Towards a new generation of soft actuators using phase transition: application to morphable-texture skins and soft grippers

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ABSTRACT

Soft robotics emerged a few years ago as a new trend in the design of artificial robotics system. By leveraging the unique properties of highly deformable materials and systems, new functions can be imagined, including improved interaction between the robotic system and the user, complex mode of deformations bringing more flexibility compared to classical rigid-part based robots, integral processing through 3D printing. As in any robotic system, the success of such technology heavily relies on the availability of high-performance sensors and actuators.

Soft actuators are usually based on externally provided pressurized fluid (pneumatic and hydraulic systems), shape memory polymer, electroactive polymers such as conductive soft polymers (PEDOT/PSS for example [1]), or piezoceramic fibers. These systems all suffer limitations that prevent today to explore the full potential of soft robotics. These limitations vary from one technology to another: high voltage, limited actuation (strain), need for bulky and expensive power sources. So there is still a need for an actuation principle that can provide large actuation, ideally based on electrical energy at relatively low voltage.

We propose here to explore the concept of Joule heating induced phase transition to the design of new families of actuators. In our concept, the transition from liquid to gas of well-chosen liquid based on electrically induced heating is leveraged. Such systems raise many challenges including the design of efficient heating element and microstructure.

We demonstrate this concept on two application.

The first application is an all-polymer base polymorph skin with controllable surface texture [2]. We present here for the first time an e-skin for which we control based on electrical stimulus the surface morphology. Such skin is fully polymer-based, based on the concept of phase transition, and will find interesting application in any process where the morphology of the surface plays an important role in controlling the interaction between the system and its environment such as drag control in pipe or gripping.

The second application is about the development of soft grippers that can experience large deformation and where the internal actuating pressure is only provided by phase transition [3]. We show here how, a well-designed electrode and a predesigned cavity with sufficient liquid can result in a high performing system.

REFERENCES

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