

Hasel actuators: two types of Hasel actuators achieve linear actuation motion.

First, there is the planar Hasel actuator, which has an elastomeric shell. It is partially covered by a pair of opposing electrodes outside and filled with a liquid dielectric inside. When we apply a voltage to the electrode, an electric field is created through the liquid dielectric. The resulting electrostatic Maxwell stress presses and displaces the liquid dielectric from between the electrodes to the surrounding volume. The actuation strain increases with an increase in the input voltage. The resulting hydraulic pressure causes the soft structure to deform into a toroidal shape and gain an elongation actuation movement. This type of actuators can be stacked to achieve higher strain and force.

Second, a peano-Hasel actuator is constructed with a series of pouches made from a flexible and inextensible shell that is filled with a liquid dielectric. Electrodes cover a portion of each pouch on both side of the actuators. The voltage applied produce an electrostatic force that causes electrodes to progressively close. The pressure force dielectric fluid into an uncovered portion of the pouch. That causes the pouch to transition from a flat cross section towards a circular cross section. This transition causes linear contraction of the actuator as the shell is inextensible. The parallel configuration obtained from this actuator greatly amplify the output force.

The Hasel actuator blends soft fluidic actuators with muscle-like performance of DEAs to achieve plenty of actuation modes without rigid frames or pre-stretched mechanisms. Hasel actuators can scale actuation output strain and force because of the hydraulic principles. This scalability gives Hasel the capability to construct a soft gripper that can handle delicate objects and an artificial muscle that can lift more than 200 times their weight. The advantage of Hasel in comparison to DEAs, is that the use of liquid dielectric enables Hasel to self-heal from a dielectric breakdown. It improves the durability and stability of Hasel actuators.

DEAs: It can generate deformations because of electrostatic interactions between two electrodes. DEAs act as capacitors when an external voltage is applied. The opposite charges are attracted in the electric field direction, while like charge repulse from each other in the perpendicular direction to the field. It exerts Maxwell stresses that squeeze the DEAs along the direction of voltage and expand them in the other two directions. A silicone or acrylic material often acts as the elastomer, with a compliant electrode that is applied to achieve large deformation. This is the reason why DEAs are extensively applied as actuators.

RFPs: It is a ferroelectric polymer material that is often used as an actuator. For example the poly(vinylidene fluoride-trifluoroethylene). Due to electronegativity of fluorine the backbones of P(VDF-TrFE) are highly polar. Therefore, we use the reversible conformational changes caused by the alignment of polar groups. When we apply an electric field perpendicular to the chain, the ferroelectric switches to the polar beta phase. This causes elongation along the chain length and contraction perpendicular to the chain direction. It has problems that are the existence of a massive hysteresis and substantial energy dissipation during actuation process when electric field is applied to reverse the polarisation. In order to eliminate this hysteresis behaviour, we can irradiate the P(VDF-TrFE) or we can add a small mass fraction of a bulky monomer to disrupt long-range order to form RFP.

CPs: They are known as conjugated polymers. The electrochemically changing oxidation state causes charge addition to or removal from the electrolyte when a voltage is applied to the two electrodes, which is also known as doping. This doping change dimension, the CP expands when it is oxidised as the anions enter the electrolyte to balance the charge, and the CP contracts when it returns to the reduced state, in which anions have been removed. The advantage of CPs over DEAs is their low driving voltage (1-2 V to 10V for higher speed and response). The CPs are attractive because of that characteristic and because of high stress renders. It is for example used in rotational motors or to actuate micro-grippers and fish robots.