How liquid crystal elastomer research is paving the way for new applications and practical devices

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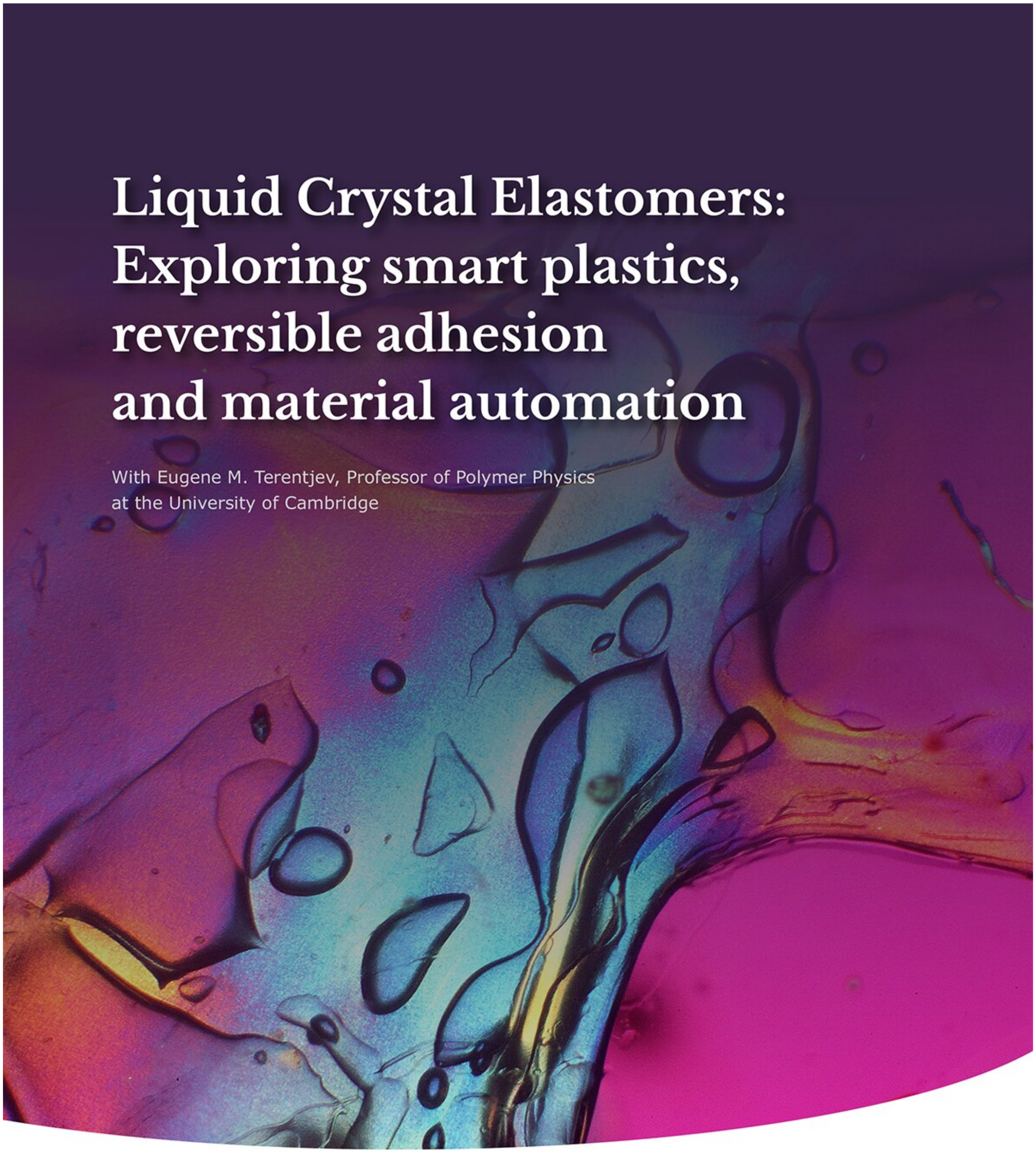

UNIVERSITY OF CAMBRIDGE

Credit: University of Cambridge

A new e-book discusses developments in liquid crystal elastomer (LCE) technology achieved with support from the APRA project. Authored by professor of polymer physics Eugene M. Terentjev of APRA project host University of Cambridge, the e-book sheds light on these smart plastics and specifically on how LCEs bring automation into materials.

What exactly are LCEs?

LCEs are a rubbery network of polymers that exhibit a reversible shape change under various stimuli. The e-book describes them as "a new class of materials with physical intelligence." It goes on to say, "These are plastics that feel and respond to their environment, making decisions, analyzing and diagnosing problems without human intervention. Liquid crystalline elastomers are truly the material of the future."

The multifunctional polymer materials developed under the APRA project are recyclable and re-processable. One unique LCE property described in the e-book is soft elasticity, "which combines the dissipation properties of a liquid with the mechanical strength of a thermoset to produce levels of vibration damping far above market-leading technologies based on polyurethane or silicone."

LCEs also have strong pressure-sensitive adhesion (PSA), being sticky to touch and bonding to most surfaces. Through APRA, the University of Cambridge is working with technology spin-off Cambridge Smart Plastics to develop a new concept using reversibly adhesive LCEs, described "as simple as a hand that grips and let's [sic] go on demand."

They have created a naturally sticky rubber whose properties change by heating it, allowing easy detaching. When it cools, the rubber becomes sticky again, giving this "truly reusable adhesive" a second life.

Another amazing property is the ability of LCEs to reversibly contract and expand on heating and cooling. "If the material is programmed to a given shape when aligned, then this will become its natural shape. However, heating the material will cause up to 100–200% contraction, which is fully reversible (the LCE extending back into its natural shape when cooled). This mechanical actuation allows us to design actuators, artificial muscles, or an LCE engine working on a difference in temperature between two containers."

A recent breakthrough made by the researchers enabled them to overcome the long-standing obstacles to using LCE actuation in practical devices. This breakthrough was the development of LCE vitrimers. "Vitrimers are much more stable than other transient elastomer networks, but still allow thermal re-molding (making the material fully renewable). This makes it possible to create complex shapes with intricate local alignment (which are impossible in traditional permanently elastomers)," according to the e-book.

These properties pave the way for a whole host of LCE applications: sound isolation pads, devices that dampen road vibration to improve light detection and ranging accuracy and passenger comfort, fully reversible adhesive tapes that "eliminate the 'single-use' nature of today's adhesives," heliotracking solar panels and engines converting waste heat into useful work. The 5-year APRA (Active Polymers for Renewable Functional Actuators) project ends in September 2023.

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