Supplementary Information

Dynamic pattern of wrinkles in a dielectric elastomer

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Movie 1

Discontinuous phase transition from the flat to wrinkled state (experimental observations): A circular dielectric elastomer membrane of $\lambda_{pre} = 3$ and $B/A = 2$ is shown in Movie 1. Voltage applied to the membrane is increased at a rate of 20V/s. The movie shows the states of the membrane starting from Φ = 7.3kV. Wrinkles nucleate first in the top right corner of the active part of membrane when the voltage reaches 7.34kV. When the voltage reaches 7.38kV, the voltage is kept constant. We can see the flat and wrinkled regions move across the membrane interchangeably. The membrane finally suffers dielectric breakdown.

Movie 2

Discontinuous phase transition from the flat to wrinkled state (finite element simulations): A circular dielectric elastomer membrane of $\lambda_{pre} = 3$ and $B/A = 2$ is shown in Movie 2. The movie shows the states of the membrane starting from Φ = 8.39kV. The contour of the radial stretch is plotted on the deformed states of the membrane. As the voltage increases, the radial stretch in the active part of membrane increases, while the radial stretch in the passive part decreases. Wrinkles nucleate when the voltage reaches 8.7kV. From 8.72kV to 9kV, we can see the coexistence of the flat regions (in green) and the wrinkled regions (in red). The flat state has a smaller stretch, while the wrinkled state has a larger stretch.

Movie 3

Continuous phase transition from the flat to wrinkled state (experimental observations): A circular dielectric elastomer membrane of $\lambda_{pre} = 4.5$ and $B/A = 2$ is shown in Movie 3. Voltage applied to the membrane is increased at a rate of 20V/s. The movie shows the states

of the membrane starting from Φ = 6.16kV. Wrinkles nucleate first in the active part of membrane when the voltage reaches 6.23kV. When the voltage reaches 6.54kV, the membrane is fully wrinkled. The membrane finally suffers dielectric breakdown at 6.57kV.

Movie 4

Continuous phase transition from the flat to wrinkled state (finite element simulations): A circular dielectric elastomer membrane of $\lambda_{pre} = 4.5$ and B/A = 2 is shown in Movie 4. The movie shows the states of the membrane starting from Φ = 7.2kV. The contour of the radial stretch is plotted on the deformed states of the membrane. As the voltage increases, the radial stretch in the active part of membrane increases, while the radial stretch in the passive part decreases. The entire membrane becomes wrinkled when the voltage reaches 8.79kV.

Movie 5

Discontinuous phase transition from one wrinkled state to another (experimental observations): A circular dielectric elastomer membrane of $\lambda_{pre} = 4$ and B/A = 2 is shown in Movie 5. Voltage applied to the membrane is increased at a rate of 20V/s. The movie shows the states of the membrane starting from Φ = 6.14 kV. Wrinkles nucleate in the periphery of the active part of membrane when the voltage reaches 6.3 kV. The membrane is fully wrinkled when the voltage reaches 6.54 kV. Beyond Φ=7.0 kV, a new region with larger stretch develops and propagates, exhibiting a dynamic pattern. The membrane finally suffers dielectric breakdown.