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A two-dimensional organic-exciton polariton lattice fabricated using laser patterning: Supplementary Information

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ABSTRACT: Exciton-polaritons in 2D lattice geometries now attract considerable attention as systems in which to explore new physics. However, such structures are relatively difficult to fabricate as this can involve sophisticated milling or etching of cavity layers to create arrays of defects. Here, a straightforward technique is reported that allows rapid fabrication of 2D polariton lattices that operate at room temperature. Specifically, laser patterning has been used to write a 2D square lattice of defects into a sacrificial polymer layer. An organic microcavity structure is then built on top of the patterned polymer, with the morphology of the patterned polymer propagating through the subsequent layers and spatially modifying the optical path-length of the active cavity region. Using real- and momentum-space spectroscopy, the formation of gapped polaritonic band structures has been demonstrated at room temperature. The optical writing approach discussed here opens up the way for fabrication of more complex 2D-lattice geometries for studying topological physics at room temperature.

CONFINEMENT IN A DEEP DEFECT

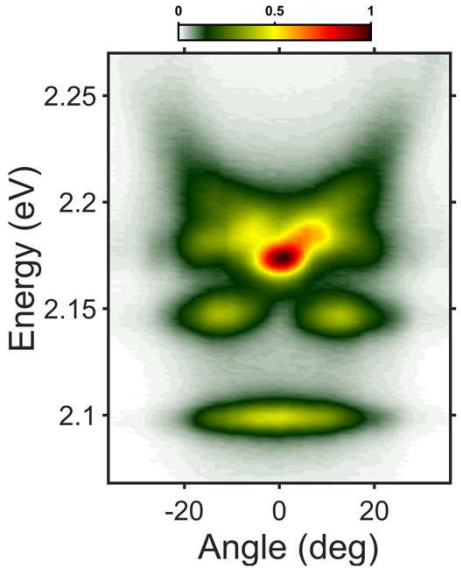

Figure S1: Angle-resolved PL spectra from a deep trap along the x direction, where the patterning time was 2.2 seconds.

The sample structure discussed here is slightly different to that presented in Figure 3(a). Here, a 360 nm thick LFO / PS layer was deposited between a 200 nm silver bottom mirror and 6 pairs of Nb_2O_5 / SiO_2 DBR top mirror on a PS substrate, where the thickness of the patterned PS layer was 1060 nm. This was then patterned using an exposure time of 2.2 seconds per point. In addition to the single lobed s-type and double lobed p-type symmetries, a three lobed d-type symmetry and a possible convolution of another higher order mode with the barrier dispersion is visible in Figure S1, with the structure having a potential depth of ~ 100 meV.

DEPTH AND ENERGY PROFILE OF THE DEFECTS

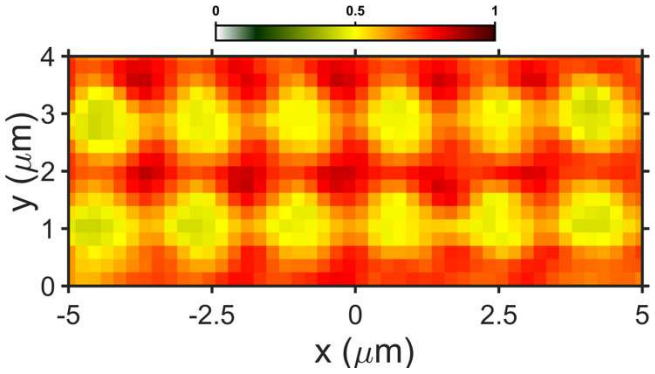

Figure S2: Real-space emission from the barriers corresponding to ~ 2.03 eV.

The PL emission corresponding to the bottom of the s-band and the barriers were determined from tomographic real-space scans, at photon energies of 1.983 and 2.03 eV respectively. A clear signature of the barrier emission as shown in Figure S2 most likely corresponds to the higher energy barrier, since emission is visible along the x and y directions. These polariton energies have been used in a transfer matrix model (see Materials and Methods) to determine the respective cavity mode energies, which are 1.994 (s-band) and 2.043 eV (high energy barrier). The potential depth is thus estimated to be 50 meV, which agrees with the value for the higher energy barrier (along y-direction) used in the calculations (56 meV), justifying the accuracy of our model.

Figure S3(a) shows the cross-sectional energy landscape of the defects along x and y directions that have been used to model the band structure of the square lattice. The measured depth profile of the defects (recorded using SFM) along both directions are shown in Figure S3(b). The average barrier height along the x direction is roughly ~ 50% of that along the y direction, whereas the average widths are > 1.2±0.1 and 0.9±0.1 μm along the x and y directions respectively, with these widths used in the band structure calculation. At this point, we have not determined a one-to-one correlation between physical depth and potential energy-depth, as the SFM imaging and optical characterization were performed on different samples. However, as the potential-energy depth of a defect is expected to be directly proportional to its physical depth, the similarity between Figures S3(a) and S3(b) gives us further confidence in our calculations.

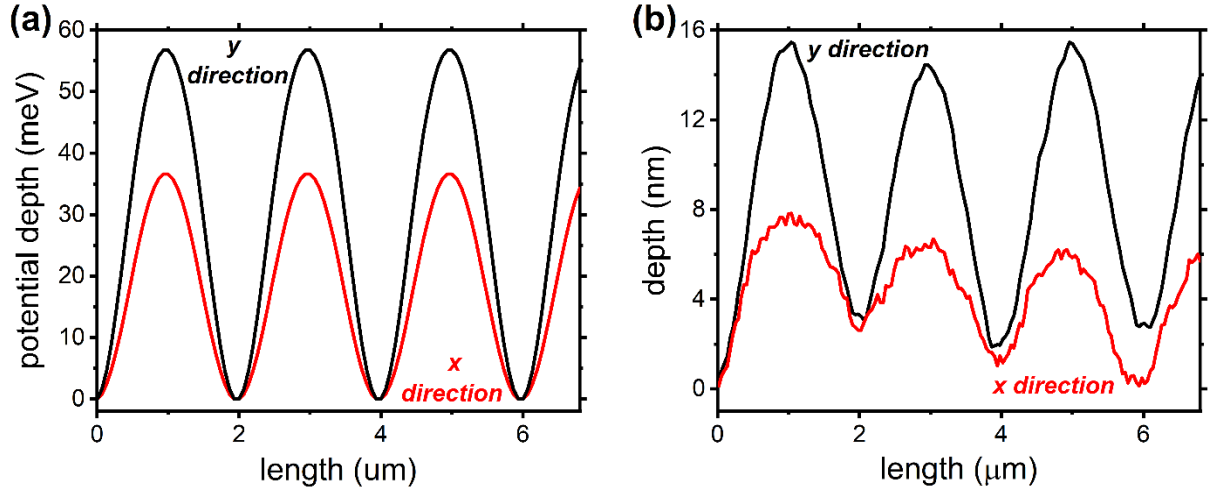

Figure S3: (a) Cross-sectional energy landscape of the defects used in the calculation of the band structure for the square lattice. (b) Depth profile of the defects extracted from a 10 μm x 10 μm SFM image of the laser patterned polystyrene substrate.

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