Micro-pump actuated dynamic color-morphing skin for octopus-like camouflage in soft robotics

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Camouflage, a strategy of animals' self-protection by mimicking the color of the surroundings, is one of the most well-investigated bio-inspired phenomena. For examples, birds and beetles can discolor passively due to their nanophotonic structures, and chameleons and octopus can change their colors actively. Although the bionic passive color-changing system has been well used in various sensors[1], the applications of active color-changing system are still under exploration[2]. Meanwhile, recent researches on soft robotics have shown great interests in automatic control[3] and multifunctional capabilities[4]. Current color shifting strategies include using thermosensitive polymers or adopting electrical control of chemical reactions to manipulate color pixels. However, these methods are limited by the requirements on external wired or tubed tethers for electrical or chemical supplies.

In this work, we present a color morphing soft robotic finger with untethered pneumatic actuation (Fig. 1). The wireless-controlled micropumps provide precise inflation pressure for internal micro-channels. Polystyrene (PS) spheres self-assembled on soft and stretchable membranes are used to imitate the "protein crystals" in octopus' skin, while the internal micro-channels performed as the "muscle" to move the finger. With the modified micro-channels, the whole soft robotic finger can be selectively actuated to alter the distance between the PS spheres by stretching the soft membranes due to pressure increase, which leads to a shifting of the reflection spectrum and hence exhibiting a dynamic coloration[5]. As shown in Fig 1, the color morphing pixels are arranged along the finger, and the micropumps manipulate the pixels status by either bending the actuator or restore it. Figure 1 (b-c) illustrates the bending behavior of the soft robotic finger and the corresponding status of the color morphing pixels. Through this design, the bending behavior and the color changing effect can be synchronized. Precise and quick response can be achieved by wireless control of the micropumps. We will report the detailed construction of the color morphing soft robotic finger and evaluate its performance in both force actuation and color shifting.

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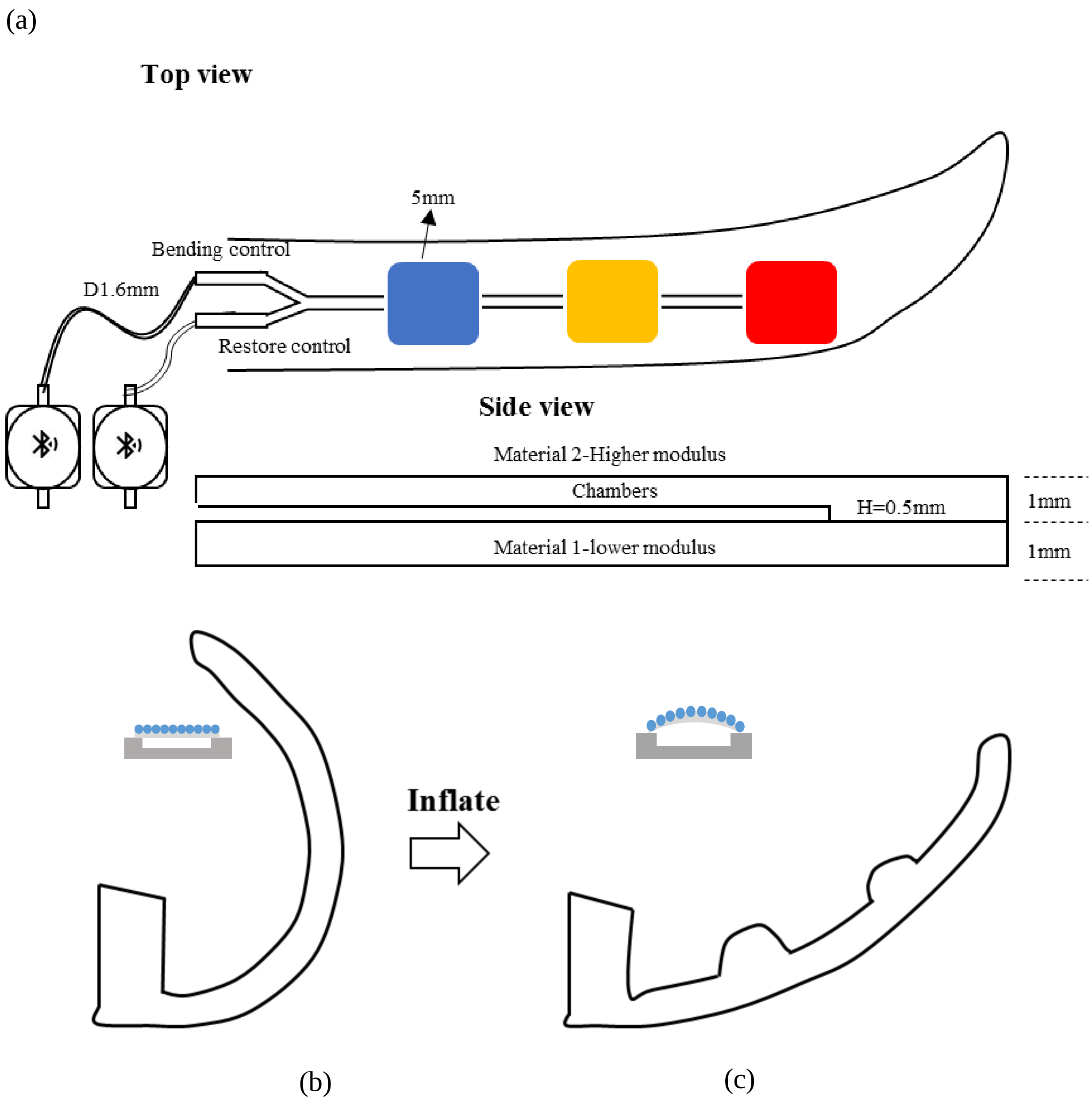

Fig. 1 (a) A schematic of the wireless-controlled octopus-like skin devices; (b) soft robotic finger before inflation; and (c) soft robotic finger after inflation. The insert figures show the principles of the color changing membrane.