Universitatea Babes-Bolyai
Cluj-Napoca

Institutul de Cercetari
Experimentale Interdisciplinare

Fabricarea retelelor periodice de orificii in filme de aur si studiul proprietatilor lor structurale si plasmonice

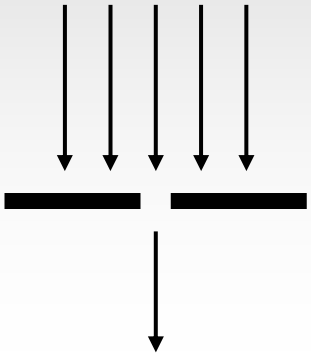
V. Canpean, S. Astilean

Laboratorul de Nanobiofotonica , Institutul de Cercetari Experimentale Interdisciplinare
Universitatea Babes-Bolyai, M. Kogalniceanu 1, 400084 Cluj-Napoca, Romania

A 7-a editie a Seminarului National de Nanostiinta si Nanotehnologie
Bucuresti, 20 martie 2008

Introducere

– 1944, H. A. Bethe: ***Transmisia optica printr-un singur canal*** *cu diametru mai mic decat lungimea de unda a luminii (H. A. Bethe, Phys. Rev. 66 (1944) 163)*

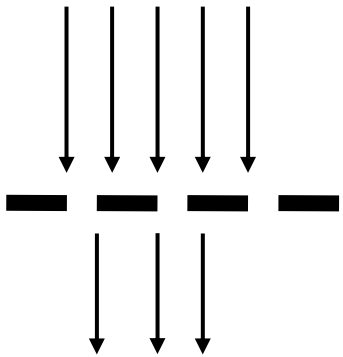


$$T \propto \left(\frac{r}{\lambda}\right)^4$$

r – raza
λ – lungimea de unda

Diametru 150nm => $T \sim 10^{-3}$

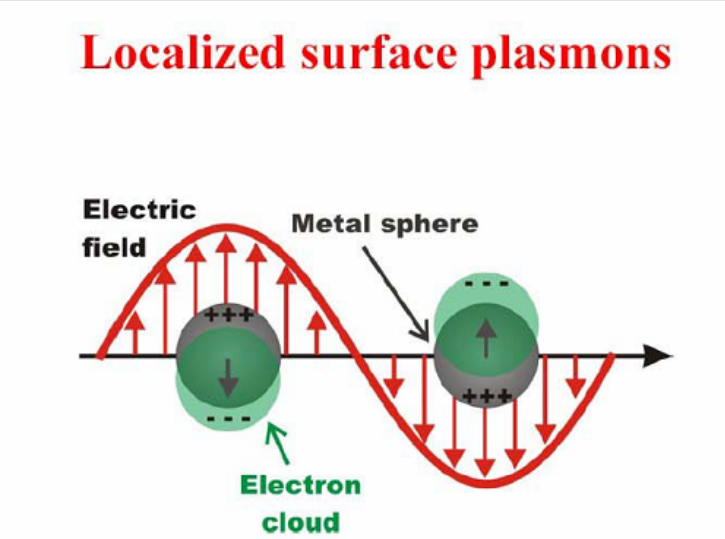
– 1998, T. W. Ebbesen: ***Transmisia optica printr-o retea periodica de canale*** *metalice cu diametru mai mic decat lungimea de unda a luminii* (T.W. Ebbesen, H.J. Lezec, H.F. Ghaemi, T. Thio and P. A. Wolff, Nature 391 (1998), 667)

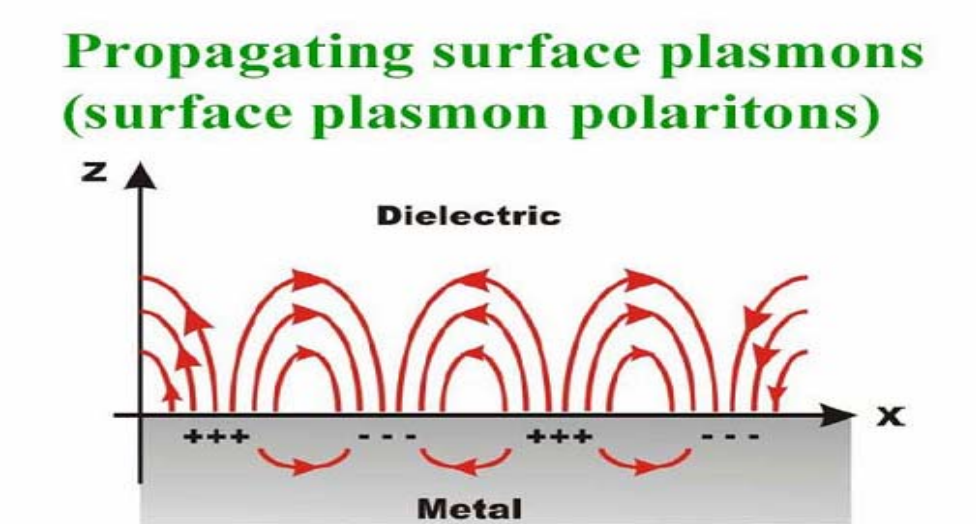


AMPLIFICAREA TRANSMISIEI de 10^3 ori

Surface Plasmon Resonance (SPR)

– **plasmoni de suprafata** (SP)– oscilatii ale densitatii de electroni la surafata de separare dintre un metal si un dielectric





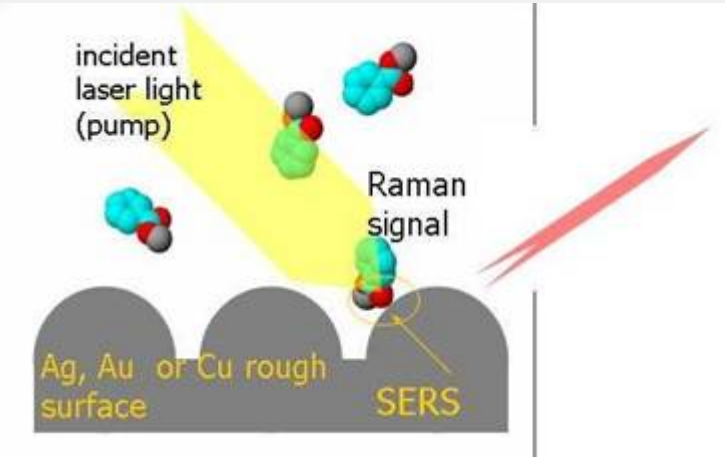
$$\sigma_{ext} = 9\frac{\omega}{c}\epsilon_m^{3/2} V \frac{\epsilon_2(\omega)}{[\epsilon_1(\omega) + 2\epsilon_m]^2 + [\epsilon_2(\omega)]^2}$$

$$k_{spp} = \frac{\omega}{c} \cdot \sqrt{\frac{(\varepsilon_1(\omega) \cdot \varepsilon_m)}{(\varepsilon_1(\omega) + \varepsilon_m)}}$$

– SPP nu pot fi excitati optic direct pe o suprafata neteda

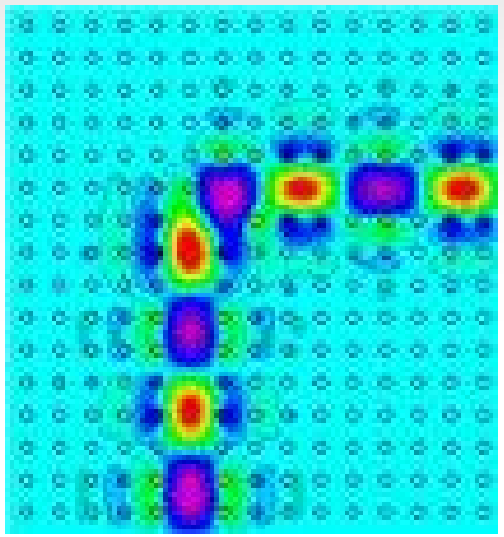
Aplicatii

Amplificarea detectiei bio-chimice



- Tehnici spectroscopice amplificate de suprafata (SERS, SEIRS, Fluorescenta)
- Detectia bio-chimica utilizand SPR

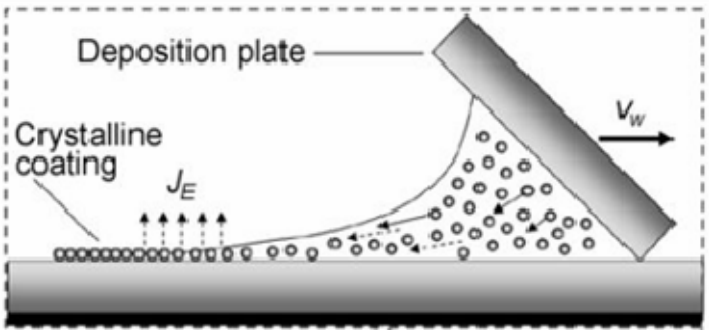
Controlul propagarii luminii

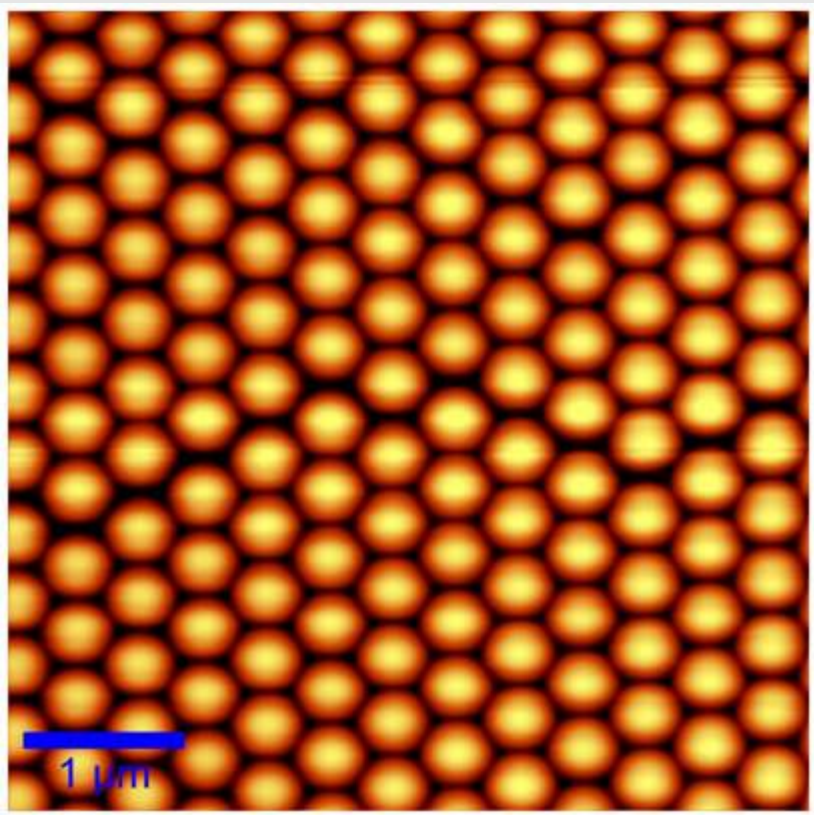


- Transmisia luminii prin orificii cu diametre mai mici decat limita de difractie
- Propagarea luminii prin ghiduri de unda
- Amplificarea transmisiei

Fabricare

A. Asamblarea Convectiva

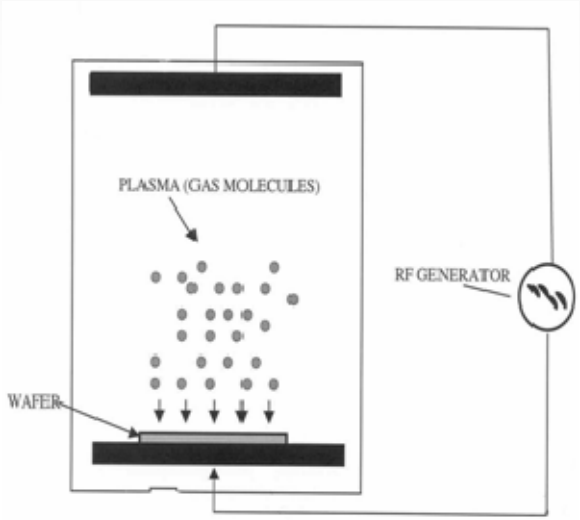


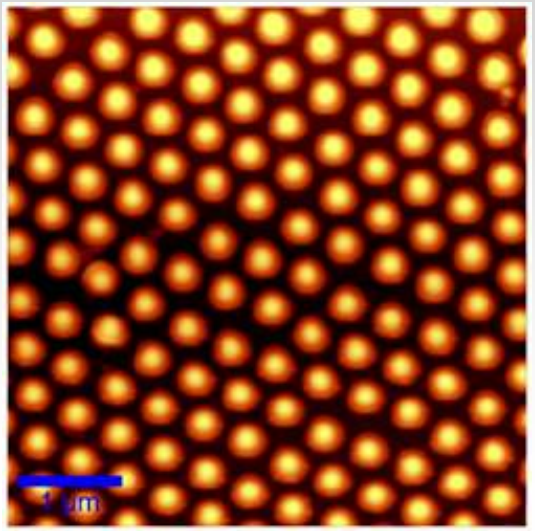


D = 450nm

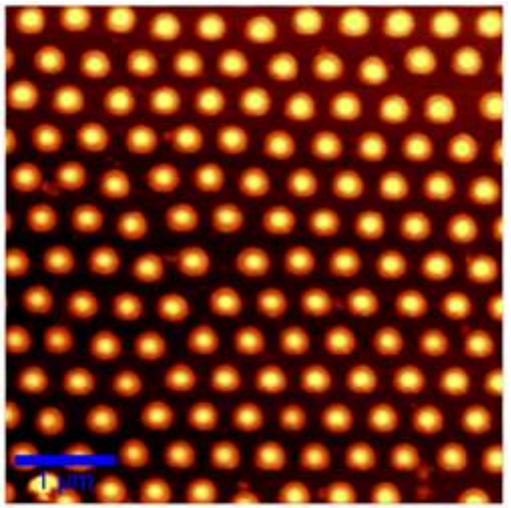
Fabricare

B. Corodarea Fizica





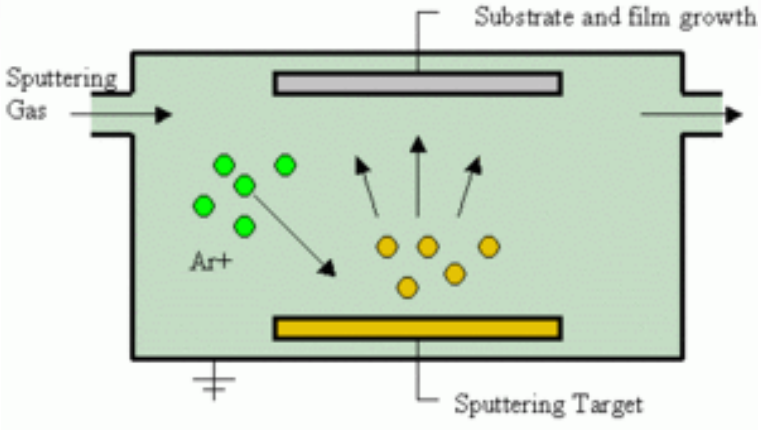
D = 280nm

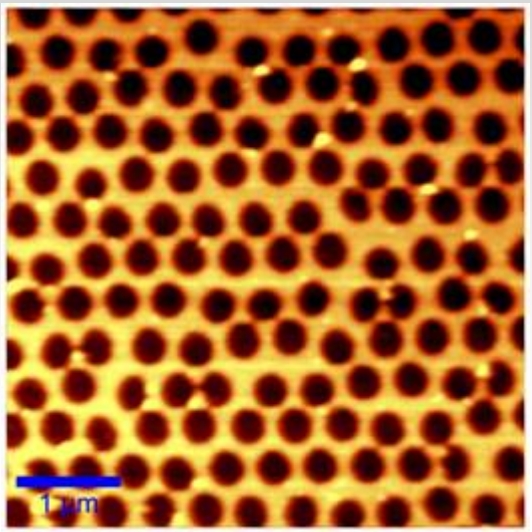


D = 180nm

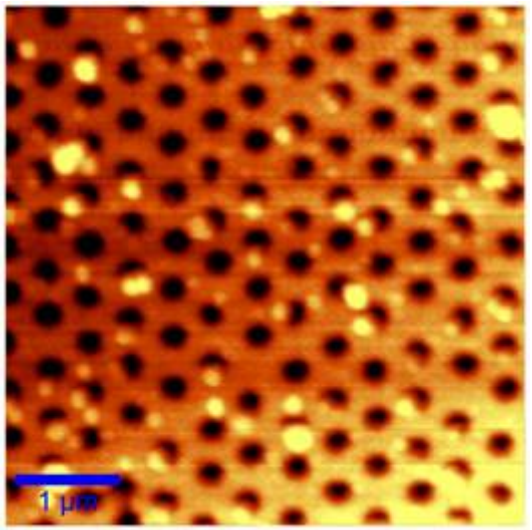
Fabricare

C. Depunere metal



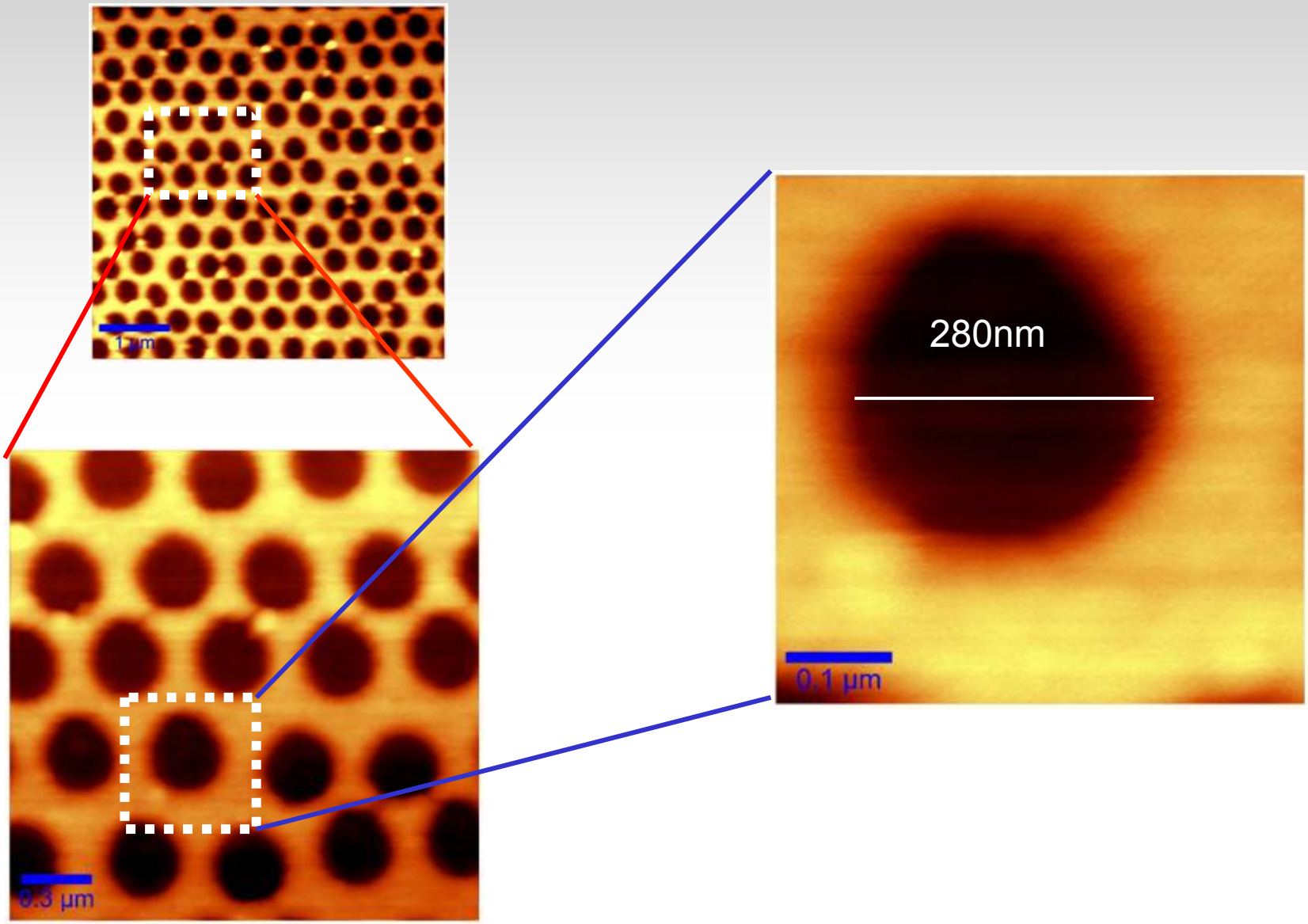


D = 280nm

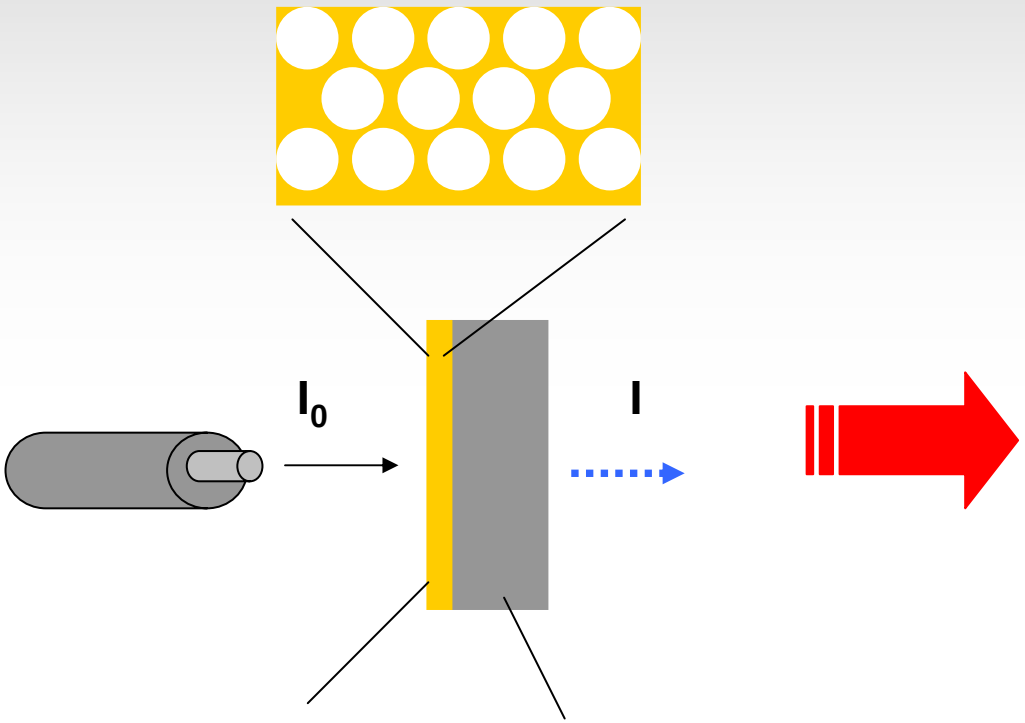


D = 180nm

Caracterizare AFM

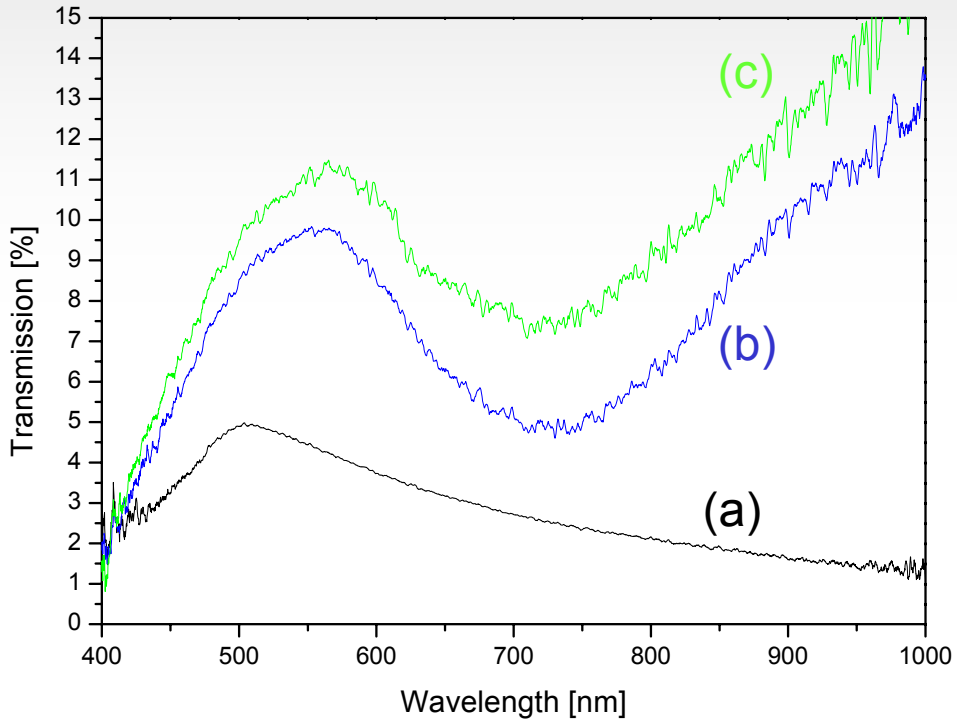


Caracterizare optica



Film de aur cu orificii

Substrat de sticla

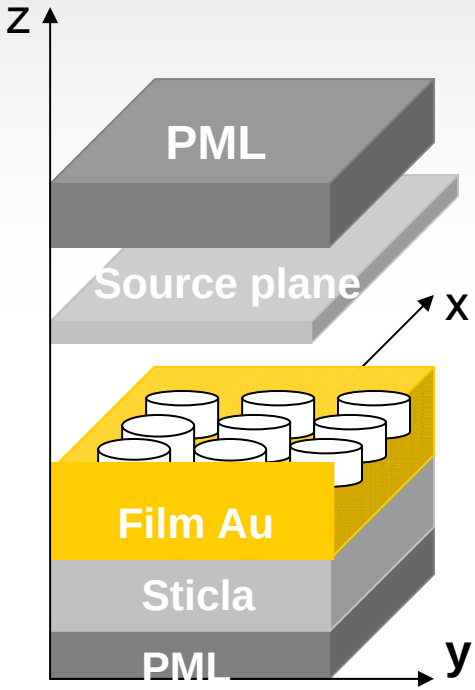


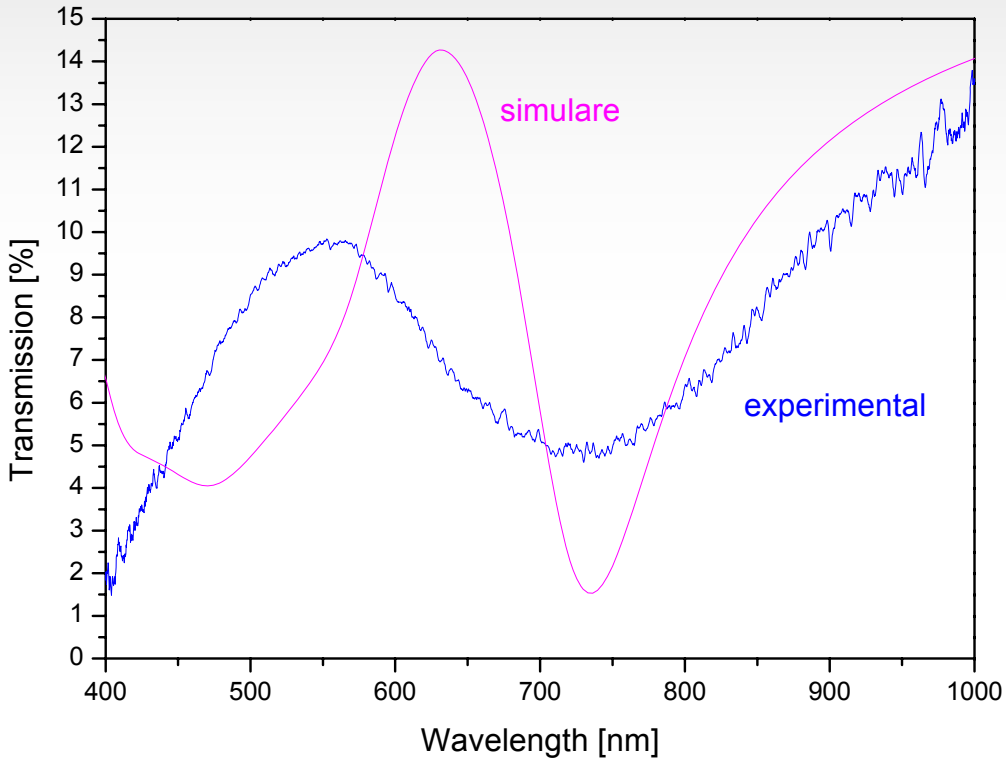
(a) Film de aur neted (grosime 40nm)

(b) Film aur cu orificii de d=180nm

(c) Film aur cu orificii de d=280nm

Simulari FDTD





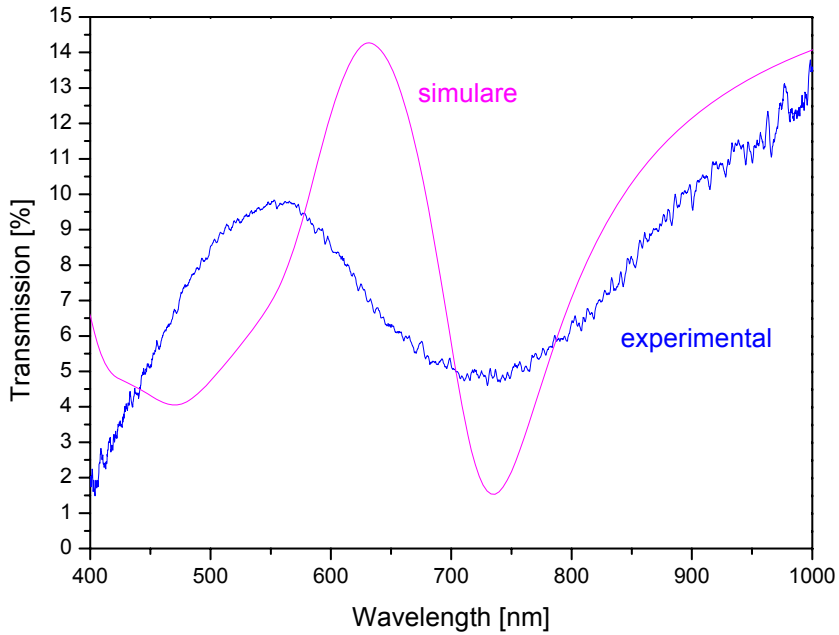
Mecanismele amplificarii

– prin intermediul plasmonilor de suprafata localizati in orificii

– prin intermediul plasmonilor propagativi de suprafata

– prin cuplajul plasmonilor de pe interfetele filmului metalic

$$\lambda_{\max}(i,j) = \frac{d}{\sqrt{i^2 + j^2}} \sqrt{\frac{\varepsilon_d \varepsilon_m}{\varepsilon_d + \varepsilon_m}}$$



Concluzii

– am fabricat retele ordonate de canale in filme metalice utilizand:

- asamblarea convectiva a nanosferelor de polistiren
- corodarea fizica indusa in fascicol de ioni de oxigen
- depunerea de filme metalice

– structurile fabricate manifesta o amplificarea de 3 ori a transmisiei comparativ cu filmul flat

Perspective

– aprofundarea studiului mecanismelor de amplificare a transmisiei prin modificarea grosimii filmului de metal, diametrului canalelor si a unghiului de incidenta a luminii

– utilizarea retelelor de orificii ca substrate multifunctionale in:

– senzori optici bio-chimici → SPR

– analiza spectroscopica ultrasensibila → SERS

Multumiri pentru suportul financiar acordat de ANCS in cadrul proiectului CEEX 71/2006 si CNCSIS PN II – TD 28/2007

VA MULTUMESC!