Liquid Crystal Elastomers with Frozen Orientational Disorder as Electrically Read Physical Unclonable Functions

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Physical unclonable functions offer rich disorder, but many require optical alignment, imaging, or spectroscopy [1]. Liquid crystal elastomers provide a covalent network that can preserve orientational states formed during processing [2]. This work uses anisotropic liquid crystal elastomer fibers as electrically readable physical unclonable functions. Small differences in mesogen alignment are locked into the network during crosslinking and appear in the dielectric and conductive response of each fiber. A charge-balanced pulsed challenge samples the bulk resistance through two electrodes before interfacial polarization dominates the signal. The analog traces separate nominally identical networks and are encoded by sigma zone threshold majority voting into two-dimensional binary keys. The anisotropic keys give a bit uniformity of 0.50, an inter-fiber Hamming distance of 0.45, and a per bit min entropy of 0.74. A repetition code fuzzy extractor stabilizes repeated reads, while hashing and model resistance tests give a usable identifier. Isotropic controls show that frozen director order strengthens separation beyond chemistry alone. Ten anisotropic networks are then combined into a composite authenticator with an identity layer Hamming distance of 0.502 plus or minus 0.024 and zero within-network distance. The result is a soft material credential formed during fabrication and recovered through simple electrical contact.

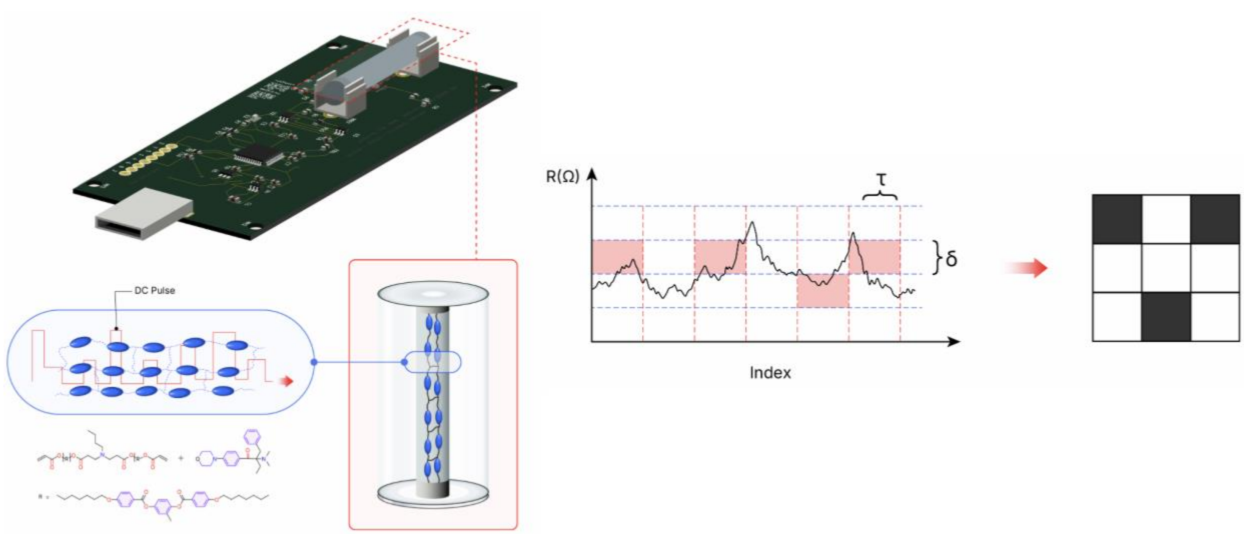

Figure 1. Electrical readout of frozen orientational disorder in liquid crystal elastomer networks and conversion of the resistance trace into a material key.

References

[1] Y. Gao, S. F. Al-Sarawi and D. Abbott, "Physical unclonable functions", Nature Electronics 3, 81-91, 2020.

[2] T. J. White and D. J. Broer, "Programmable and adaptive mechanics with liquid crystal polymer networks and elastomers", Nature Materials 14, 1087-1098, 2015.