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Photonic/Plasmonic Structure from Metallic Nanoparticles in Glass

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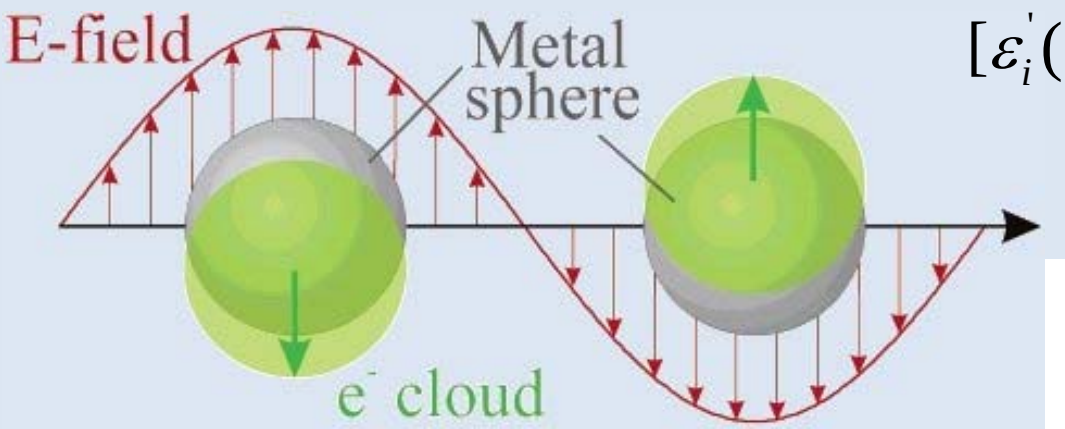
Outline

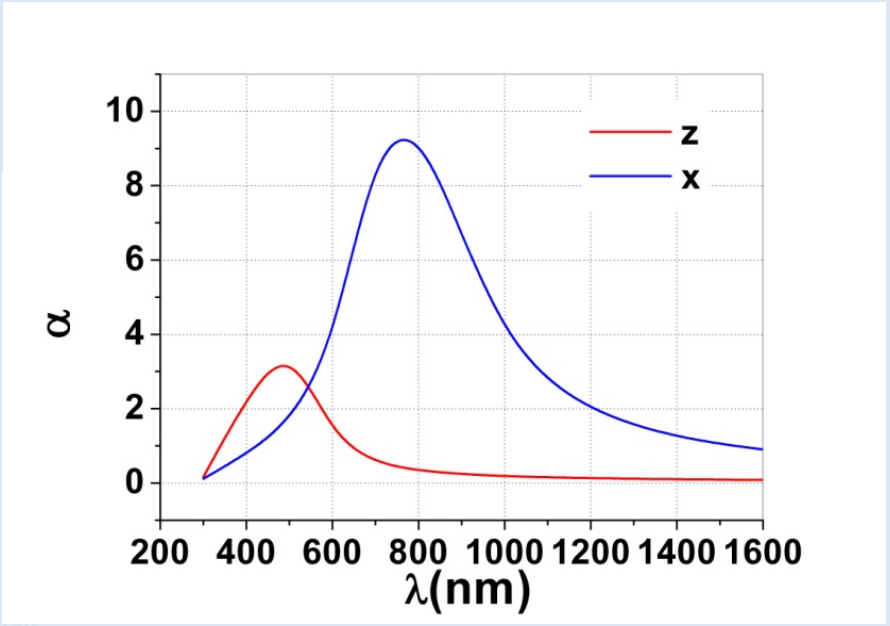
- Optical properties of metallic nanoparticles
- Fabrication of plasmonic structures
- Effective medium theory
- Application of EMT
- Conclusion



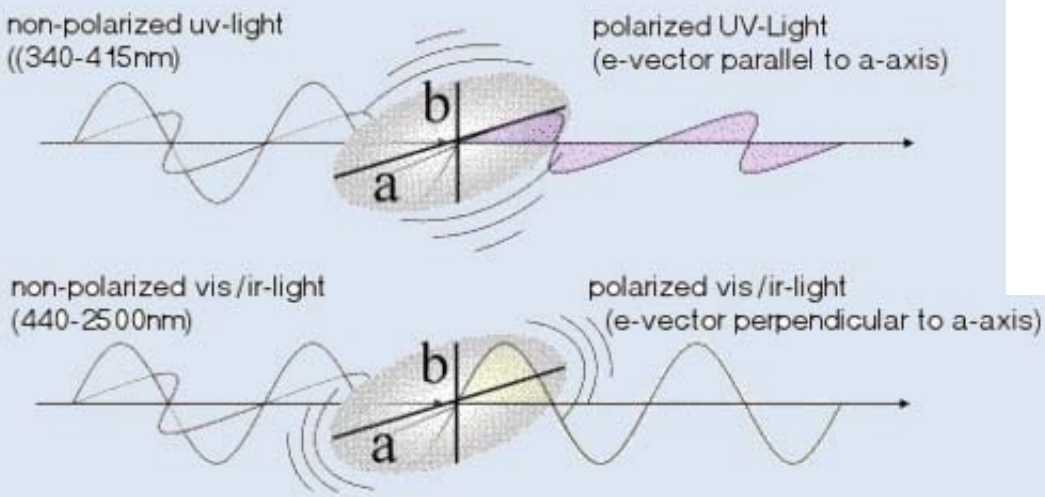
Interaction between metallic nanoparticles and electromagnetic wave

$$[\varepsilon_i'(\omega_{SP}) + 2\varepsilon_h]^2 + \varepsilon_i''(\omega_{SP})^2 \rightarrow Min$$

Surface plasmon resonance



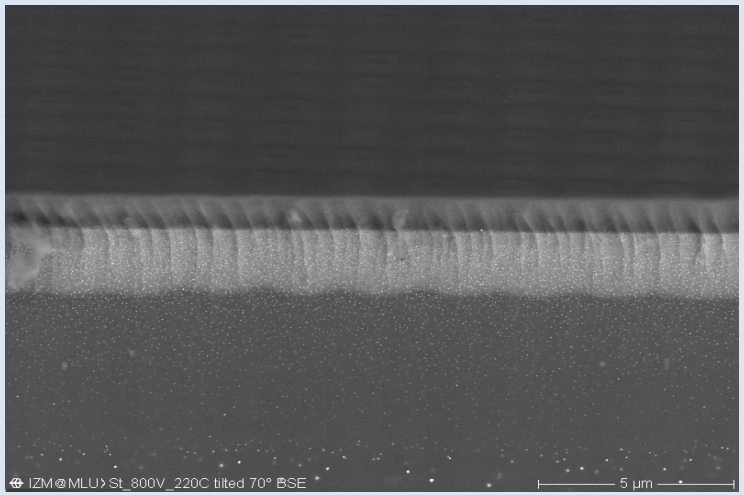
Extinction as function of wavelength



Metallic nanoparticles as a polarization system

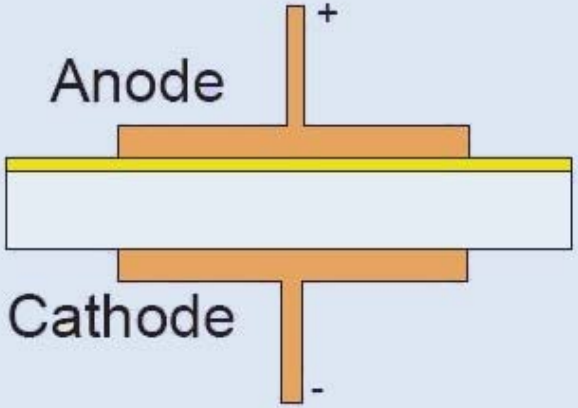
http://www.codixx.de/

$$\alpha = \frac{2\pi}{\lambda} \mathrm{Im} \sqrt{\varepsilon_{eff}(\lambda)}$$

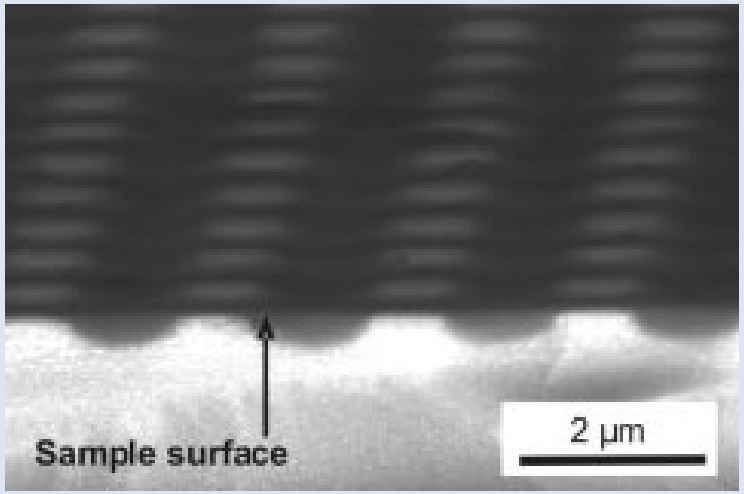


Layer of silver nanoparticles in glass

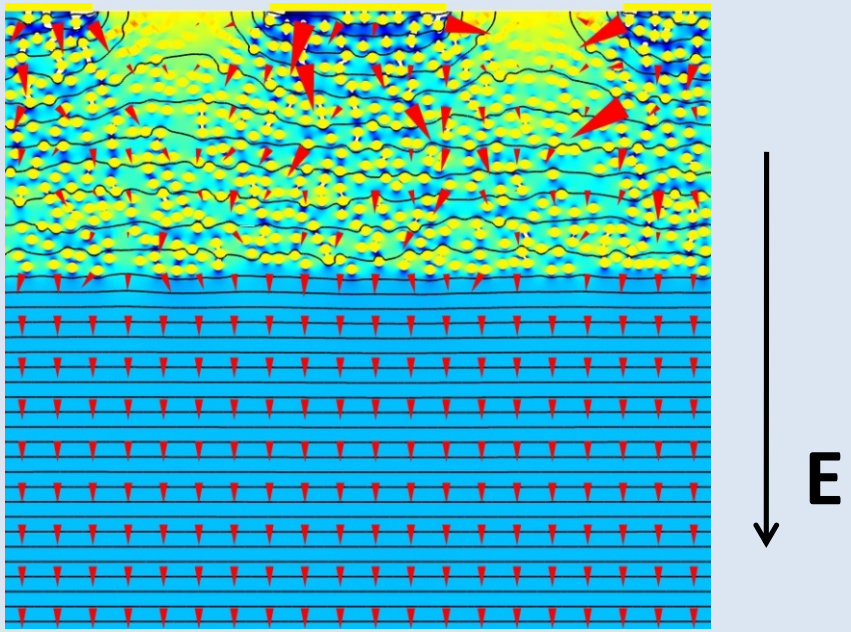
$$f = \frac{V_{inclusions}}{V_{bulk}}$$



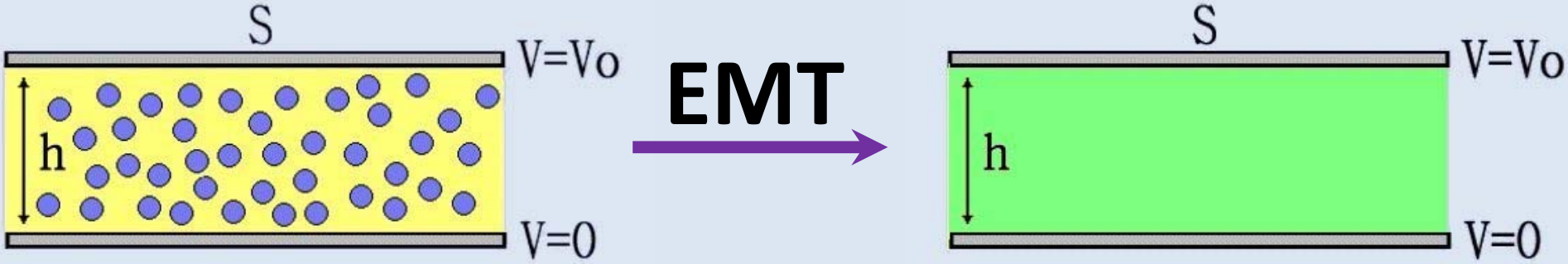
Patent: WO/2005/102951



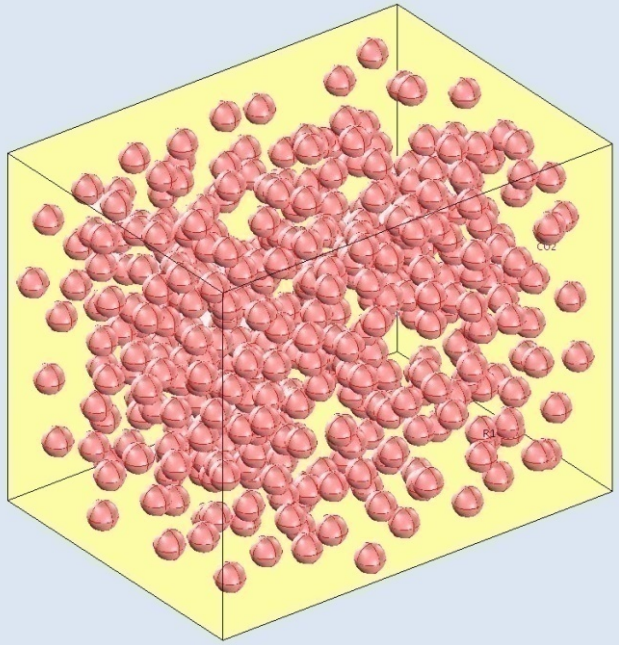
Experimental plasmonic structure, produced by electric-field-assisted dissolution method



Distribution of electric field between anode and cathode. Calculated by Comsol Multiphysics



$$W = \frac{1}{2}\varepsilon_0 \int_V \varepsilon(\vec{r})[\nabla\phi(\vec{r})]^2 d^3r \qquad W = \frac{1}{2}\varepsilon_0 \varepsilon \frac{S}{h} V^2$$

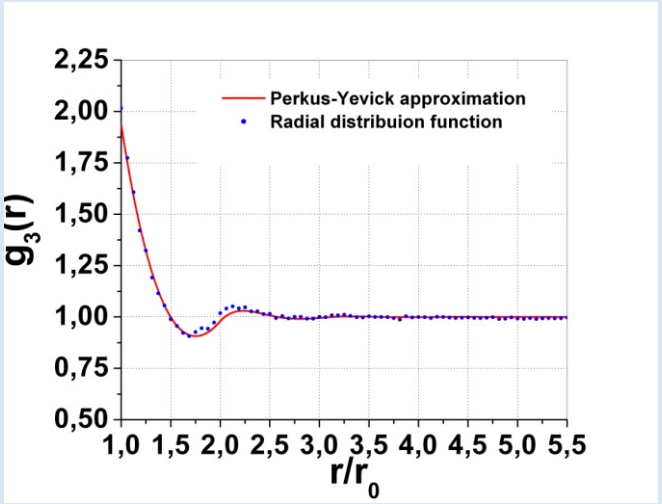


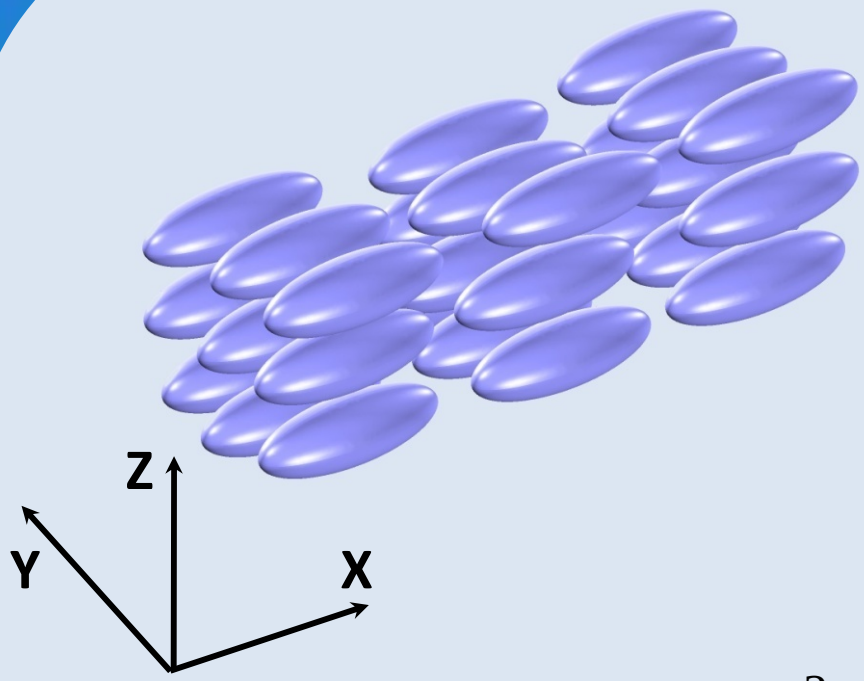
$$\nabla \cdot [\varepsilon(\vec{r})\nabla\phi(\vec{r})] = 0$$

Equal distribution of nanoparticles in glass

Algorithm from molecular physic for equal distribution

Radial distribution function for the ensemble of nanoparticles.

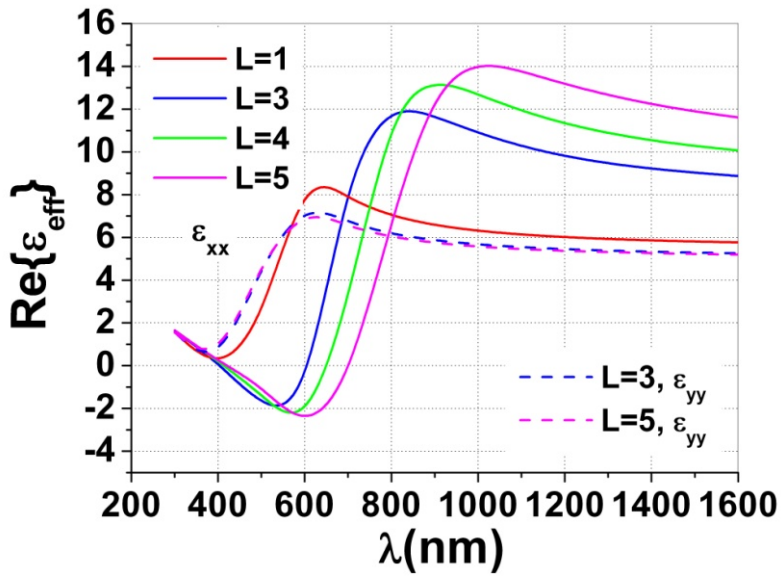


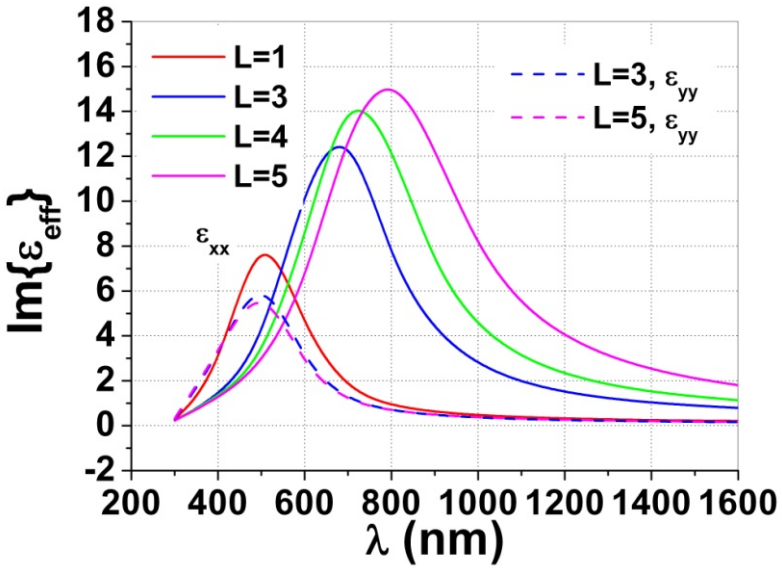


$$\varepsilon_{sph} = \varepsilon_b + 1 - \frac{\omega_p^2}{\omega^2 + i\gamma\omega}$$

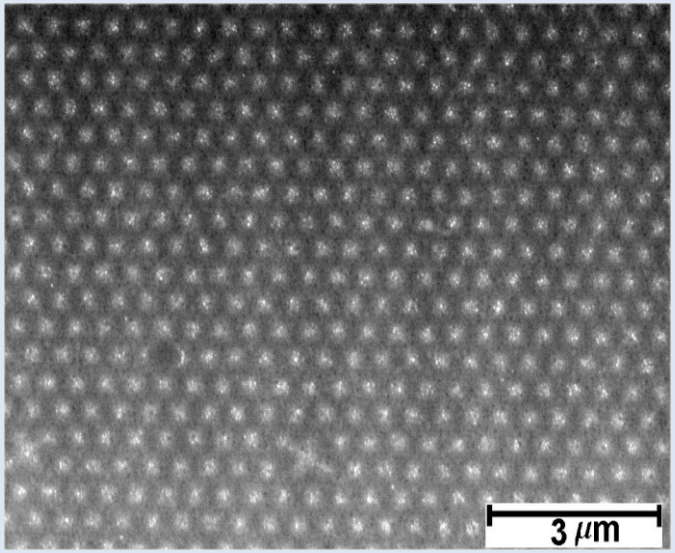
$$L = \frac{a_x}{a_y}, a_y = a_z$$

$$\varepsilon_{eff} = \begin{pmatrix} \varepsilon_{xx} & 0 & 0 \\ 0 & \varepsilon_{yy} & 0 \\ 0 & 0 & \varepsilon_{zz} \end{pmatrix}$$

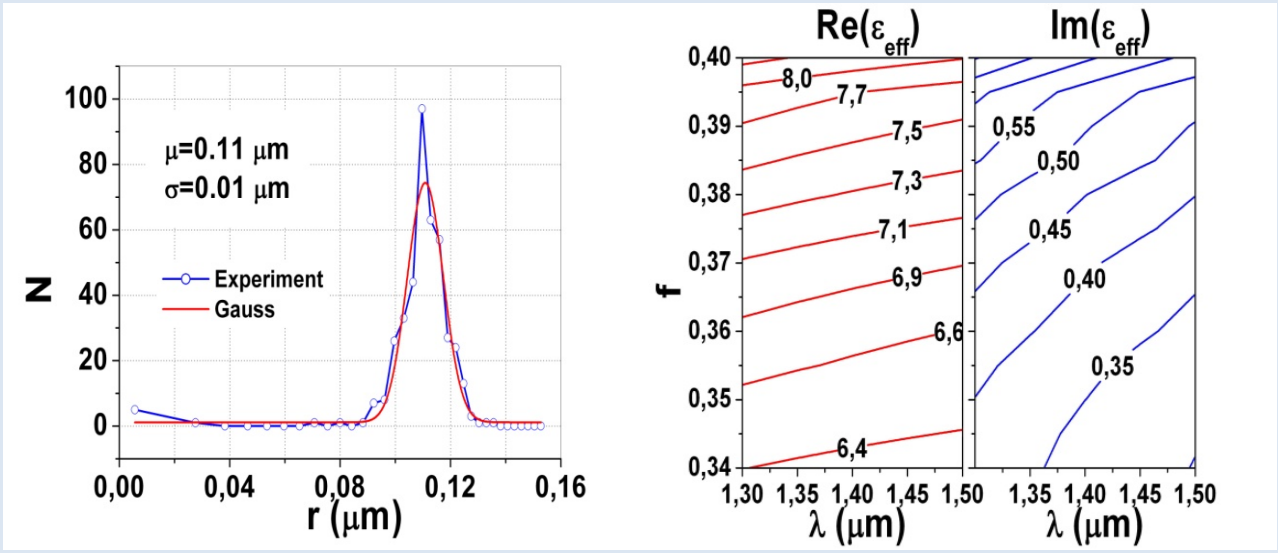




All calculations were made for f=0.3



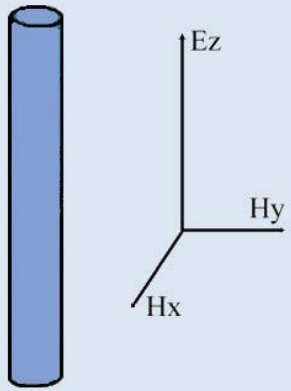
Experimental sample

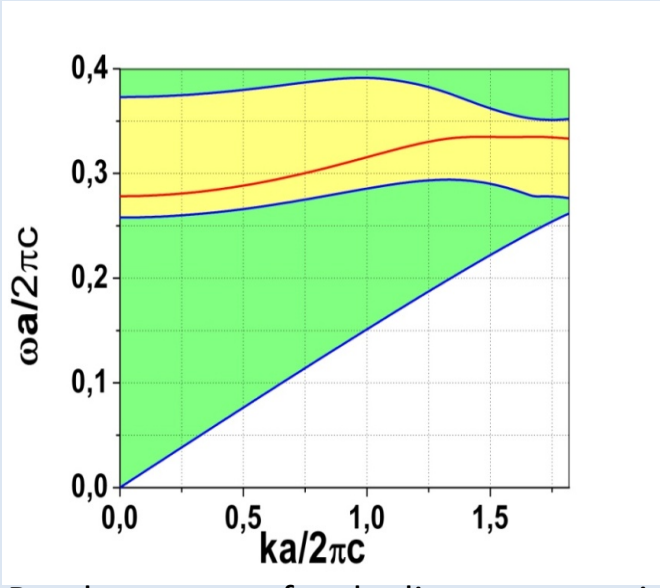


Distribution for radii

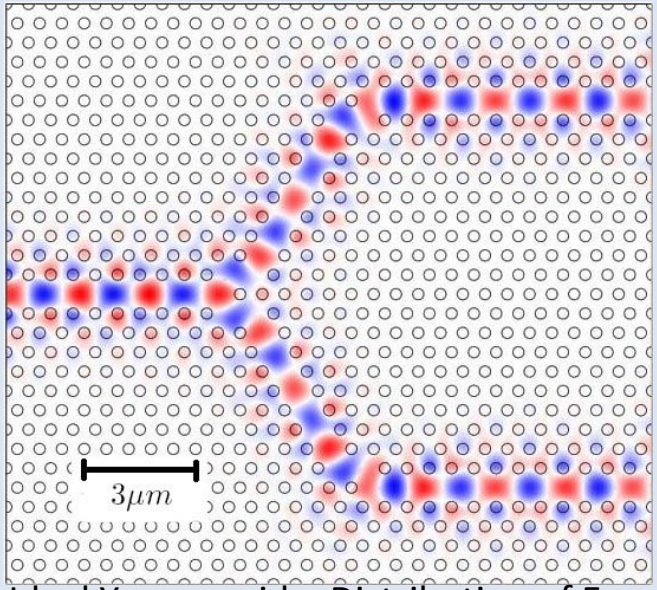
Filling factor

TM mode



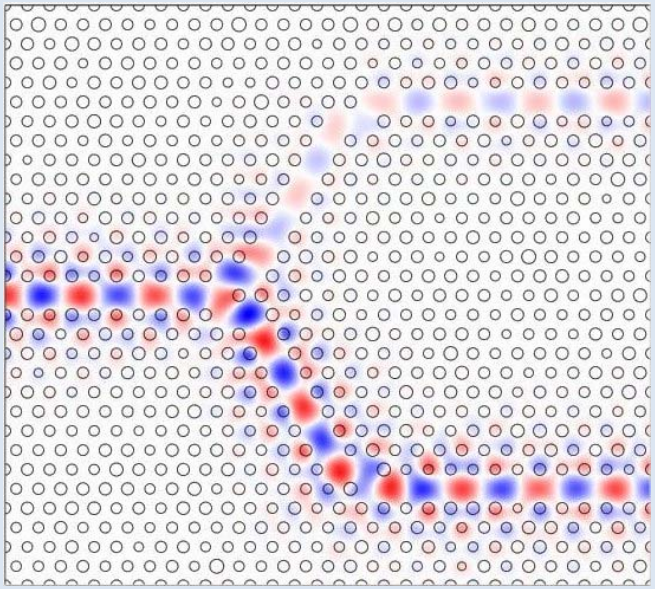


Band structures for the linear waveguide

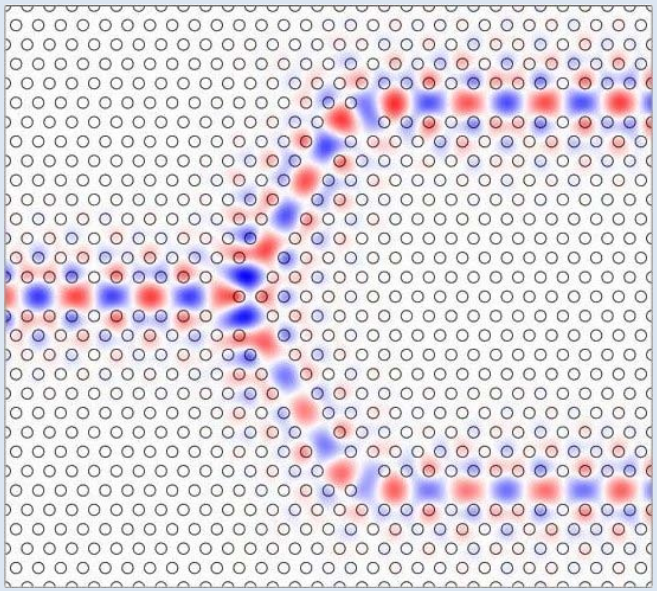


Ideal Y waveguide. Distribution of Ez

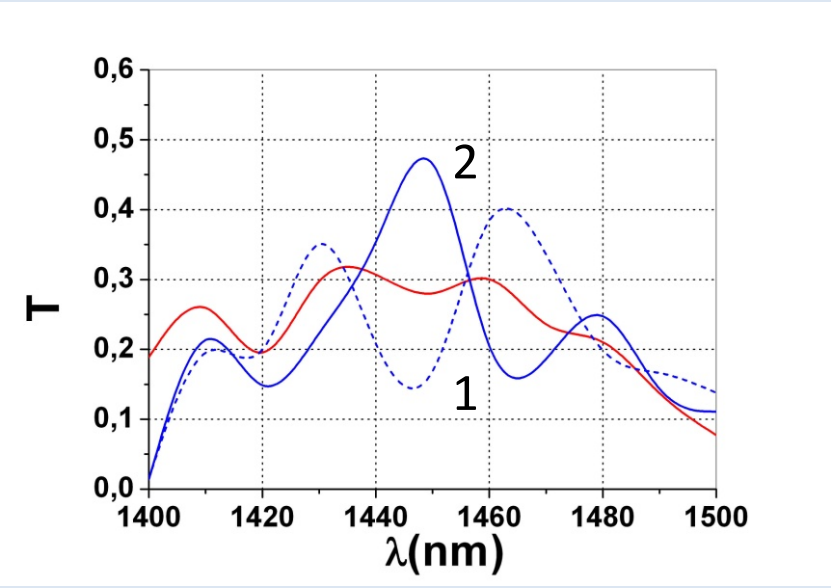
$\lambda = 1,45\mu m$



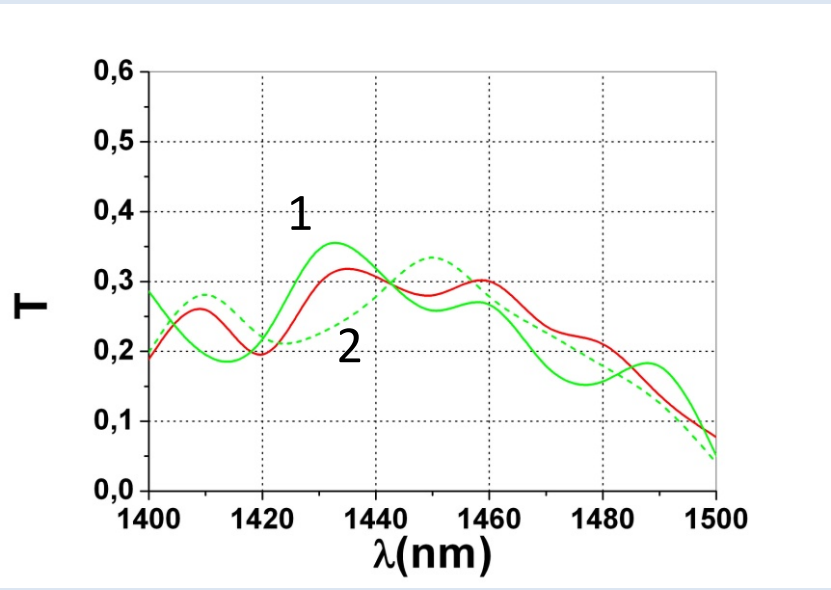
$0,09 \le r \le 0,15\mu m$



$0,34 \le f \le 0,40$



Distribution of radii for 2D photonic crystal



Distribution of filling factor for 2D photonic crystal

✓Calculation of effective permittivity for nanocomposite glass

✓ Model of experimental setup by statistical analysis

✓ Design of waveguides using optical properties of structure

✓ Dependence on propagation EM waves in the different waveguides

Thank you for your attention