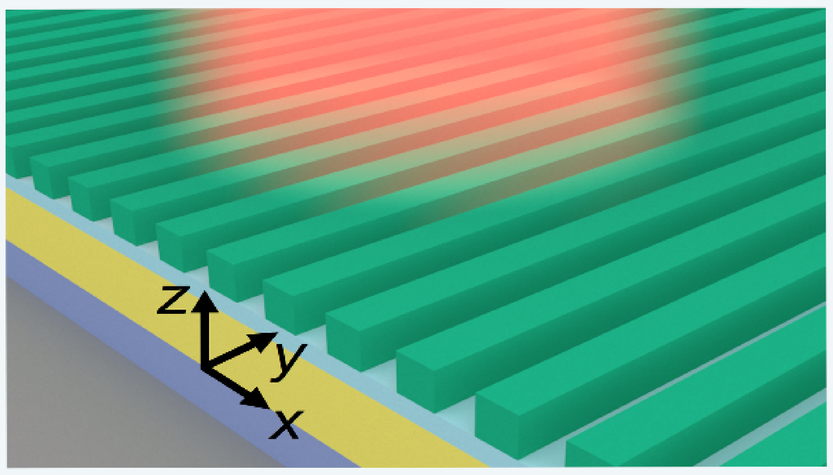


Characterizing polarizers with direct electrical readouts

L. Jiao [1,†], L. Xie [1,†], Q. Long [1], X. Li [1], Y. Wu [2], W. Shao [1,*] and Q. Zhou [1,*]

[1] School of Physical Science and Technology,Guangxi Normal University, Guilin, China.

[2] School of Physical Science and Technology, Tiangong University, Tianjin, China.

Abstract

The polarization of light is recognized as a key physical quantity in describing light-matter interactions. Polarizers quantitatively characterize the combinations of dif-ferent polarizations in light beams. In practice, the operations of polarizers require bulky and expensive terminal photodetectors, e.g., spectrophotometer, to measure the spectral responses associated with different polarizations. To get rid of the unfavorable reliance on conventional photodetectors, polarizers having a Cu-ZnO junction for efficient hot-electron extraction have been designed to give rise to direct electrical readouts. De-tailed photoelectric studies reveal the designed device excites guided-mode resonances with which the device exhibits polarization-dependent energy depositions in absorbable Cu, leading to distinct electrical responses between transverse electric and transverse magnetic polarizations. In specific, the electrical extinction ratio increases from 2.7 to 4.4 when resonance wavelength increases from 767 nm to 869 nm.

Methods

Quantitative analysis of hot electron dynamics under different incident polarization directions is performed by calculating the device's hot electron generation rate, transmission probability, and injection probability.

$$G = \frac{\frac{1}{2}\omega \mathrm{Im}(\varepsilon)|E(x,z)|^2}{hv}$$

$$D(E_\mathrm{e}) = \frac{\rho(E_\mathrm{f}-hv)f(E_\mathrm{f}-hv)\rho(E_\mathrm{f})[1-f(E_\mathrm{f})]}{\int \rho(E_\mathrm{f}-hv)f(E_\mathrm{f}-hv)\rho(E_\mathrm{f})[1-f(E_\mathrm{f})]dE_\mathrm{e}}$$

$$P_\mathrm{tra}(x,z) = \frac{1}{2}\int_0^{\frac{\pi}{2}} \sin\theta \exp\left(-\frac{d}{\lambda_\mathrm{e}|\cos\theta|}\right)d\theta$$

$$P_\mathrm{inj} = \int_0^{k_\mathrm{ZnO}} \frac{4\sqrt{(k_\mathrm{Cu}^2-k_\mathrm{y}^2)(k_\mathrm{ZnO}^2-k_\mathrm{y}^2)}}{\sqrt{(k_\mathrm{Cu}^2-k_\mathrm{y}^2)+(k_\mathrm{ZnO}^2-k_\mathrm{y}^2)}\,2k_\mathrm{Cu}\sqrt{(k_\mathrm{Cu}^2-k_\mathrm{y}^2)}} k_\mathrm{y}dk_\mathrm{y}$$

$$N_\mathrm{tra}(E_\mathrm{e}) = \int G(x,z)\times D(E_\mathrm{e})\times P_\mathrm{tra}(z,E_\mathrm{e})dxdz$$

$$N_\mathrm{col}(E_\mathrm{e}) = \int G(x,z)\times D(E_\mathrm{e})\times P_\mathrm{tra}(z,E_\mathrm{e})\times P_\mathrm{inj}(E_\mathrm{e})dxdz$$

RESULTS

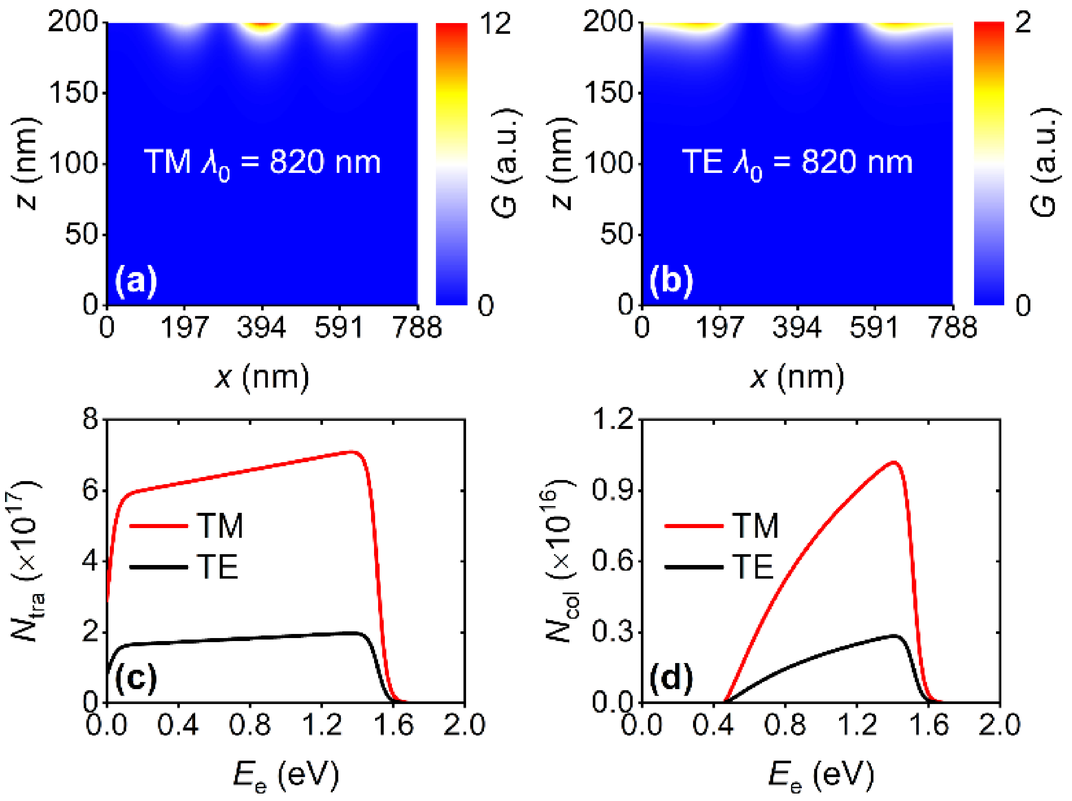


Fig. The profiles of the hot-electron generation rates under (a) TM- and (b) TE-polarized in-cidences at 820 nm. (c) The Ee-dependent flux (N_{tra}) of hot electrons reaching to the Cu-ZnO interface and (d) the flux (N_{col}) of hot electrons that surmount the Cu-ZnO Schottky barrier.

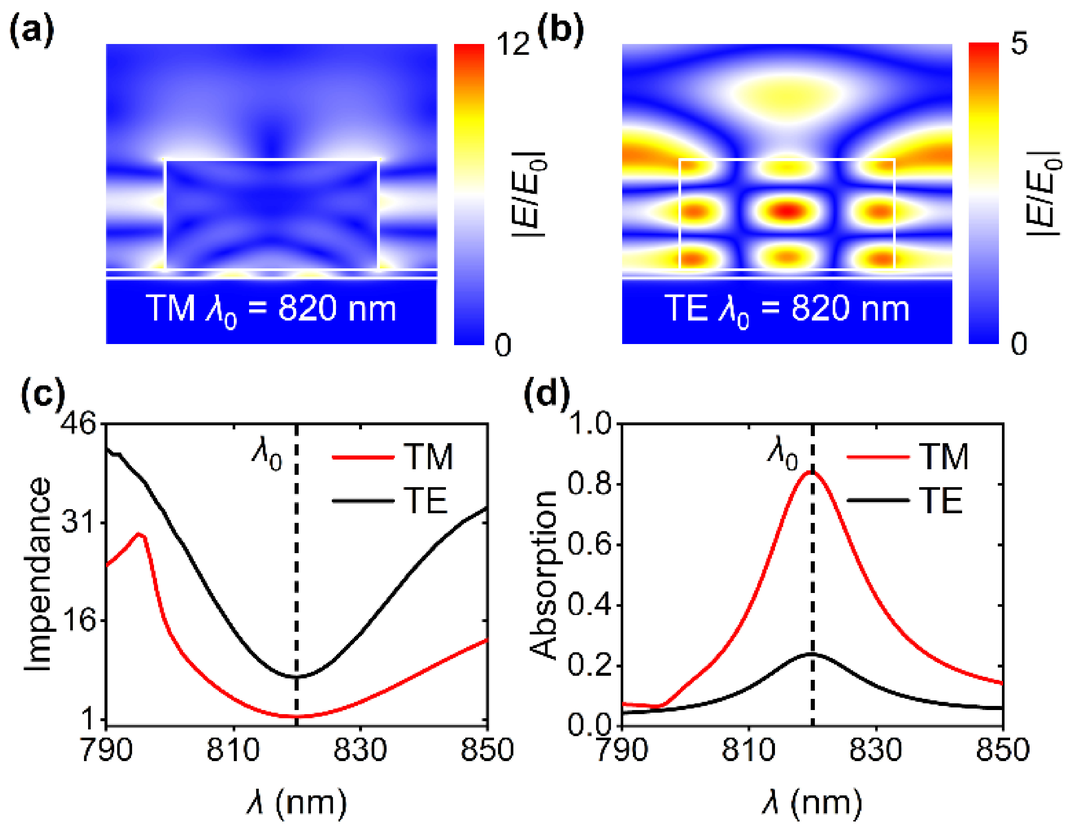


Fig. Spatial distributions of the normalized electric fields ($|E/E_0|$) at 820 nm under (a) TM- and (b) TE-polarized incidences. (c) Impedance and (d) absorption spectra in the case of TM and TE polarizations. λ0 is the resonance wavelength.

CONCLUSIONS

We present a design of polarizers whose performances can be assessed by direct electrical readouts, rather than through optical responses. The designed device is composed of a planar Cu-ZnO junction capped with a TiO_2 grating. Optical studies reveal the polarizer support GMR excitations at identical resonance wavelength but with distinct reflection efficiencies related to incident polarizations which can be harnessed to describe polarization combinations in incident light. Further optical calculations show tunable optical ER from −4.7 dB to −23.2 dB when GMR wavelengths increase from 767 nm to 869 nm. In terms of EER for assessing the designed polarizer, EER is varied in range from 2.5 to 4.5 for the considered range of resonance wavelength.

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廣西師範大學 GUANGXI NORMAL UNIVERSITY