ADVANCED MATERIALS

Supporting Information

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Structured Organic–Inorganic Perovskite toward a Distributed Feedback Laser

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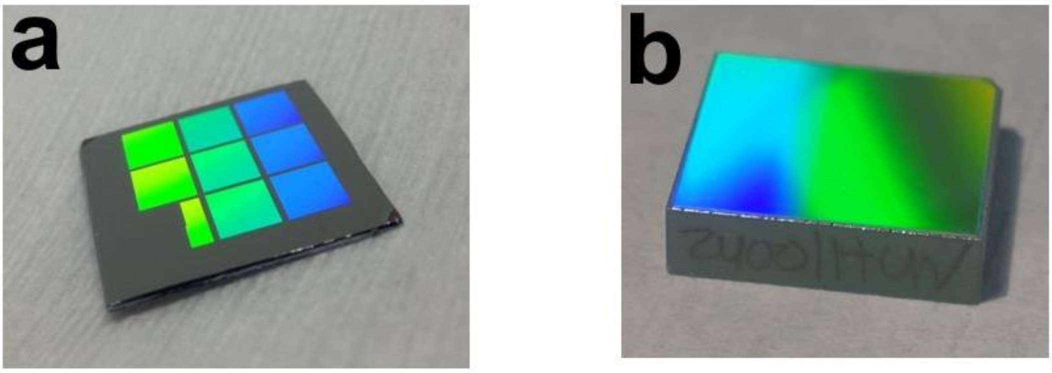

Figure S1. (a) Multistamp containing 8 different corrugation patterns with periodicities varying from 370 to 440 nm in steps of 10 nm covering an area of 0.27 cm^2 per pattern. (The pattern in the bottom left was mainly left unpatterned to allow for a large area for control experiments.) (b) Thorlabs diffraction grating with a periodicity of ~416 nm covering an area of 1.6 cm^2.

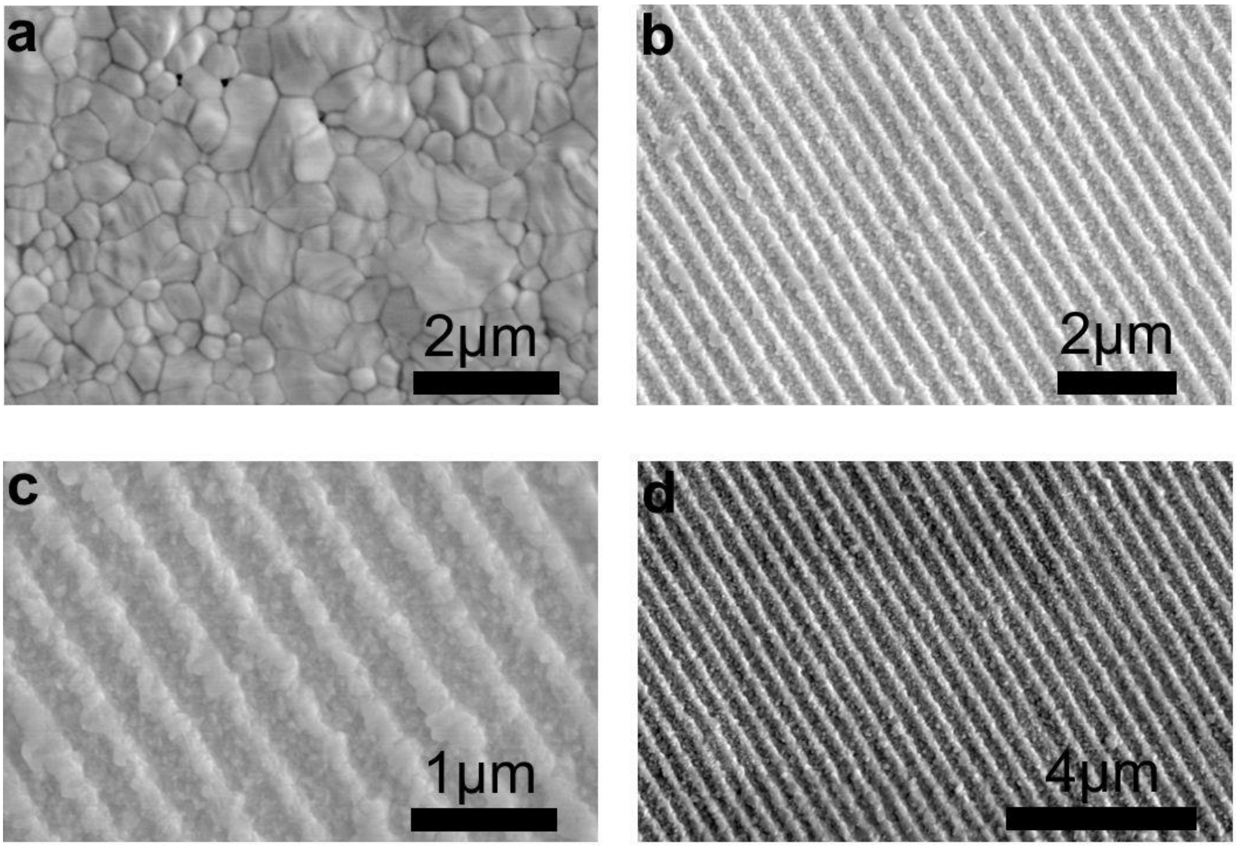

Figure S2. SEM top view of a ~ 120 nm thick evaporated perovskite layers on (a) an unpatterned substrate and (b-d) a patterned substrate with Λ ~ 416 nm

For Figure S3, we used a large-area single stamp (1.6 cm^2) with a periodicity of ~ 416 nm with a slightly lower corrugation depth and evaporated accordingly a thinner 80 nm perovskite film. Indeed, our observations are repeated in this system where we observed a clear amplified emission peak at 796 nm with FWHM of 1.4 nm, and a threshold at ~ 1 μJ/cm^2/pulse. The experiment was repeated 3 times and showed the same trend each time.

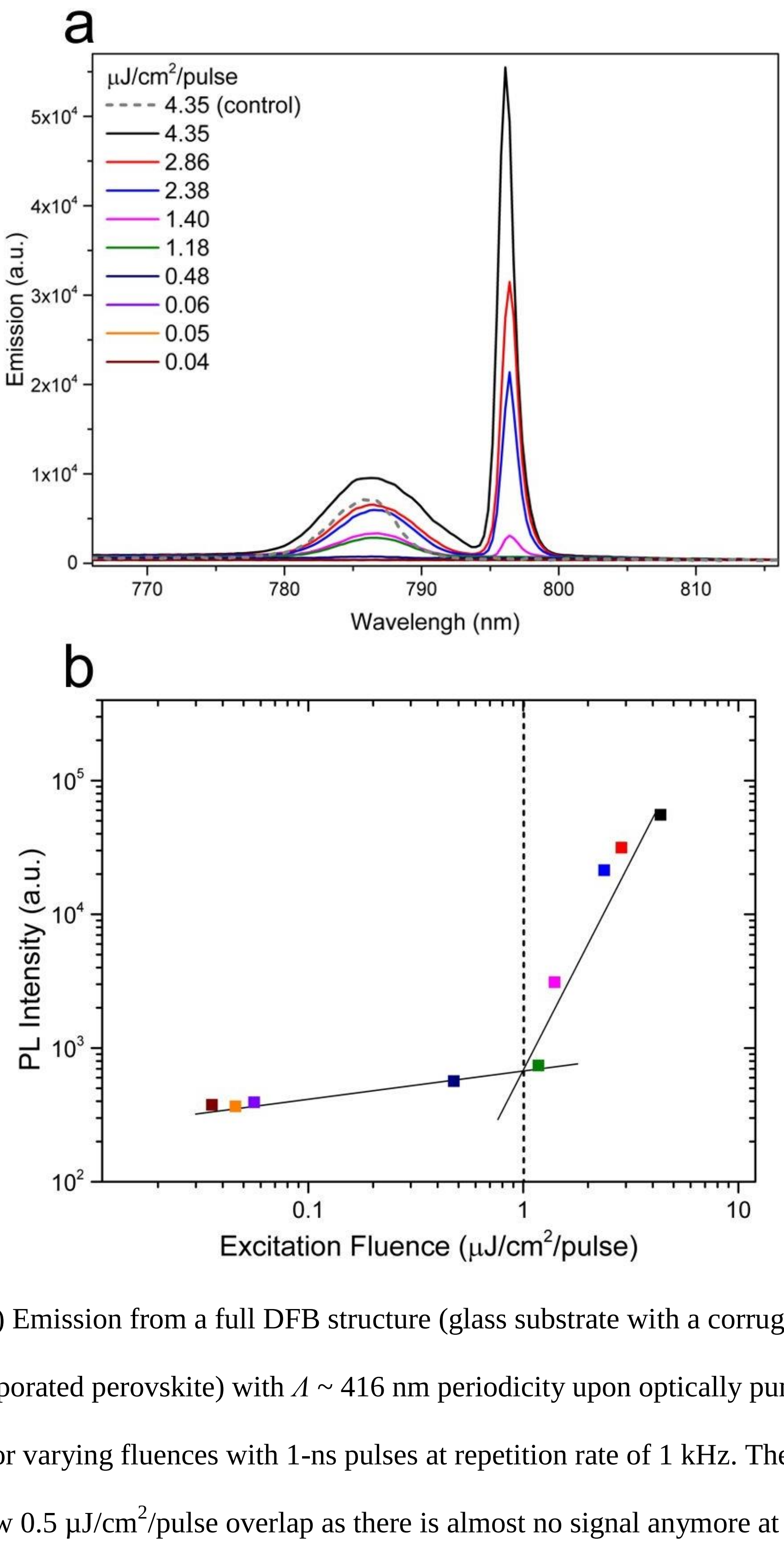

Figure S3. (a) Emission from a full DFB structure (glass substrate with a corrugated polymer resist and evaporated perovskite) with Λ ~ 416 nm periodicity upon optically pumping at Λ = 532 nm for varying fluences with 1-ns pulses at repetition rate of 1 kHz. The curves for fluences below 0.5 µJ/cm^2/pulse overlap as there is almost no signal anymore at such low excitations.

(b) Extracted PL intensity at the amplified emission peak (796 nm with FWHM of 1.4 nm) as a function of excitation fluence. The threshold is derived to be at ~1 µJ/cm^2/pulse.

Table S1. Simulated fundamental DFB modes for different periodicities *Λ*. The effective indices of the waveguide modes are estimated by solving numerically the phase-matching conditions for a three-layer waveguide[1] consisting of a polymer substrate, a 100-nm thick perovskite film and air as the cover medium. The refractive indices of the individual layers are assumed as fixed at 780 nm.

Mode	n_{eff}	*Λ* = 400 nm	*Λ* = 410 nm	*Λ* = 420nm
TE0	1.916	766	785	805
TM0	1.541	616	632	647

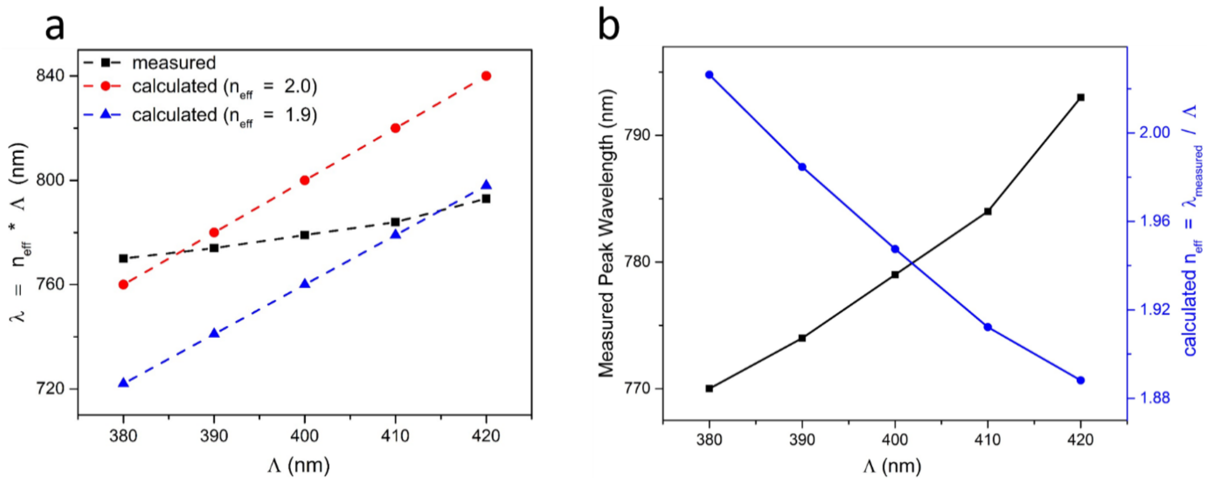

Figure S4. (a) Measured peak wavelength (squares) as a function of the periodicity Λ

Calculated modes $\lambda = n_{eff} \times \Lambda$ (second order Braff scattering) with constant $n_{eff} = 1.9$ (triangles) and 2.0 (circles).

(b) Measured modes (squares) as a function of the periodicity Λ

Calculated $n_{eff} = \lambda_{measured} / \Lambda$ (circles) using the measured modes indicating a drop in the effective refractive index with increasing wavelength.

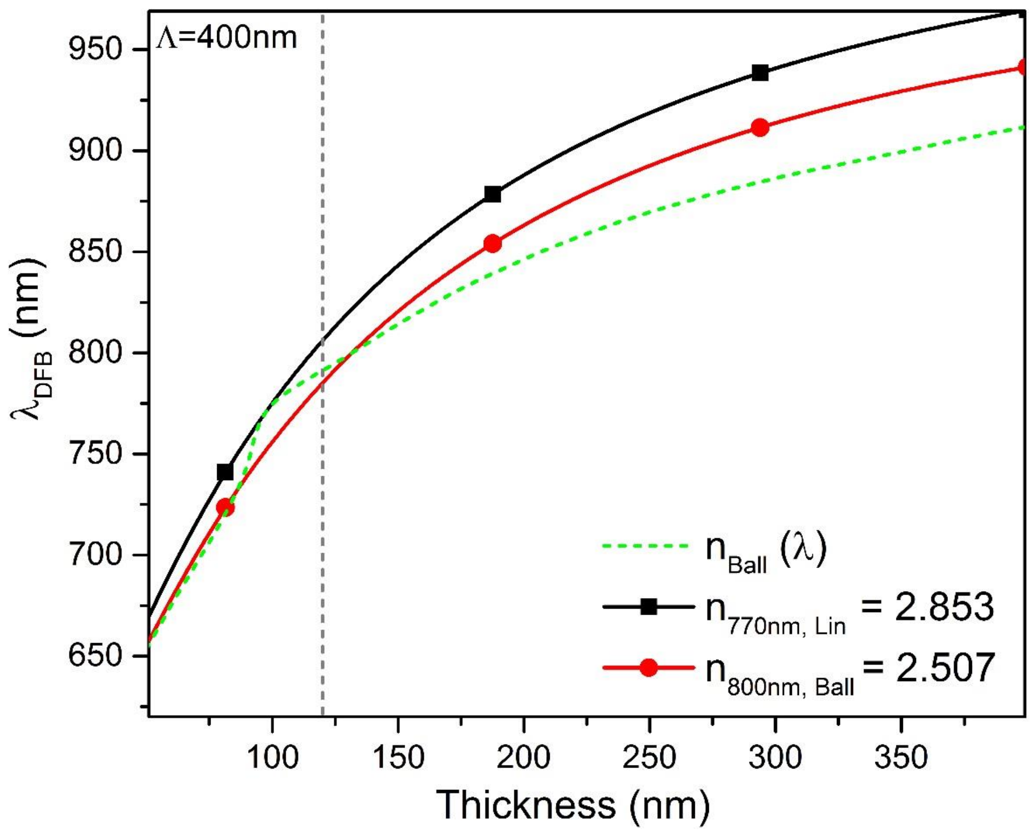

Figure S5. Estimated lasing wavelength for a DFB grating with a periodicity of 400 nm over the film thickness using the smallest value for the refractive indices of perovskite in the 770 - 800 nm range with $n_{800nm,Ball}$ = 2.507 (squares) and the largest value $n_{770nm,Lin}$ = 2.853 (circles) according to Ball *et al*.[2] and Lin *et al*.[3] The dashed curve takes the dispersion relation into account as measured by Ball *et al*.[2] The vertical dashed line indicates the experimental film thickness emphasizing the importance of accurate optical data.

[1] K. Okamoto, *Fundamentals of optical waveguides*, Academic press, London, UK, **2006**.
[2] J. M. Ball, S. D. Stranks, M. T. Hoerantner, S. Huettner, W. Zhang, E. J. W. Crossland, I. Ramirez, M. Riede, M. B. Johnston, R. H. Friend, H. J. Snaith, Energy & Environmental Science **2015**, 8, 602.
[3] Q. Q. Lin, A. Armin, R. C. R. Nagiri, P. L. Burn, P. Meredith, Nat Photonics **2015**, 9, 106.