

Supplementary Figures

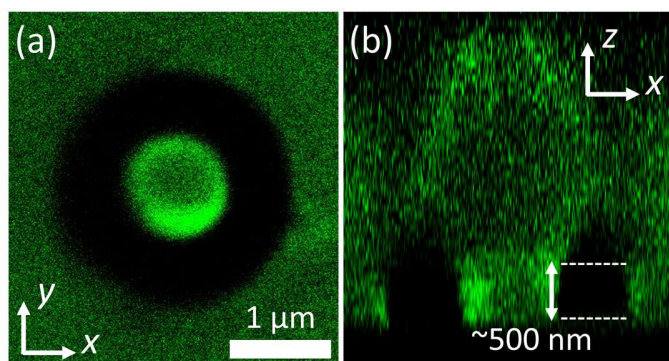


Figure S1. Fluorescence confocal polarizing microscope (FCPM) image of a $g=1$ handlebody particle. (a) In-plane view and (b) cross-sectional view of the particle. The cross-sectional image confirms the handlebody particle has thickness of approximately 500 nm.

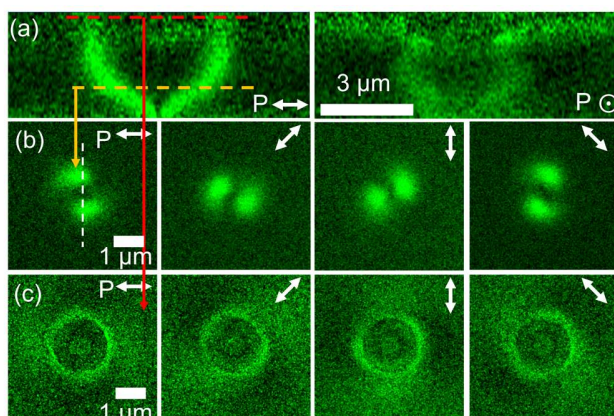


Figure S2. FCPM images of the hybrid structure of a $g=1$ handlebody and a toron. (a) The cross-section images of this structure taken under different polarizations of the excitation light. Red and yellow dashed lines in panel (a) indicate the locations where the FCPM images were taken in (b) and (c). (b) FCPM images at the lower focal plane close to the point defect of the toron. The dashed white line indicates the location of the cross-section where images in (a) were obtained. (c) FCPM images at a higher focal plane passing through the handlebody particle. These images were processed with a Gaussian filter and contrast enhancement to enhance clarity. The white arrows and circle dot symbol represent the polarization direction of the FCPM excitation light.

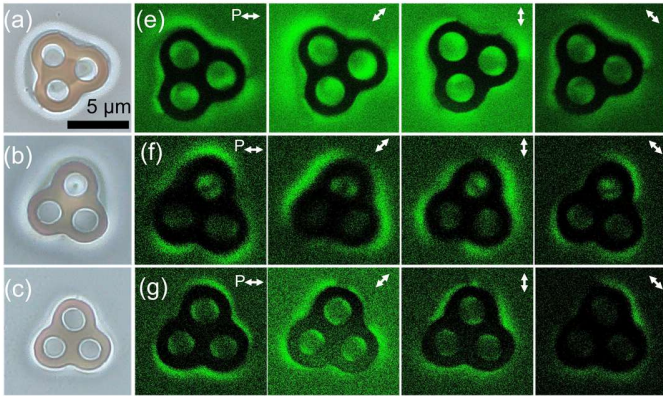


Figure S3. Micrographs of hybrid structures involving $g=3$ handlebodies and solitonic structures. (a-c) Bright-field microscopy images of (a) a $g=3$ handlebody with planar anchoring, (b) a $g=3$ handlebody particle with homeotropic anchoring and a point defect at the center of one of its holes, and (c) a $g=3$ handlebody particle with homeotropic anchoring with only line defects. (e-g) Corresponding FCPM images taken under different polarization directions of the FCPM excitation light as indicated by the white arrows.

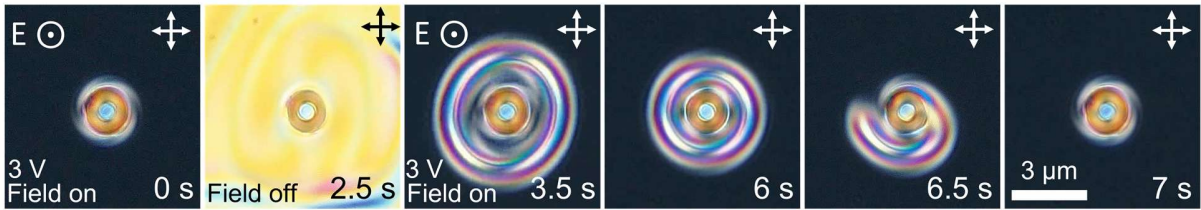


Figure S4. Polarizing micrographs showing the process of hybridization over time after switching the electric field off and on. Crossed arrows indicate the crossed polarizations of the polarizer and analyzer; the circled dot symbols marked with E represent the direction of the electric field applied to the sample.

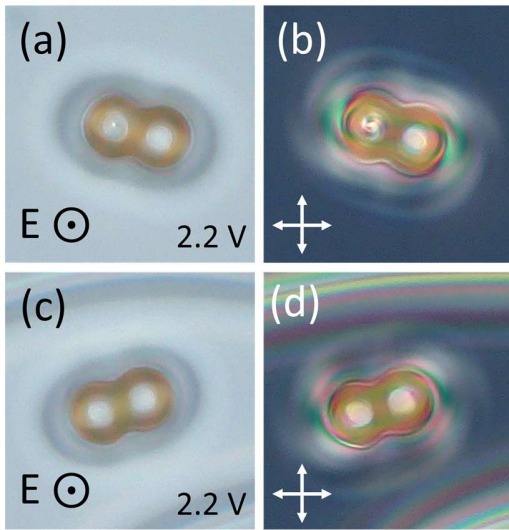


Figure S5. Hybridization of a solitonic structure with a $g=2$ handlebody particle under an electric field. (a) Bright-field and (b) POM images showing the hybridized structure with a point defect located in one of the handlebody's holes. (c) Bright-field and (d) POM images of the hybridized structure, where only disclination loops remain. The configurations in (c) and (d) were obtained by turning the electric field off and on from the state shown in (a) and (b), without any additional external perturbation.