Metamaterials and stuff

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2008

Metamaterials

Background

- Metamaterial: properties determined by large-scale structure, not chemical composition
- Structures can affect light if scale is small compared to wave length
- We can make all sorts of weird structures

Optical interactions

- Generally, refractive index is $n = \sqrt{\epsilon\mu}$
- $\mu, \epsilon > 0$: the usual case
- $\mu < 0$ xor $\epsilon < 0$: refractive index is complex, amplitude decays with propagation in material
- $\mu, \epsilon < 0$: strategic abuse of power laws permits $n < 0$

Article in question

Article

- Optical Negative Refraction in Bulk Metamaterials of Nanowires
- Jie Yao, Zhaowei Liu, Yongmin Liu, Yuan Wang, Cheng Sun, Guy Bartal, Angelica M. Stacy, Xiang Zhang
- Science, August 15 2008, Vol. 321 p. 930

Content

- Construction of bulk metamaterial
- Parallel silver nanowires embedded in alumina
- Negative refractive index observed in (near) visible part of spectrum

Experimental setup

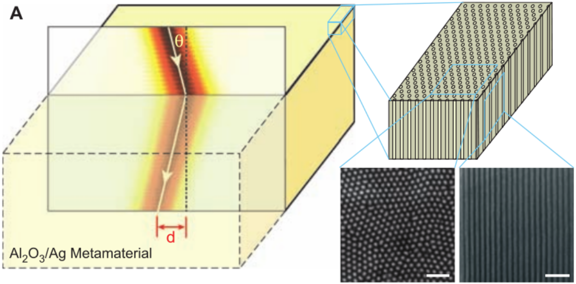

Figure: Design of metamaterial. White bar is 500 nm. Imaging by SEM

What happens

- Input: diode laser at angle θ with TE or TM polarization
- Measure: intensity around distance d on the figure

Measurements

Results

- Move optical fiber across beam exit region
- Measure intensity as function of displacement (Figs B, C)
- Evidently the TM mode has negative refractive index
- With different angles of incidence (Fig D), Snell's law holds

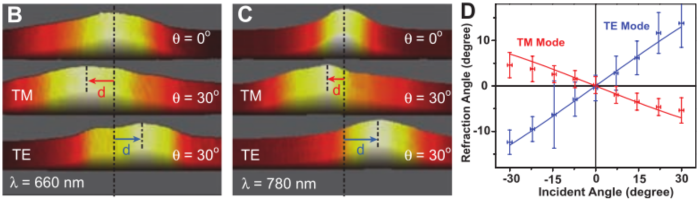

Figure: TM reflected left, TE reflected right. B, C: different wave lengths. D: Angles of refraction. Fully drawn lines correspond to EMT calculation