EAPs where extremely high input voltage is required to reach sufficient mechanical strain [2].

The terpolymer actuators were designed with active circular shapes, as showed in Figure (1B). Experimental result showed that compared to the pure terpolymer, the plasticized sample exhibited a 20-fold increase in the strain (S_{33}) under relatively low applied electric field. With the aim of improving actuation performance at the same input electric field, multilayered based modified terpolymer has been involved, by depositing layer by layer like a succession of capacitors in parallel as depicted Figure (1C). The proposed approach gives rise to an increase of total strain from 0.5 % for the one-layer sample to 2.0 % for the six-layer sample under $E = 10 \text{ V}/\mu\text{m}$. In addition, the developed material is somewhat cheap, commercially available, and could potentially break a technological lock of conventional electroactive polymer especially for application where low electric field is mandatory.

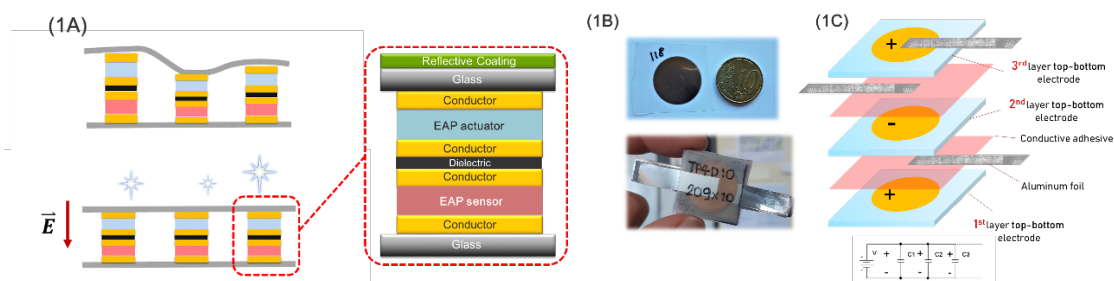


Figure 1 (A) A design of hybrid system used for mirror deformable application (B) terpolymer actuator (C) terpolymer multilayered design

Keywords: Electroactive polymer, plasticized terpolymer, high mechanical performance actuator, multilayered actuator, actuator under low electric field.

- [1] J. F. Capsal, J. Galineau, M. Lallart, P. J. Cottinet, and D. Guyomar, "Plasticized relaxor ferroelectric terpolymer: Toward giant electrostriction, high mechanical energy and low electric field actuators," *Sensors Actuators, A Phys.*, vol. 207, pp. 25–31, 2014.
- [2] N. Della Schiava, M. Q. Le, J. Galineau, F. Domingues Dos Santos, P. J. Cottinet, and J. F. Capsal, "Influence of Plasticizers on the Electromechanical Behavior of a P(VDF-TrFE-CTFE) Terpolymer: Toward a High Performance of Electrostrictive Blends," *J. Polym. Sci. Part B Polym. Phys.*, vol. 55, no. 4, pp. 355–369, 2017.

Explain the impacts of your work especially to Thailand.

According to the statistic of R&D growth, for instant, R&D expenditures, innovations, scientific publication, science and technology personnel in Thailand are still low [3]. In order to drive and reform country's R&D system, many scientific research and projects have to be commercialized or further developed for real usability. Extra technology may be needed. To carry out large-scale R&D in Thailand, we may need to have partnerships with accomplished laboratories which expertise in the research field as well as the private sector to conduct research faster and more efficient in favor of accessing professional equipment and machines, financial support, including exchanging knowledge and ideas.

In this research project, we have a strong cooperation team being expert in the different scientific field to develop polymer actuator including performing smart materials and exploiting them to modern applications.

The possible advantages of **electrostrictive actuator technology** to Thailand;

Smart optical communication systems:

Optical communication and remote sensing including astronomy requesting high-dynamic range observations are currently limited by the cost and manufacturing restrictions of their high-quality optics. The technological and scientific ambitions of this new approach are high and extend beyond conventional active of deformable mirror technologies. An extremely smooth surface and including smart remote sensing system is now still required for replacing the classical polished rigid glass. To achieve active surface shape control, force actuator-sensor fabricated from an optimized EAP will be integrated into the hybrid system. Our long-term vision for the new technology based on the structural element of a hybrid material proposed (Figure 2). A high precision that allows deformation resolutions in nanometer range and the capabilities of mass-production of high-quality mirrors can be applied with applications in:

- ✓ Space surveillance (of both Earth and near-Earth environment) for security and resources
- ✓ Wireless optical communication systems (UV and free-space systems)
- ✓ Hyper-aperture multi-mirror structures
- ✓ Geo-engineering (space-mirror)
- ✓ Astronomical systems

Medical surgery development:

Another aspect concerns the possibility of using this material for the realization of specific tools, e.g. in minimally cardiovascular surgery. Recently, F. Ganet et al [4] reported on the development of a smart guidewire using a 3D electrostrictive tube for steerable orientation equipped with force feedback. As illustrated in Figure 3, an electrostrictive tube was designed to equip with the distal tip of a guide wire for endovascular navigation in order to reach the target regions inside blood catheter vessels and through the tortuously curved pathways of blood vasculature. Another feature of the developed electroactive actuator is to take into account the patient's safety by using biocompatible plasticizers or by adding a protection system into the catheter.

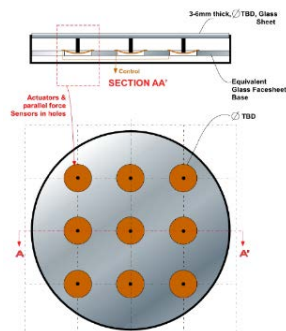


Figure 2 the trial model of hybrid system control (9 actuators integrated to the mirror)

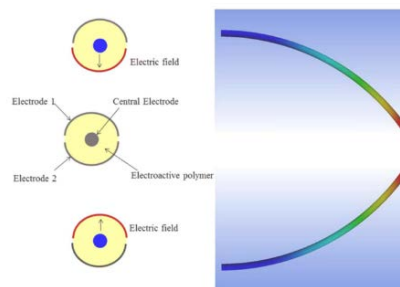


Figure 3 Principle of a "smart" guide wire with 2 degrees of freedom [1]

[3] <http://www.sti.or.th/home.php>

[4] F. Ganet et al., "Development of a smart guide wire using an electrostrictive polymer: Option for steerable orientation and force feedback," *Sci. Rep.*, vol. 5, no. August, pp. 1–12, 2015.

Explain how your work fits with the ATPER conference theme

Concerning the theme of ATPER2018 *“Thailand Digital Health and Smart Society Development”*, we proposed the possibility on developing the low-cost smart optical communication system as well as R&D in medical surgery development with electroactive polymer actuator. For the propose of breaking new ideas and sharing point of views with researchers in particular field, it is able to accelerate research & innovation projects based on the integration of materials science and engineering with digital health and smart society to ensure practical implementations.