Supplementary Materials

Charge transport in phthalocyanine thin-film transistors coupled with Fabry-Perot cavities

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Materials and methods

Fabrication of transistor-in-cavity structure

Optically thick aluminum (200 nm) was thermally deposited through a shadow mask on a glass substrate (cleaned by sonication in cleaning detergent, deionized water, acetone and isopropanol for 10 min respectively, followed by UV ozone treatment for 15 min). A 60 nm thick aluminum oxide (Al_2O_3) layer was then electrochemically grown by anodizing the aluminum. A 20 nm thick tetratetracontane (TTC) layer was thermally evaporated on top and annealed at 60 °C for 30 min. Next, a 30 nm thick H_2Pc layer was evaporated, followed by metallization of silver source and drain with transistor channel length and width of 50 μm and 2000 μm, respectively. The cavity structure was completed by chemical vapour deposition (CVD) of Parylene-N (Par-N) and thermal evaporation of a silver top mirror of 20 nm in thickness.

Optical/electrical measurements

The extinction spectrum for H_2Pc was measured using a UV/VIS/NIR spectrometer (Lambda 900, Perkin Elmer Instruments). Reflection (*R*) were measured using a thin film analyzer (F20, Filmetrics) to determine the absorption ($A = 1 - R$). The transistor characteristics were obtained using a probe station connected with a semiconductor characterization system (Keithley 4200) under nitrogen atmosphere. The areal capacitance, calculated using dielectric constants of Al_2O_3 (~ 9) and TTC (~ 2.5) assuming they are connected in series, was used for extracting electron and hole mobility values from transfer curves.

Finite-Difference Time-Domain (FDTD) Simulations

FDTD Solution (Lumerical) was used for the simulated spectra. The simulation size was 20 nm on x and y, and 2300 nm on z. Anti-symmetric, symmetric and perfectly matched layers (PML) boundary conditions were respectively used for x, y and z to establish the infinitely large cavity structure in xy-plane. The mesh size was set to be 2 nm for all three axes. The simulation consists of an optically thick aluminum layer at the bottom, followed by an aluminum oxide (n = 1.7675), TTC layer (n = 1.475), a H_2Pc layer, a Par-N layer (n = 1.6585), and a silver layer on top. The permittivity values of the aluminum and silver were provided by the default material in the Lumerical software (Al (Aluminium) - Palik and Ag (Silver) - Palik (0-2um)). The complex permittivity of H_2Pc was determined by ellipsometry and imported for the simulations. A plane-wave normal to the film with a wavelength range of 300-1170 nm was used as a source. Reflection (R) monitor was installed on the same side as the source to calculate the absorption ($A = 1 - R$).

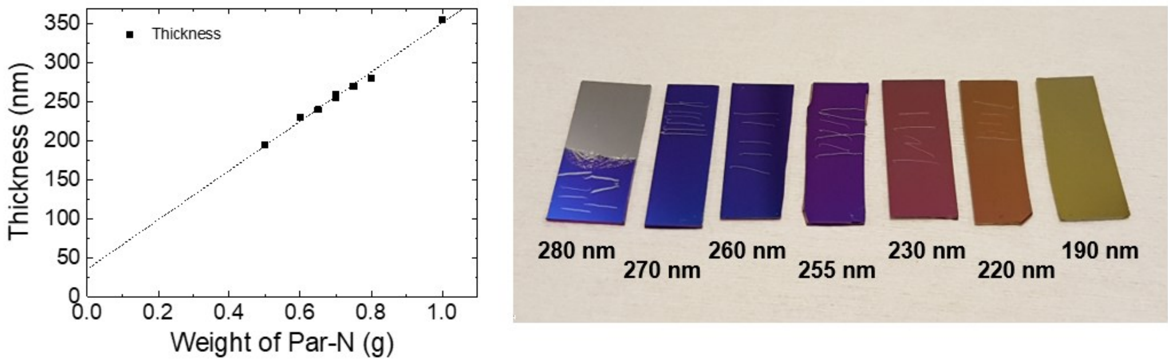

Figure S1. Thickness optimization of Par-N layer. Depending on the weight of the Par-N powder used in the CVD process, the thickness was successfully controlled, resulting in different colors when deposited on Si wafer substrates.

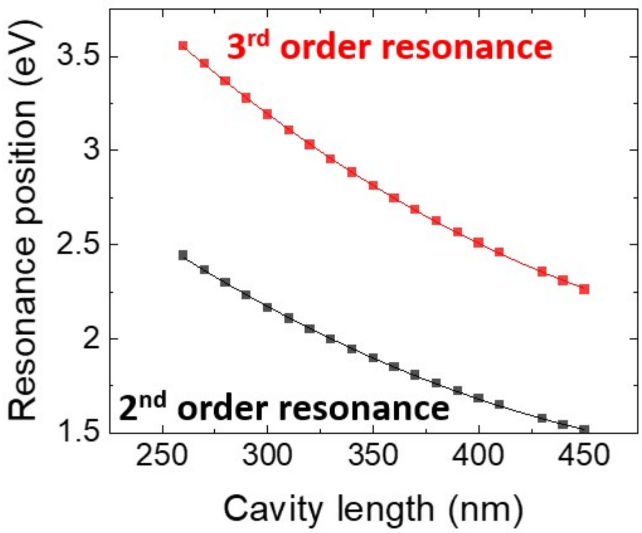

Figure S2. The 2nd and 3rd order cavity resonance positions obtained in the FDTD simulation. The positions of the non-coupled 2nd order resonance for the cavity structures used in the manuscript were estimated from the positions of the non-coupled 3rd order resonance.

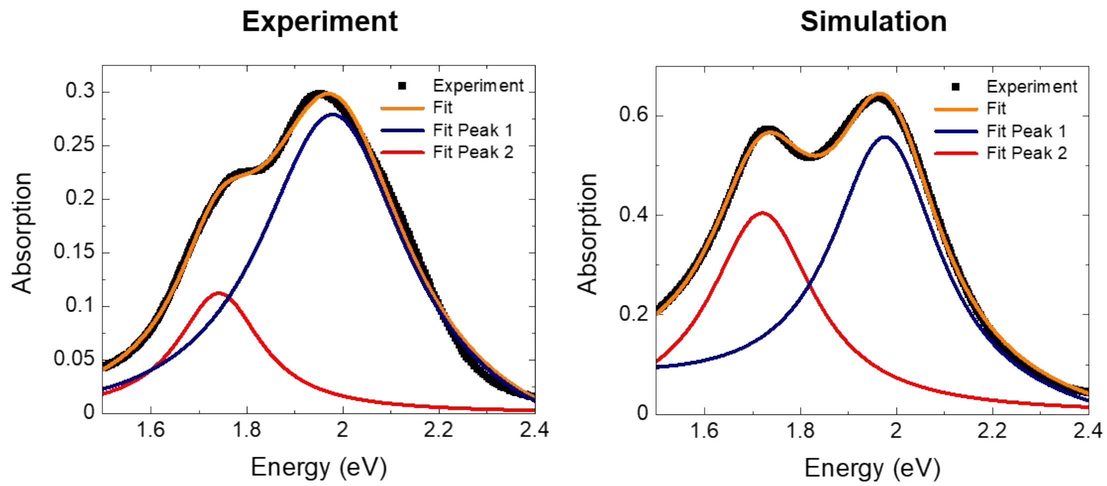

Figure S3. Peak deconvolution results to determine the exciton resonances and linewidths.

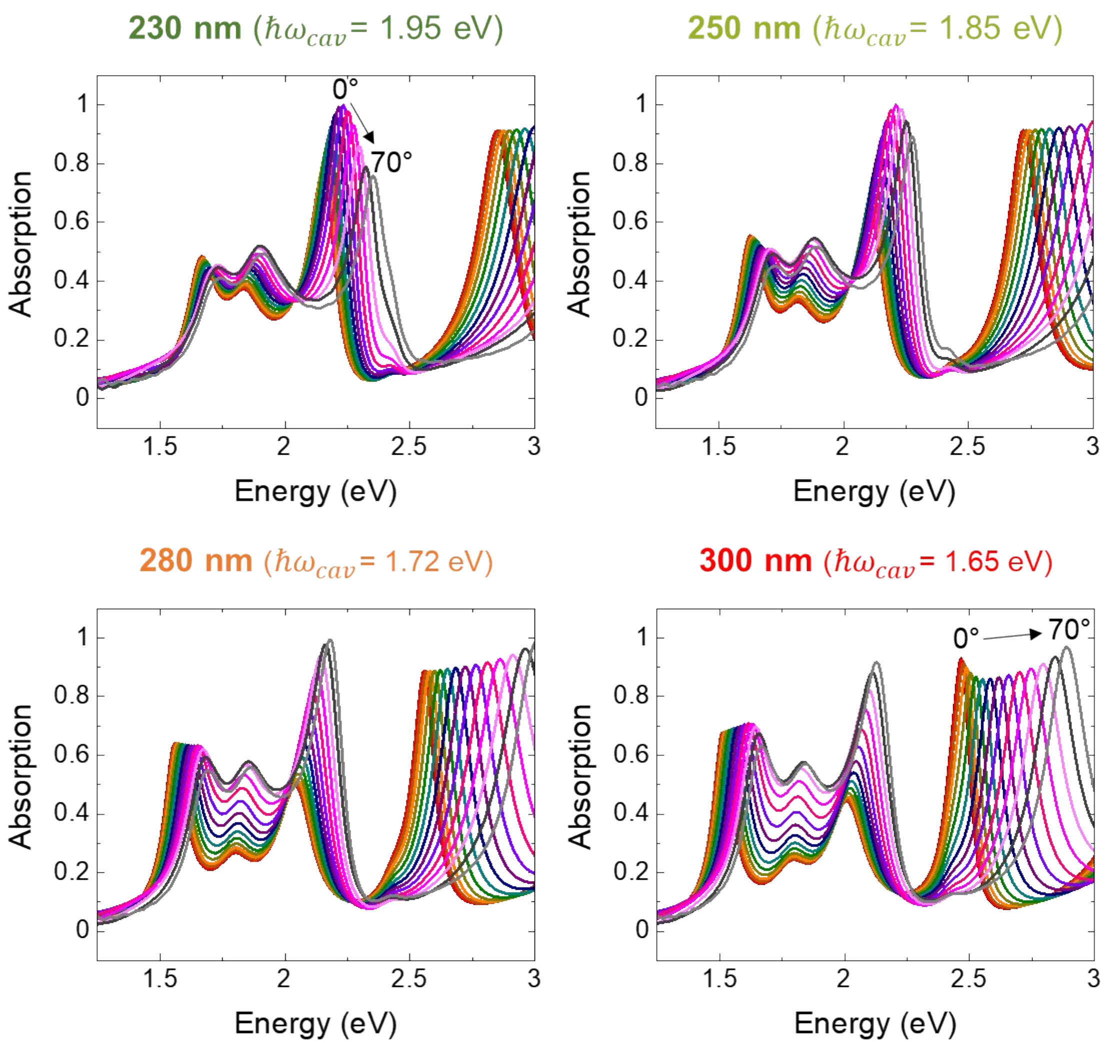

Figure S4. Absorption spectra using FDTD simulation with increasing incident angle for different thicknesses of Par-N corresponding to the experimentally obtained cavity resonances.

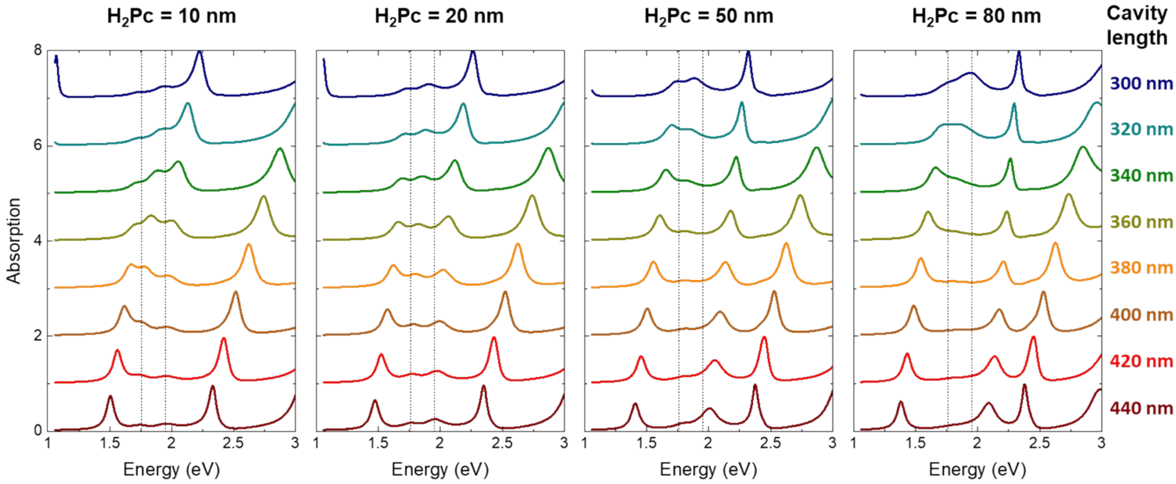

Figure S5. Simulated absorption spectra for different thicknesses of H_2Pc. The cavity lengths, defined as the distance between the bottom and top mirror of the cavity, are designated.

Table S1. Polariton peak positions and size of splittings for different thicknesses of H_2Pc shown in Fig. S5.

Thickness (nm)	$\hbar\Omega_{UP}$ (eV)	$\hbar\Omega_{MP}$ (eV)	$\hbar\Omega_{LP}$ (eV)	$\hbar\Omega_{UP-LP}$ (meV)	$\hbar\Omega_{UP-MP}$ (meV)	$\hbar\Omega_{MP-LP}$ (meV)
10	2.005	1.843	1.711	294	162	132
20	2.063	1.833	1.675	388	230	158
30	2.102	1.830	1.648	454	272	182
50	2.142	1.818	1.600	542	324	218
80	2.205	1.807	1.588	617	398	219