2025 IEEE World Haptics Conference (WHC)
Suwon Convention Center, Suwon, Korea
July 8 ~ 11, 2025

Transparent and Electrically Switchable Thin Film Tactile Actuators Based on Molecular Orientation

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***Abstract*—Most tactile actuators generate fine touch sensations through vibrations or the mechanical and electrochemical formation of surface bumps or textures. Innovations using ultrasonic vibration, electroadhesion, and electromechanical or dielectric soft-material actuators have expanded the field, yet even with these innovations, the current offerings of tactile actuators remained limited by high power consumption, bulky hardware with difficult integration into existing devices (e.g. screens), slow response times, or narrow variety of tactile sensations. These limitations have constrained the broader adoption of haptics in virtual reality, remote surgery, consumer electronics, and assistive devices.**

I. Introduction

In this demo, we present a promising new type of tactile actuator based on liquid crystal molecular reorientation, enabling switchable tactile sensations without mechanical displacement or the formation of surface bumps or textures [1], [2], [3]. Our approach leverages the inherent stimuli-responsive phases of liquid crystals embedded in a thin, transparent polymer film [4], [5], [6] that respond to a low-power DC electric field. Unlike traditional tactile actuators, this device modulates surface friction by switching the material's molecular alignment—producing a user-perceivable change in tactile feel from "tacky" to "polished" as one slides a finger across the surface.

II. Demo Overview

The film is fabricated onto comb electrodes and can be patterned to selectively activate individual regions, allowing spatial control over the tactile feel to enable localized, pixel-like haptic zones across the surface. The tactile actuator currently operates at ~100 V DC and corresponding current of ~1 -10 μA and switches rapidly (<17 ms) – faster than ionic or fluid-driven systems. The molecular switching from an aligned phase to a disrupted phase is visually observable under cross-polarizers.

At the demo, participants will interact with either a flat or flexible version of the film, mounted on transparent PET-ITO electrodes. They will be able to feel how changing molecular ordering directly alters surface feel, demonstrating a new mode of fine touch actuation that is lightweight and screen-compatible. The actuator's transparency and conformability make it well suited for easy integration into screen displays, steering wheels, wearables devices, or educational tools.

This platform introduces a new design space for tactile interfaces based on molecular orientation rather than mechanical displacement, offering high-speed, low-power, and easy integration into existing devices.

Acknowledgment

We acknowledge funding from the National Eye Institute of the NIH (R01EY032584). L. V. K. acknowledges funding from the Arnold and Mabel Beckman Foundation through a Beckman Young Investigator award. We would like to acknowledge Katie Herbert, the scientific program manager at the Center for Plastics Innovation at the University of Delaware, for her advice on liquid crystal fabrication. This study was conducted and approved by the Institutional Review Board (IRB) of the University of Delaware (Project #1484385-2).

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National Eye Institute of the NIH (R01EY032584)