Supplementary Information

Dynamics of interacting folds under biaxial compressive stresses†

Hyunjae Shin,[a] Atray C. Dixit,[b] Howard A. Stone,[b] Manouk Abkarian,*[c] and Pilnam Kim*[a]

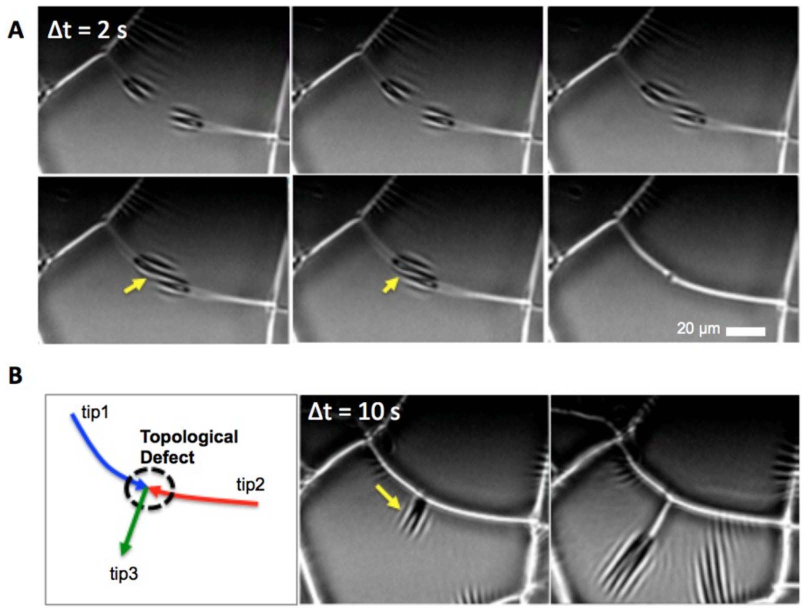

Figure S1. (A) A representative sharing of wrinkles ahead of the fold tips. The yellow arrows show the overlapped wrinkle, facilitating coalescence. (B) Once the tips coalesced, the point of the intersection reveals a topological defect that affects further fold propagation.

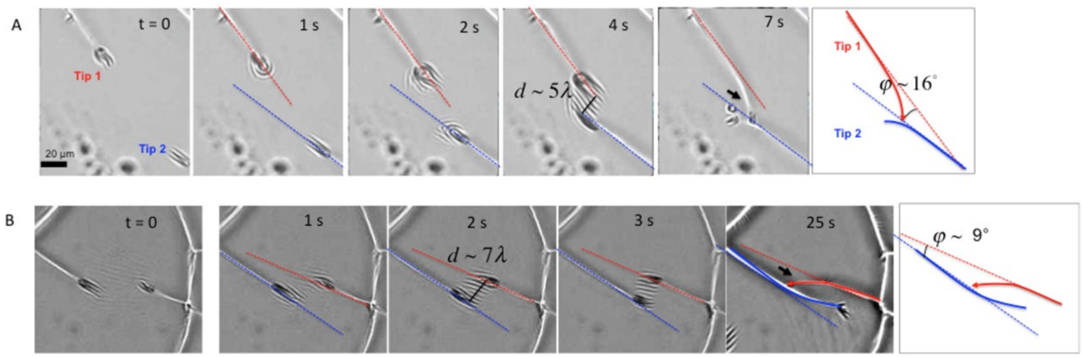

Figure S2. Images showing the change of φ and d with time. When we tracked the tips under continuous compression, the relative orientation φ was constant prior to bending. The orientation of tip changed when the tip was close enough to develop wrinkles parallel to the direction of the folds axis between the tips. Once the tips reached a critical separation (i.e., common wrinkle evolved), the tips tended to bend, facilitating coalescence or intersection, in which the critical distance d_c was determined.

Simulation

A finite element analysis model supporting our observations was constructed using COMSOL Multiphysics commercial software (version 5.1.). In stationary studies, the governing equation in our calculation is $-\nabla \cdot \vec{\sigma} = \vec{F}_V$ and this equation is expressed in the form of virtual work that is $\delta W = \int_V \left(-\varepsilon_{test}:s + \vec{u}_{test} \cdot \vec{F}_V\right)dv + \int_S \left(\vec{u}_{test} \cdot \vec{F}_S\right)ds + \int_L \left(\vec{u}_{test} \cdot \vec{F}_L\right)dl + \sum_p \left(\vec{U}^{\,t}_{test} \cdot \vec{F}_p\right)$. Here, the plane strain condition was used for 2D approximation. Gaussian elimination method was used in a process of calculation by MUMPS, which is an interior direct solver in COMSOL program. For modeling fold on 2D space, ratio of moduli, $E_{fold}/E_{flat} = 10^{-3}$, was applied and we imposed 2 μm displacement for generating σ_c on each side (top, bottom, left, right) that has a length of 360 μm**.** These may not represent real situation exactly however, these can estimate fold tip interaction. Finally, the result were selectively plotted nearby tips where the size of window was 140×140 μm^2 and the direction which were perpendicular to the maximum strain near tips were plotted for estimating the directions of propagating tips.