Electronic Supplementary Material (ESI) for Soft Matter.

Supplementary Material (ESI):

Sticking and sliding of lipid bilayers on deformable substrates

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Figure S1
(a) Advancing, receding and static contact angles of aqueous droplets on PDMS substrates oxidized by plasma for duration of 1, 2 or 3 seconds. The advancing and the receding angles are measured during the spreading or the retraction of the droplets, which is caused by a slow rate injection or withdrawal of water, respectively (see images). Each symbol corresponds to a measurement on different substrate.
(b) Contact angle hysteresis, defines as the difference between the advancing and the receding angles, as a function of the oxidation time. The error bars are the standard errors in the mean values.

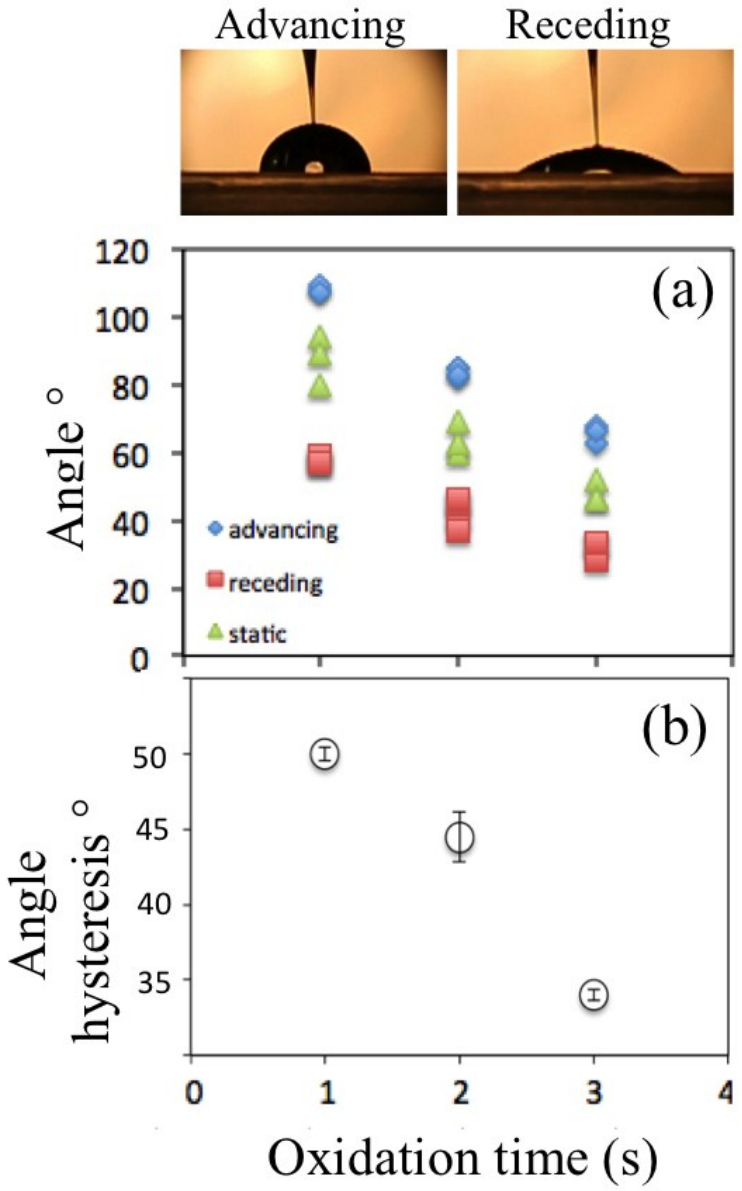


Figure S2
(a) 20x20 µm AFM scan of DOPC membrane patch on PDMS substrate, plasma oxidised for 3 seconds. The scale bar indicates a height of approximately 5 nm which corresponds to the thickness of a unilamellar lipid membrane.
b) 2x2 µm AFM scan of the squared region indicating homogeneous membrane with some small defects
c) Line profile of the membrane height along the dotted white line on b). The height drop through the hole defect is 5-6 nm, corresponding to the thickness of a unilamellar lipid membrane.

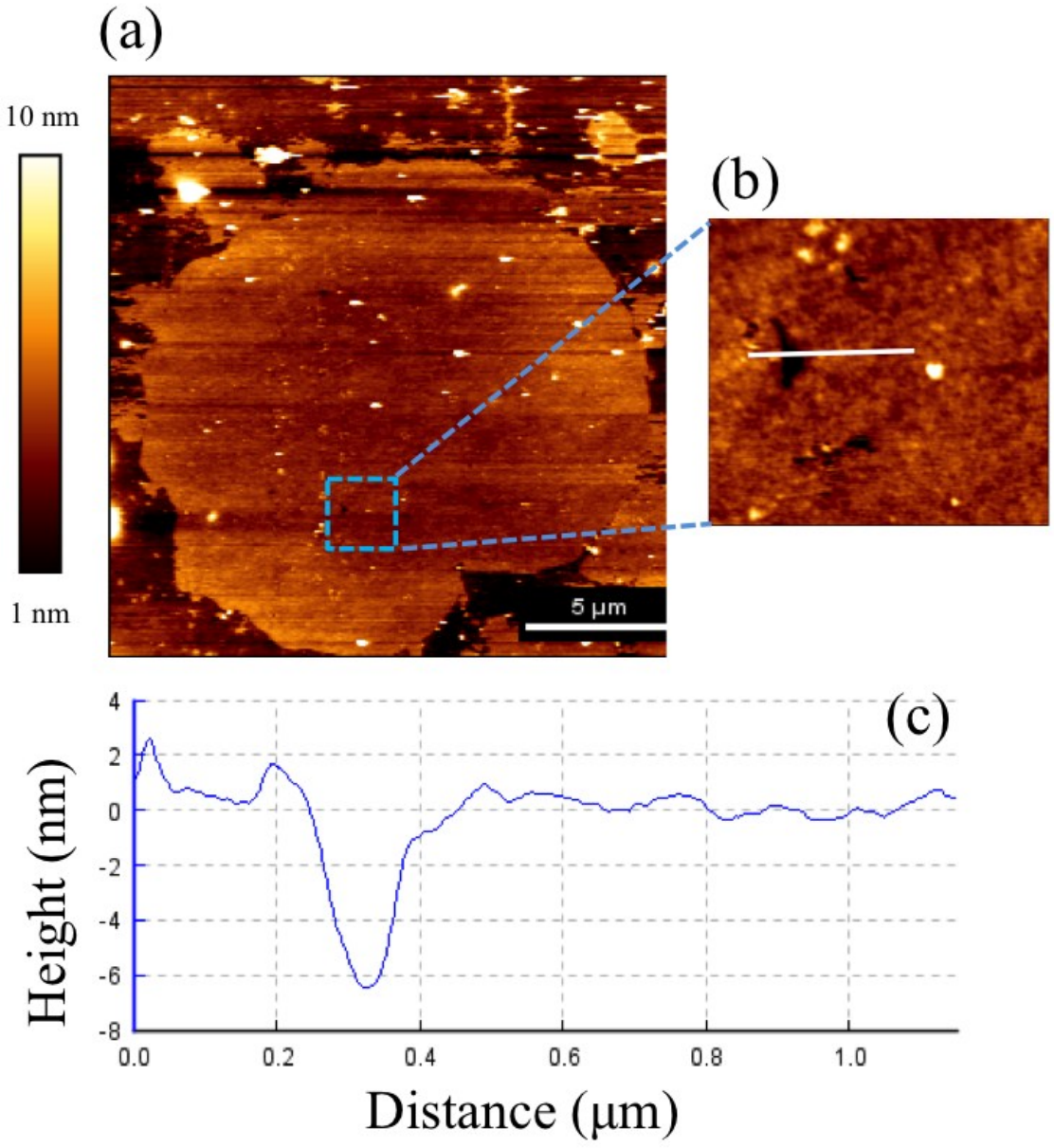


Figure S3

a.) Fluorescence recovery after photobleaching of unstressed lipid bilayer patches supported on a partly hydrophilic substrate. Data points represent an average over 7 examples. Recovery time 23.2-25.6s.
b.) Fluorescence recovery after photobleaching of stressed lipid bilayer patches supported on a partly hydrophilic substrate. Data points represent the average recovery from 4 samples. Recovery time 27.8-29.4s.

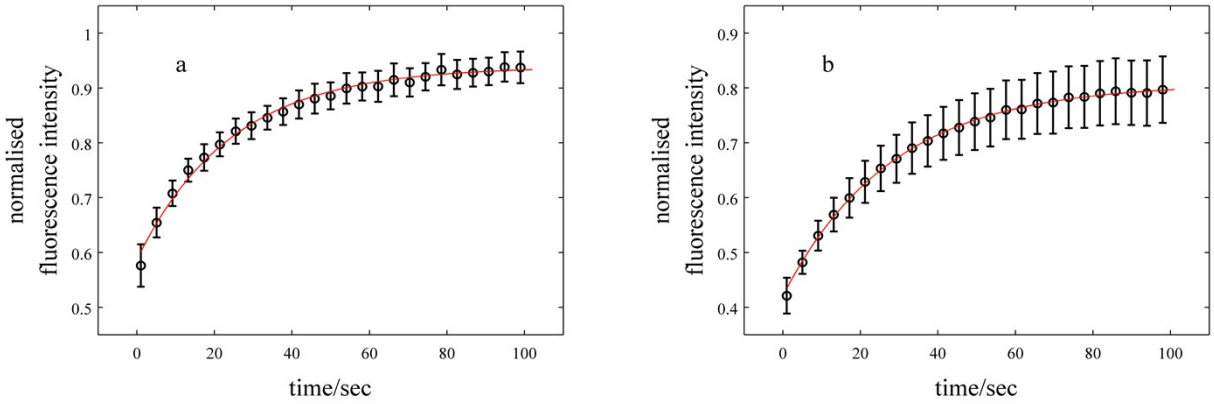


Figure S4.
Normalised tube area as a function of time. Data points are averaged over several adjacent time points and error bars derived from the distribution of measurements about this mean. Large fluctuations in tube area are observed due to the Brownian motion of the tubular projections.

The plot shows that the tubular protrusions are long lived over observation times much greater than typical stress-strain experiments.

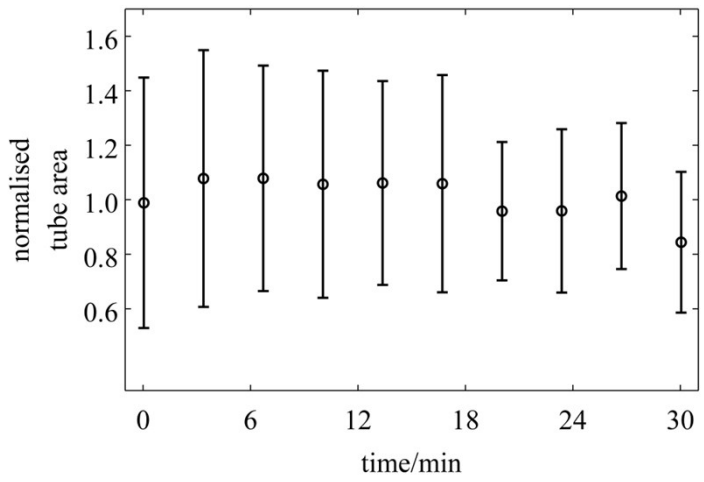
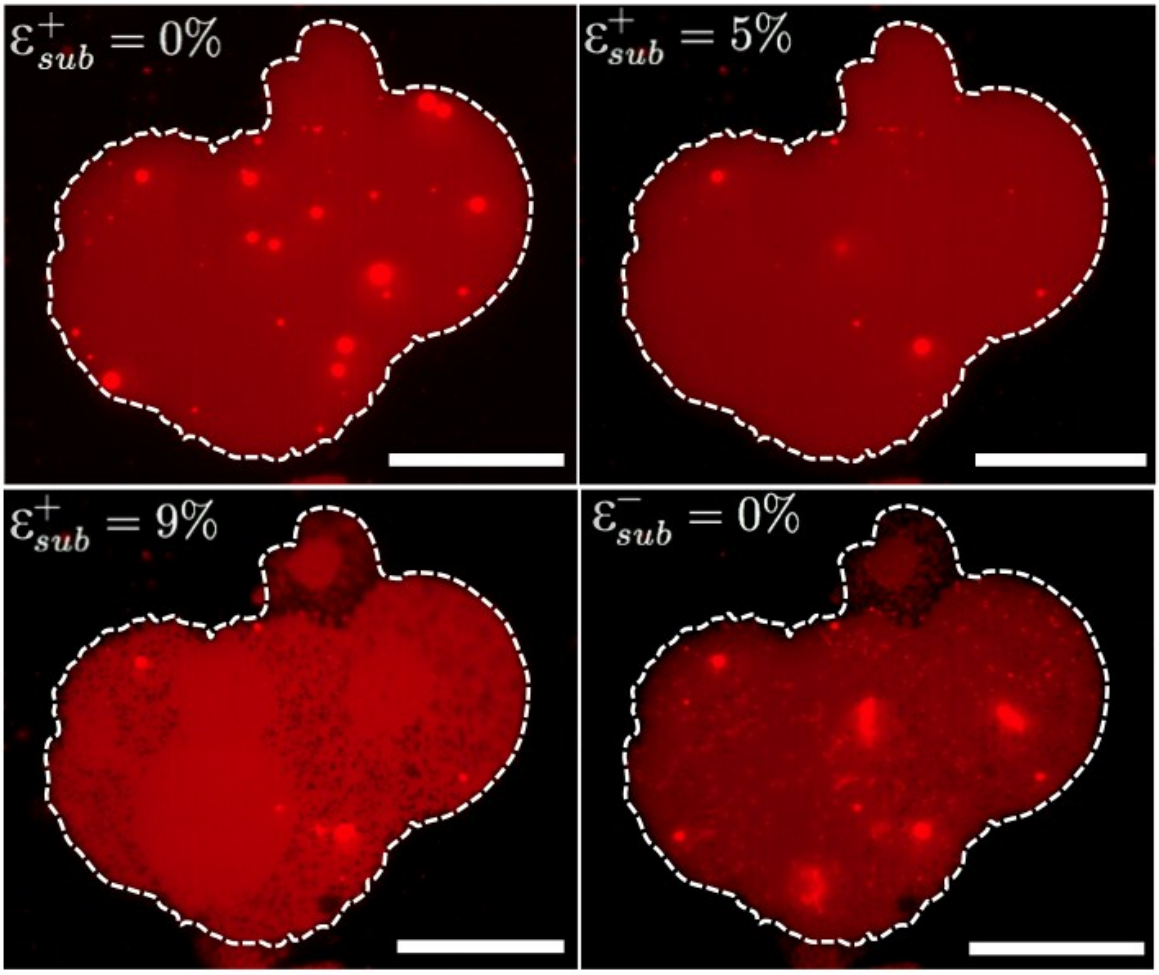


Figure S5
Expansion of membrane patches on PDMS substrate plasma oxidised for 3 seconds. ε_{sub} is the substrate strain during expansion (+) or compression (-) at which the image has been taken. The white contour marks the area, which the membrane would have covered if it had followed exactly the changes in the PDMS area. Scale bar is 20 μm.



At extensional substrate strain of 9% the available lipid reservoir has been exhausted and the membrane ruptures by forming pores. Upon compression, the ruptured patch prefers to expel tubes than to close its pores.

Figure S6. Hysteresis of pore area vs substrate strain. The pore area is normalised by the maximum pore area. Data points in red refer to substrate expansion, data points in black refer to compression. Substrate expansion and compression are performed at equal rates. Error bars derived from the pore area distribution from 3 repeat readings at equivalent substrate strain.

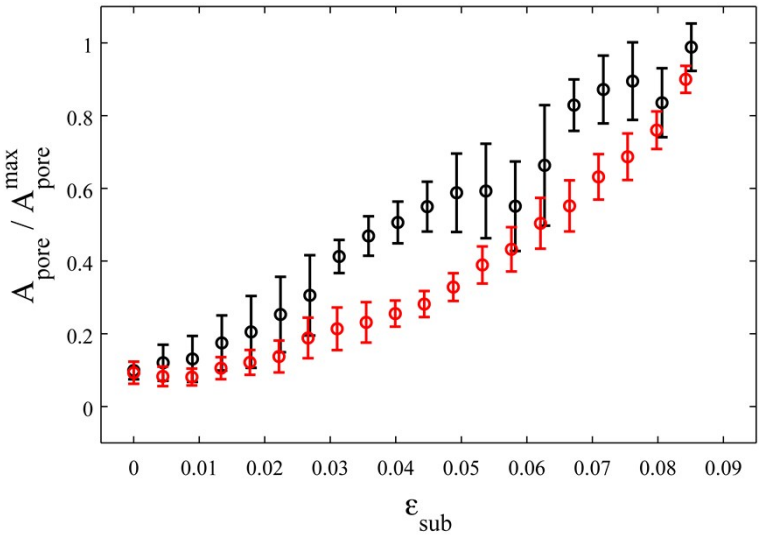


Figure S7. Pore area depends on strain rate. Images a.), b.) and c.) refer to a region of the DOPC membrane at substrate strains of 0, 4.6 and 10.4% respectively, applied at a rate of expansion of 0.01% s^{-1}. Images d.) e.) and f.) refer to the same region of DOPC bilayer and to the same substrate area strains as in a.), b.) and c.), but applied at 10 times faster rate of expansion, i.e. 0.11% s^{-1}. Scale bar 25µm.

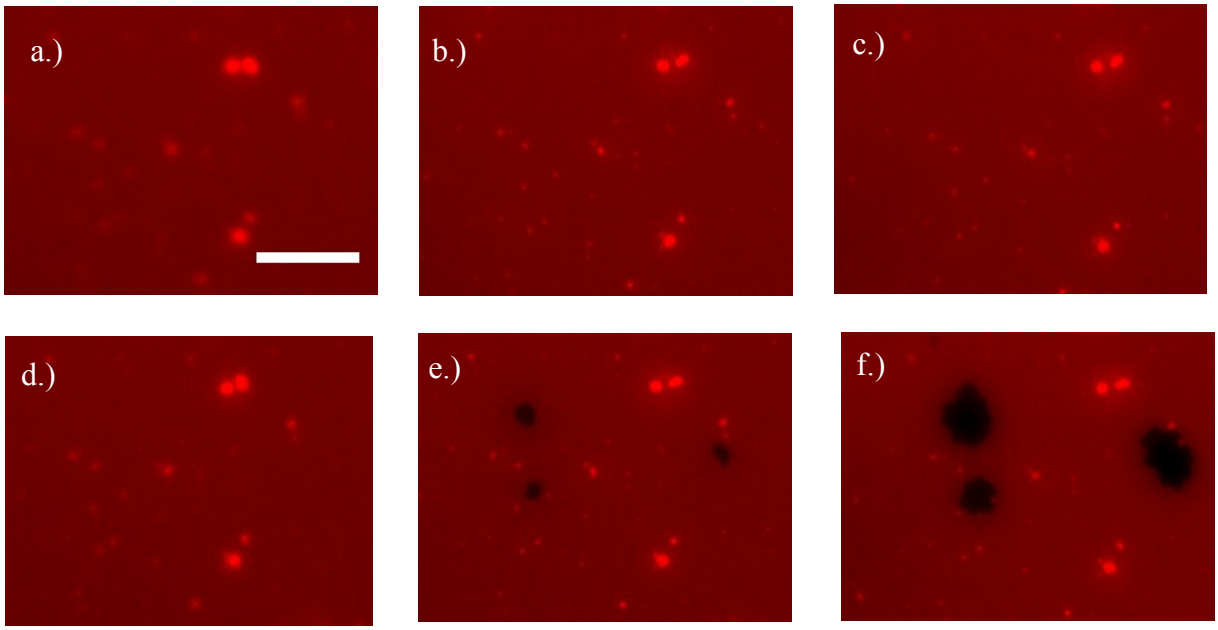


Table S1.

Measurements of membrane area relaxation for different samples. Patch numbers 1, 2 and 3 refer to independent samples. Relaxation parameters, τ, are derived from unweighted least squared fits to individual relaxation experiments. Errors are estimated on the basis of 95% confidence bounds to the fits. Area quoted refers to the area of the patch at the end of the observation period.

$$A(t) = A_{final} - Cexp\big(-(t - t_0)\tau\big)$$

Patch number	**τ / s**	**error / s**	**Patch area /μm²**	**error /μm²**
1	50	6	12920	50
	40	3	12850	50
2	21	3	2613	5
	28	3	2613	5
	15	5	2619	8
3	50	15	3930	5
	20	6	3936	3
	35	20	3942	3
	50	17	3947	4
	42	25	3950	6

Table S2.
Critical substrate strains during expansion and compression at which sliding of patches initiates, on substrates exposed to plasma for 30 seconds. The errors in the strain depend on the frame rate of recording and are defined as half of the strain change between the frame at which the sliding starts and the subsequent frame.

Patch area /μm²	Critical expansion strain	Error	Critical compression strain	Error
5.29E+04	0.011	0.004	0.015	0.002
4.59E+04	0.029	0.014	0.019	0.003
2.72E+04	0.043	0.012	0.016	0.006
1.34E+04	0.030	0.006	0.040	0.004
1.32E+04	0.023	0.005	0.016	0.001
2.82E+03	0.007	0.003	0.033	0.006
1.68E+03	0.022	0.004	0.036	0.005
1.64E+03	0.042	0.004	0.020	0.004

Supplementary Movies

Video S1: Expansion of membrane patch supported onto a PDMS substrate exposed to low pressure air plasma for 3 seconds. The patch absorbs the lipids protrusions sitting on top of it (main text).

Video S2: Compression of the same patch as in Video S1. The patch expels lipid tubules.

Video S3: Expansion of membrane patch on hydrophilic substrate that displays sliding behavior as in figure 3 (main text)

Video S4: Compression of the same membrane patch as in Video S3.

Video S5: Membrane patch on hydrophilic PDMS that first shows sliding behavior and subsequently forms pores upon further substrate expansion.