Supplemental Document

applied optics

Photonic metamaterial with a subwavelength electrode pattern: supplement

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1. METAMATERIAL ELLIPSOMETRY FITTING

Ellipsometry fits on the metamaterial show a strong link between its thickness and refractive indices. When a fit is performed using a Tauc-Lorentz and Drude oscillator, the fitted thickness yields 460nm. On the other hand, SEM images reveal that the thickness is significantly smaller in reality at 420nm. The fitting parameters for the constrained model are shown in Table S1. The thickness discrepancy translates into the large difference in real refractive index, shown in Figure S1.

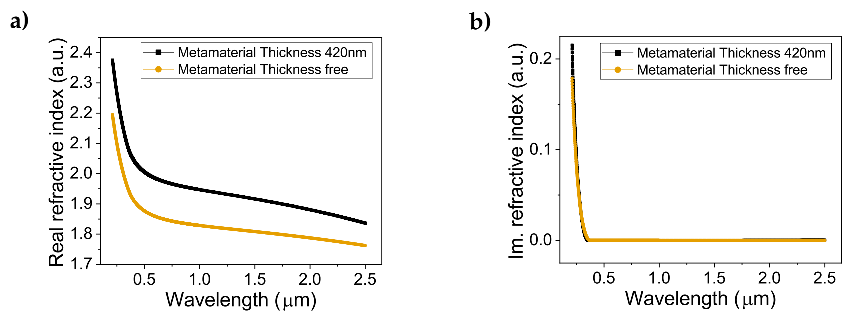

Fig. S1. The real and imaginary refractive index extracted from identical ellipsometry models. One having its thickness as fitting parameter, the other fixed to the SEM value.

Table S1. Metamaterial fitting parameters for a Tauc-Lorentz and Drude oscillator model when the thickness is constrained to 420nm.

Metamaterial Tauc Lorentz Parameter	Amp (eV)	Eo (eV)	Br (eV)	Eg (eV)
Value	133.331	12.048	9.699	3.458
Metamaterial Drude Parameter	Resistivity (Ω cm)		Scattering time (fs)	
Value	9.355E-5		478.405	

2. RCWA FITTING

Two RCWA models were used to fit the measured Mueller matrix data which includes: (1) a model based on the SiN refractive index fitted by normal ellipsometry and (2) a model that assumes the metamaterial has 45nm sized embedded electrodes in a SiN matrix with pitch 90nm.

A. Model 2 IGZO pillar width sensitivity

While performing the RCWA LSQ optimization for model 2, we noticed a very weak sensitivity to the pillar electrode width and period. Figure S2 shows the part of the Jacobian used in the fitting algorithm for both the electrode width and the metamaterial thickness. Evidently, the Jacobian for the pillar width is much weaker, about tenfold, compared to the metamaterial thickness, indicating that this parameter has a much smaller influence on the Mueller matrix. We attribute this negligible sensitivity to the nearly matched refractive indices of SiN and IGZO. More advanced models that include both parameters, result in non-physical fitted values. Consequently, the period and electrode with are kept at the intended values, namely 90nm and 45nm respectively.

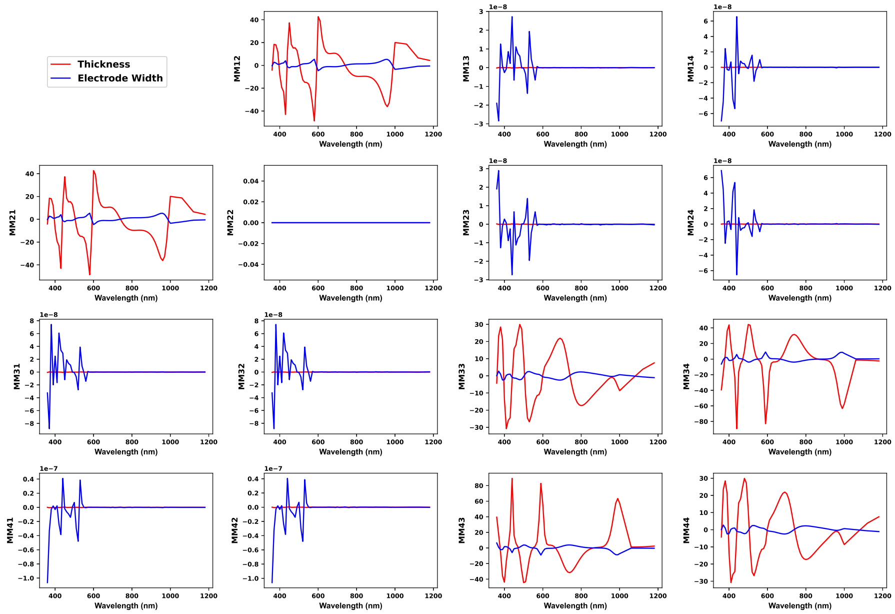

Fig. S2. Comparison of Jacobian terms for the metamaterial thickness and the pillar width, plotted to match the 16 elements of the Mueller matrix from which they are calculated.

B. Model 1 and 2 thickness sweep

For both model 1 and 2 a complete LSQ optimization does not need to be performed since there is only one fitted parameter (thickness) meaning that the Jacobian devolves to a normal derivative. Instead, a thickness sweep is performed while the LSQ is calculated as usual. Figure S3 a) and b) respectively show the LSQ value for various metamaterial thicknesses for model 1 and 2. For model 1 a 2*D* pySCATMECH model could be used, having 25 Floquet orders and 100 levels for the thickness. On the other hand, for model 2 a 3*D* pySCATMECH model was used, having 5 Floquet orders and 50 levels.

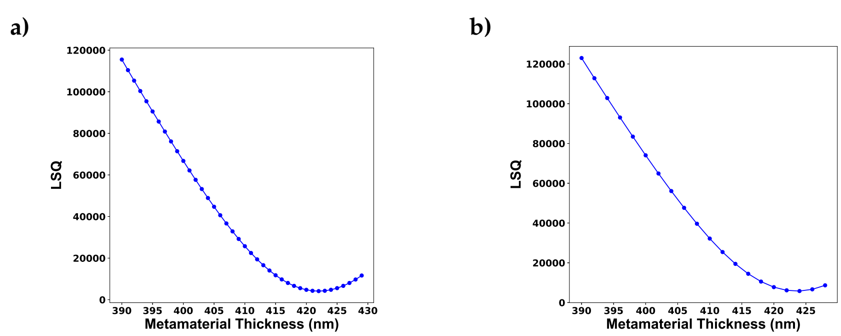

Fig. S3. a) LSQ for various thicknesses using model 1. b) LSQ for various thicknesses using model 2.