Supplementary material for "Creasing to cratering instability in polymers under ultrahigh electric fields"

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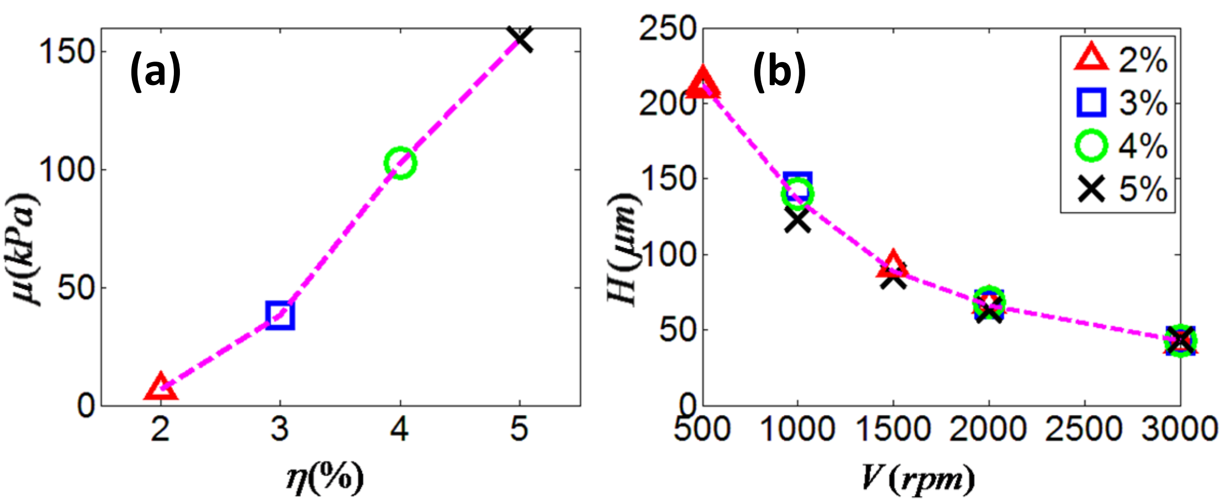

Figure s1. The shear modulus of the PDMS elastomer as a function of the crosslinker concentration (a), and the PDMS-film thickness as a function of the spin speed for PDMS with various crosslinker concentrations (b). The shear moduli were measured by uniaxial tensile tests with a Micro-Strain Analyzer (TA Instruments, USA) under a loading rate 5×10^{-5} s^{-1}. The film thicknesses were measured by Dektak 150 Stylus Profiler (Bruker AXS, USA).

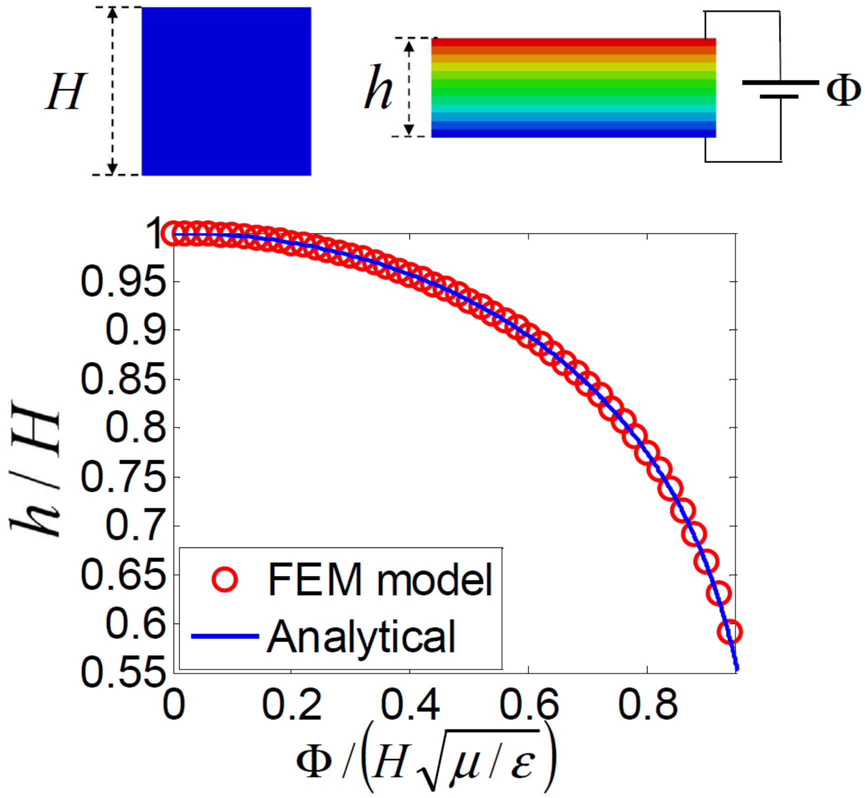

Figure s2. The deformation and electric potential distribution in a block of a polymer subject to an applied voltage. The model is taken to deform under plain-strain conditions. An analytical relation between the deformation and the applied voltage can be derived as $\Phi/\left(H\sqrt{\mu/\varepsilon}\right)=\sqrt{1-\left(h/H\right)^4}$. The result from the finite element model matches well with the analytical solution.

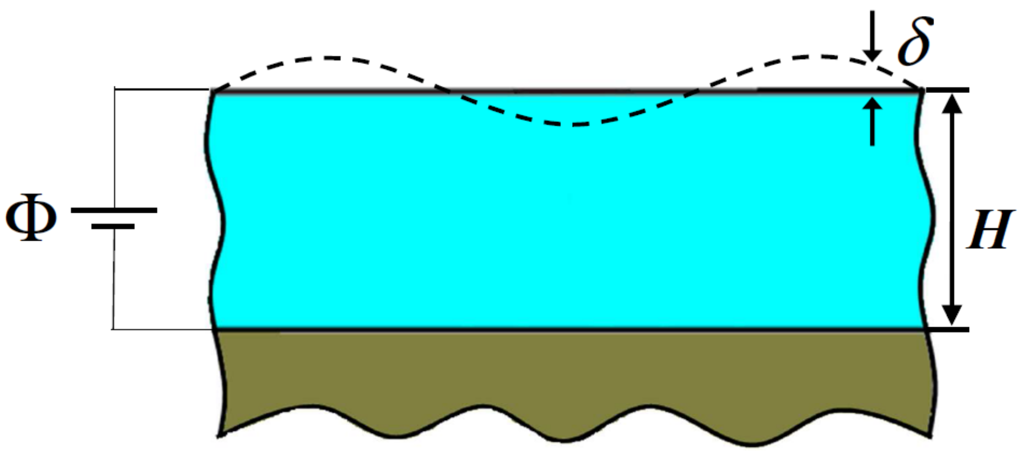

Figure s3. We perturb the surface of the flat film with a sinusoidal deflection $\delta = \xi \sin kx$. The film is taken to be incompressible, so that the change in the elastic energy from the flat state to the perturbed state per unit thickness of the region is [28]

$$\Delta\Pi_{elastic} = \int_0^{2n\pi/k} \mu \frac{\delta^2}{H} dx \tag{s1}$$

The change in the electrostatic potential energy per unit thickness of the region is [28]

$$\Delta\Pi_{electric} = \int_0^{2n\pi/k} \left[-\frac{\varepsilon\Phi^2}{2(H-\delta)} + \frac{\varepsilon\Phi^2}{2H} \right] dx \tag{s2}$$

To the leading order of the perturbation amplitude, the changes in the potential energy is

$$\Delta\Pi = \Delta\Pi_{elastic} + \Delta\Pi_{electric} = \frac{n\pi\xi^2}{Hk} \left[\mu - \frac{\varepsilon}{2} \left(\frac{\Phi}{H} \right)^2 \right] \tag{s3}$$

Setting Eq. (s3) to zero, the critical electric field can be calculated as $E_c = \sqrt{2\mu/\varepsilon}$.

Video s1. Video segments illustrating the evolution of instability structures in a substrate-bonded PDMS film subject to a ramping voltage with a rate of $10Vs^{-1}$.