SURFACE PLASMONS-BASED OPTICAL MANIPULATION

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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** ($d<<\lambda$)
Surface Plasmon Polaritons (extended plasmons)

Coupling light to a surface plasmon mode

The “Kretschmann configuration”:

Reflectivity curve

40 nm gold film on glass

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 than conventional optical tweezers
- **Nano-scale:** enhanced spatial confinement of the evanescent field
Trapping in a SP landscape

OPTICAL SET-UP

Illumination diameter~100 µm (unfocused)

λ=785 nm

p-polarization
Trapping in a SP landscape

SINGLE GOLD PAD

4.8 µm PS bead

Trapping process

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Trapping in a SP landscape

PARALLEL TRAPPING

$I \approx 5 \times 10^7 \text{ Watt/m}^2 \ll 10^9 \text{ Watt/m}^2 = I_{\text{min}}$ for conventional tweezers
Trapping in a SP landscape

MODELING THE SP TRAP

- Square gold pad (0.45 × 0.45 µm²)
- 200 nm PS bead

Dissipated heat (per time unit)

\[ Q = \frac{\omega}{8\pi} \int \varepsilon''(\omega_0) |E(\omega_0, \vec{r})|^2 d\vec{r} \]

CALCULATIONS BY CHRISTIAN GIRARD (CEMES-FRANCE)
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

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!

EUROCORES Programme
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SONS: Self-Organized NanoStructures