CLEO®/Pacific Rim 2007

SURFACE PLASMONS-BASED OPTICAL MANIPULATION

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Optical Tweezers Group

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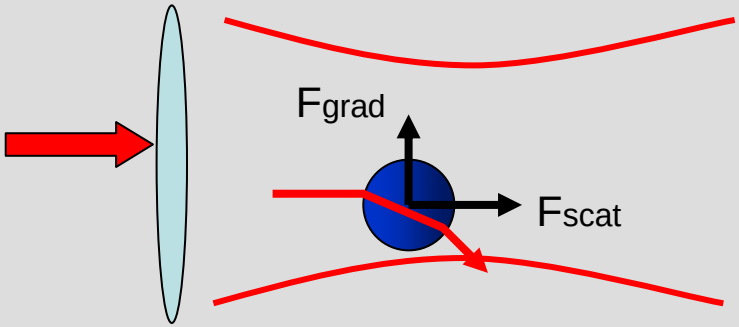
MOTIVATIONS for evanescent trapping

Conventional 3D optical trap



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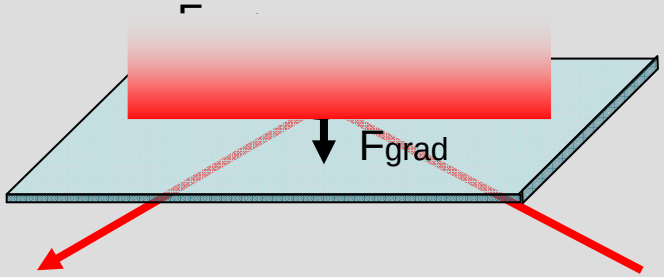
Evascent field



What motivates the use of evanescent waves in optical manipulation?

- *Manipulation with surface fields : towards integrated optically driven lab-on-a-chip devices*

- *Overcoming the diffraction limit to achieve nano-optical manipulation (d<<λ)*

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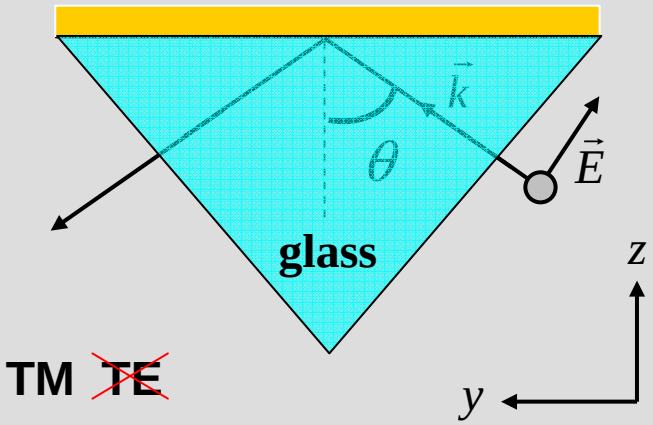
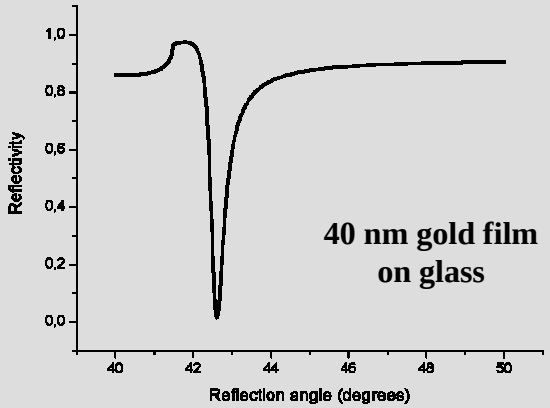
Surface Plasmon Polaritons (extended plasmons)

Coupling light to a surface plasmon mode

The "Kretschmann configuration":



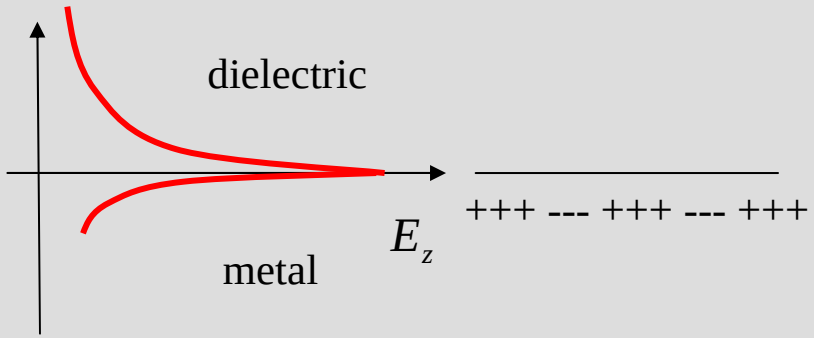
Reflectivity curve



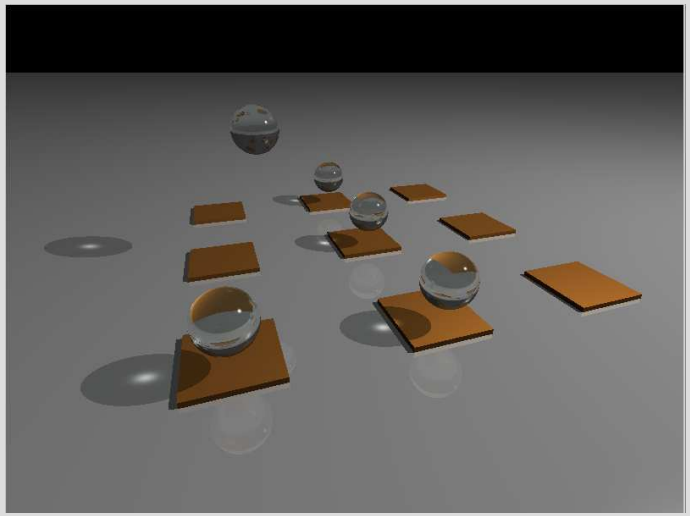
SP Field expression:

$$E^{(l)} = E^{(l)} e^{i(k_y y - \omega t) - k_z |z|}$$

Enhancement factor ~40 (Gold)



Why using surface plasmons?



☺ **Low-power:** expected intensity one order of magnitude weaker then conventional optical tweezers

☺ **Nano-scale:** enhanced spatial confinement of the evanescent field

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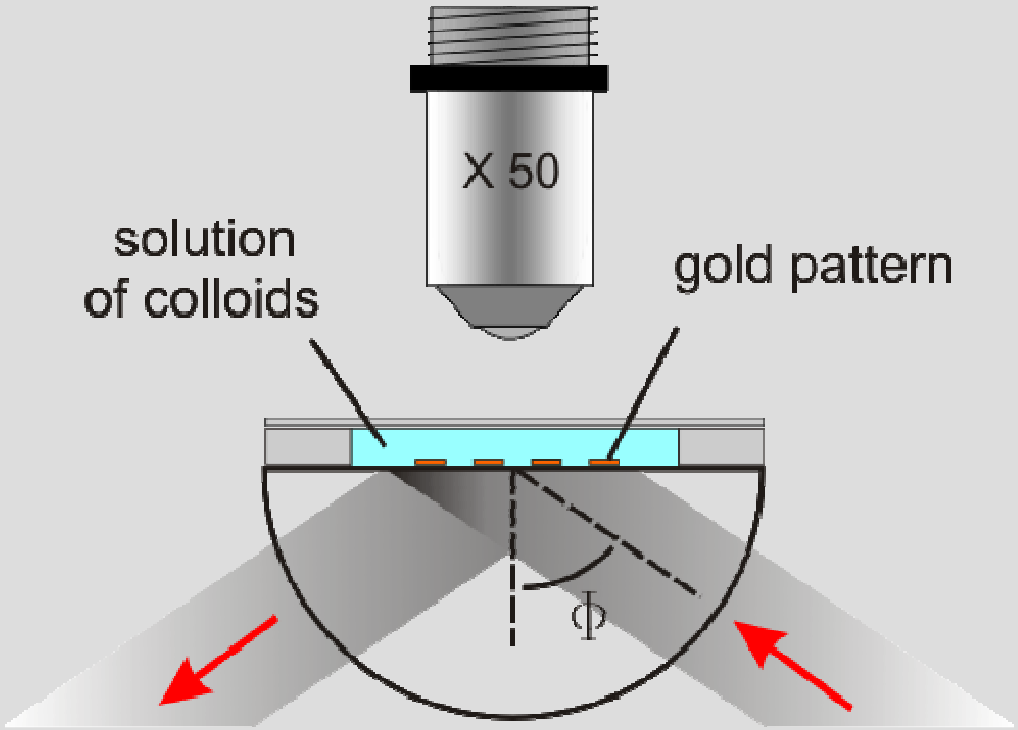
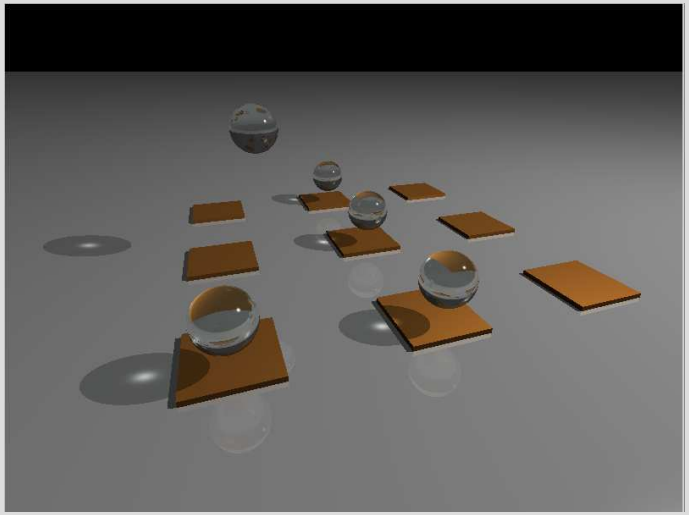
Trapping in a SP landscape

OPTICAL SET-UP





Illumination diameter~100 μm (unfocused)

λ=785 nm

p-polarization

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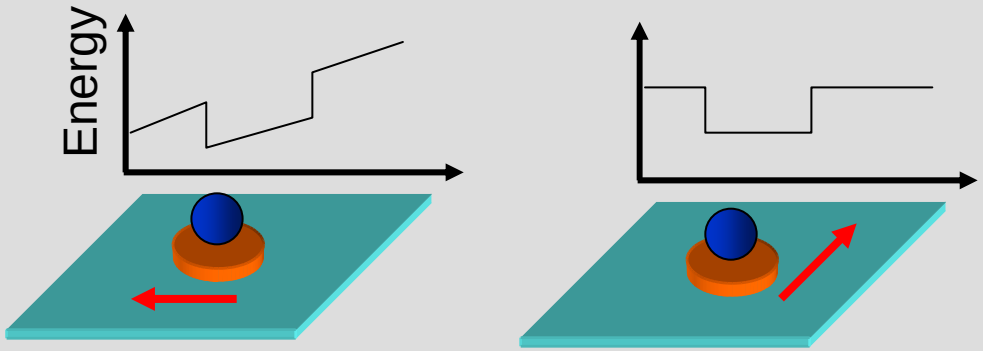
SINGLE GOLD PAD

4.8 μm PS bead



Trapping process

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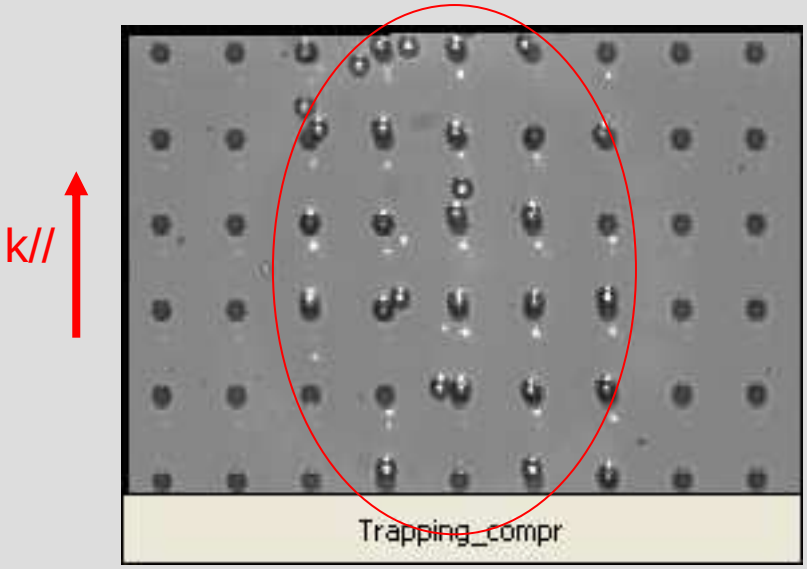
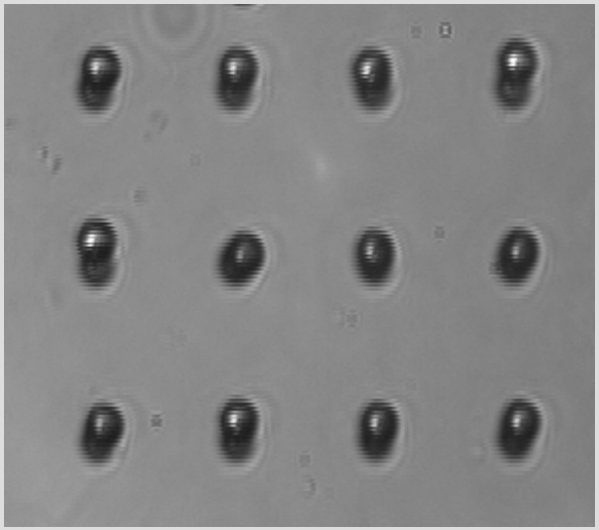
PARALLEL TRAPPING





I~5.10^{7} Watt/m^{2}<< 10^{9} Watt/m^{2} = I_{min} for conventional tweezers

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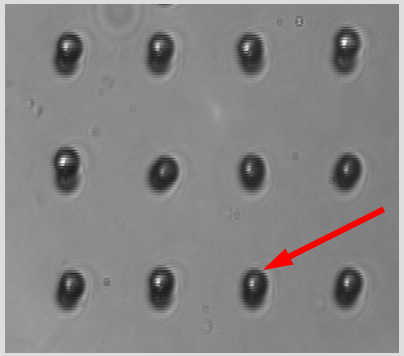
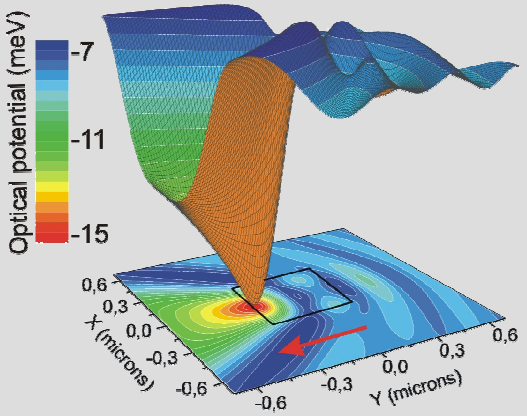
MODELING THE SP TRAP



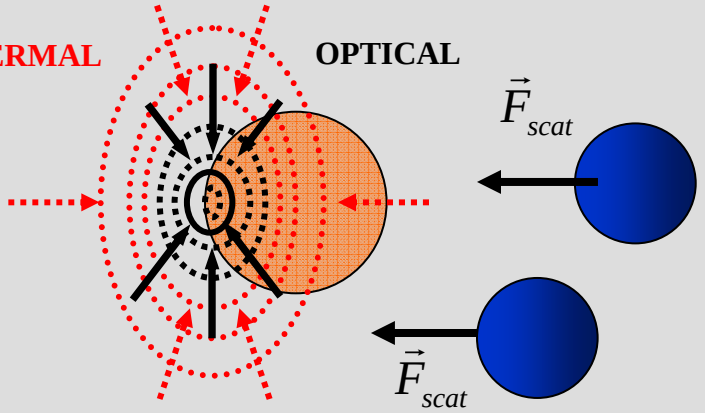
- Square gold pad ($0.45 \times 0.45\ \mu m^2$)
- 200 nm PS bead

OPTICAL POTENTIAL



Dissipated heat (per time unit)

$$Q = \frac{\omega_0}{8\pi} \int_v \varepsilon''(\omega_0) \left| E(\omega_0, \vec{r}) \right|^2 d\vec{r}$$



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CALCULATIONS BY CHRISTIAN GIRARD (CEMES-FRANCE)

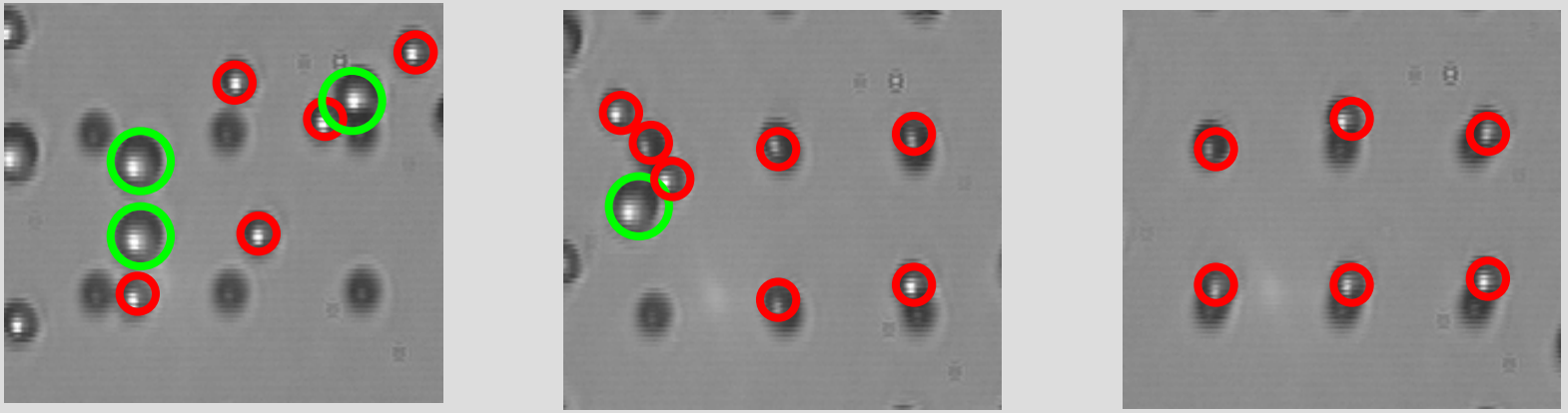
Trapping in a SP landscape

TRAPPING SELECTIVITY: TOWARDS A SPP SIEVE

SOLUTION: EQUAL PROPORTION OF TWO PS BEAD SIZES

4.8 μm (PS) 3.55 μm (PS)

7 min 14 min 21 min



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M. Righini, A. Zelenina, C. Girard and R. Quidant, Nature Physics 3, 477 - 480 (2007)

CONCLUSION & OUTLOOK

SUMMARY:

- Low power parallel trapping in an array of SPP-based traps, with only one non-focused beam
- SPP traps can be engineered to be selective to polarizability …
- Thermal effects may assist the trapping processes

FUTURE WORKS

- Extending SP-tweezers down to the nanometer scale
- Application to biological samples

Thanks for your attention!

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SONS: **S**elf-**O**rganized **N**ano**S**tructures