Laterally-Patterned Organic Microcavity Devices

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We demonstrate fabrication of organic laterally-patterned microcavity devices with lateral sizes on the micron scale using PDMS lift-off patterning. Recently, low-threshold lasing was demonstrated from pillars formed by thermally evaporating thin films of Alq_3 (aluminum tris(8-hydroxyquinoline)) doped with the laser dye DCM (4-(dicyanomethylene)-2-methyl-6-(4-dimethylaminostyryl)-4H-pyran) through thin nickel shadow masks with square, 5 x 5 um^2 openings [1-4]. Additionally, recent research efforts in microcavity exciton-polariton devices based on inorganic active materials such as GaAs or CdTe quantum wells has focused on the lateral patterning of microcavity exciton-polariton systems [5]. Such 0D cavities allow for symmetry-breaking of the in-plane wave vector, opening new pathways for parametric generation of photon pairs [6]. For the same reason, laterally-patterned organic microcavity exciton-polariton devices are also of interest. PDMS lift-off patterning, as opposed to shadow masking, allows standard lithography techniques to be used to define pattern features in silicon PDMS molds.[7, 8] Additionally, smaller features than are achievable through shadow masking are theoretically feasible even with PDMS due to the generally low aspect ratio in PDMS needed for embossing small features on the patterned organic film.

We use PDMS lift-off patterning of a thin film of thermally-evaporated TPD (N′-bis(3-methylphenyl)-N,N′-diphenyl-1,1′-biphenyl-4,4′-diamine) doped with DCM to form embossed pillars in the TPD film of 20-25 nm in thickness. The substrate is a commercially-obtained dielectric Bragg reflector (DBR). A film of Alq_3 doped with DCM is then evaporated onto the remaining TPD film, followed by a thin silver mirror, which provides the second mirror for the microcavity. Figure 1 shows the device structure (a), PDMS lift-off patterning technique (b), and molecular diagrams of the device constituents (c).

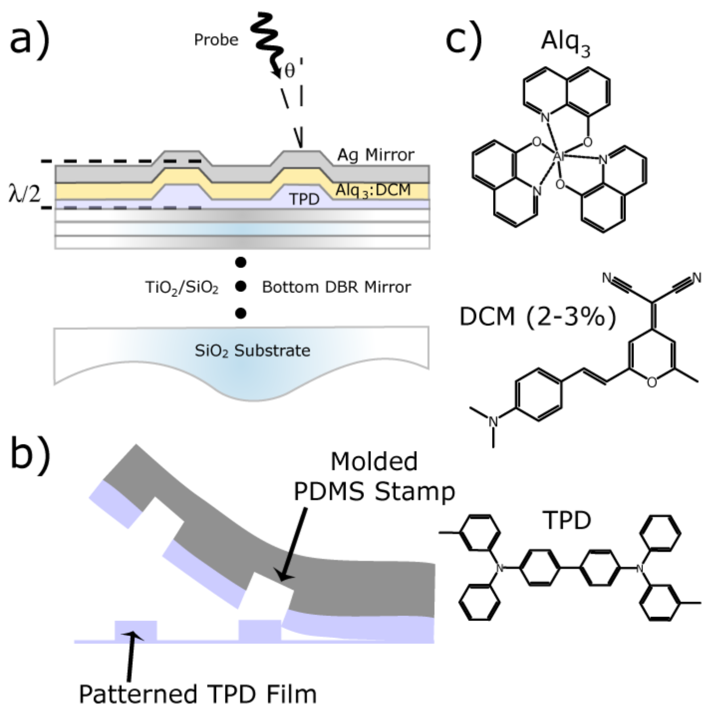

Figure 1: (a) Patterned microcavity structure. (b) PDMS lift-off patterning process. (c) Molecular structures of constituent materials.

When optically excited with a λ=408 nm light source, emission from both the unpatterned (λ~630 nm) and patterned areas (λ~655 nm) of the sample is observed, as seen in Figure 2(a). The background emission dominates since its cavity

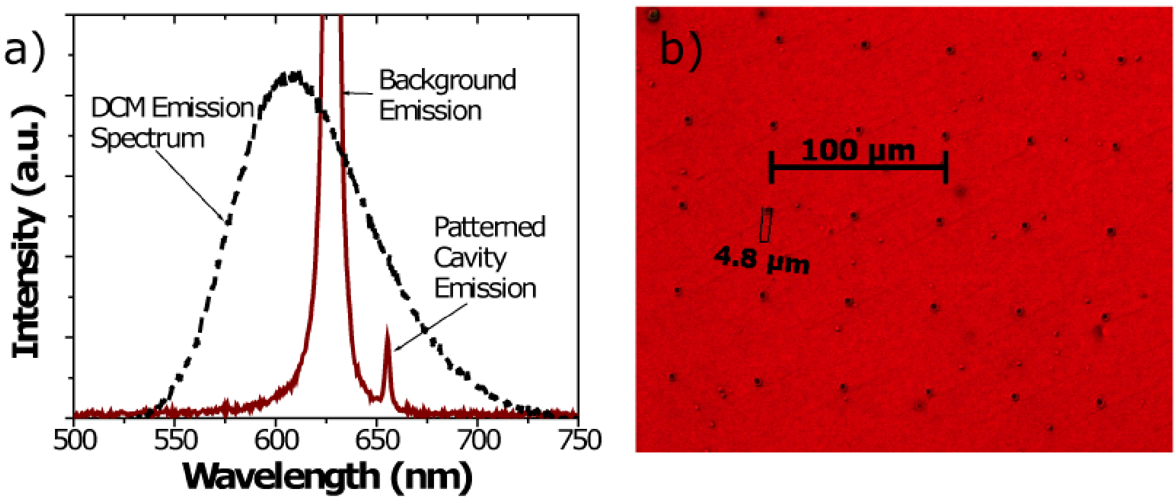

Figure 2: (a) Emission spectrum of DCM, unpatterned, and patterned microcavities when excited with λ=408 nm. (b) Microscope image of emission from patterned region showing 5 um pillars.

resonance is closer to the resonance of DCM, as shown. Figure 2(b) shows that circular pillar microcavities with a diameter of 5 um were fabricated. We discuss anticipated mode quantization as lateral microcavity size is decreased and fabrication of laterally-patterned exciton-polariton devices.

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