Ultrafast laser inscribed near field lenses in Lithium Niobate crystals

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OUTLINE

1.- Motivation: Lithium Niobate

2.- Fundamentals of ultrafast laser ablation

3.- Optical properties of single nano-holes

4.- Optical properties of ordered arrays of nano-holes

5.- Conclusions

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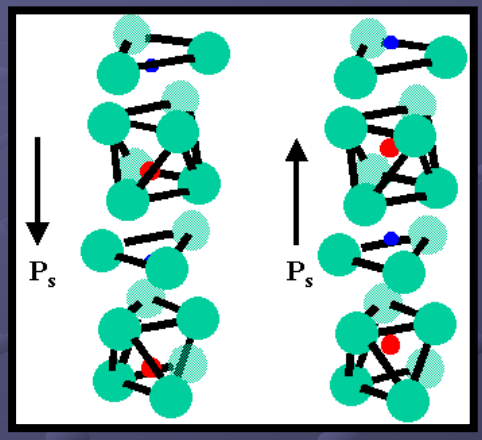
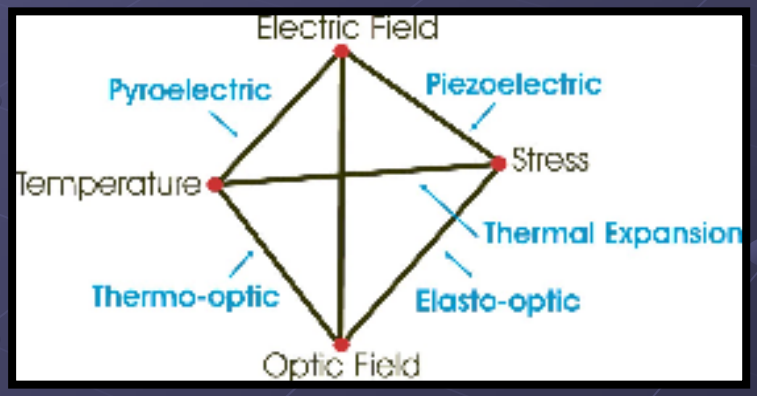
MOTIVATION:

Control and focusing light at surface of Lithium Niobate crystals





High refractive index, nonlinear properties, Electro-optical properties, piezo-optic properties, Ferroelectric, excellent laser host, …

MOTIVATION:

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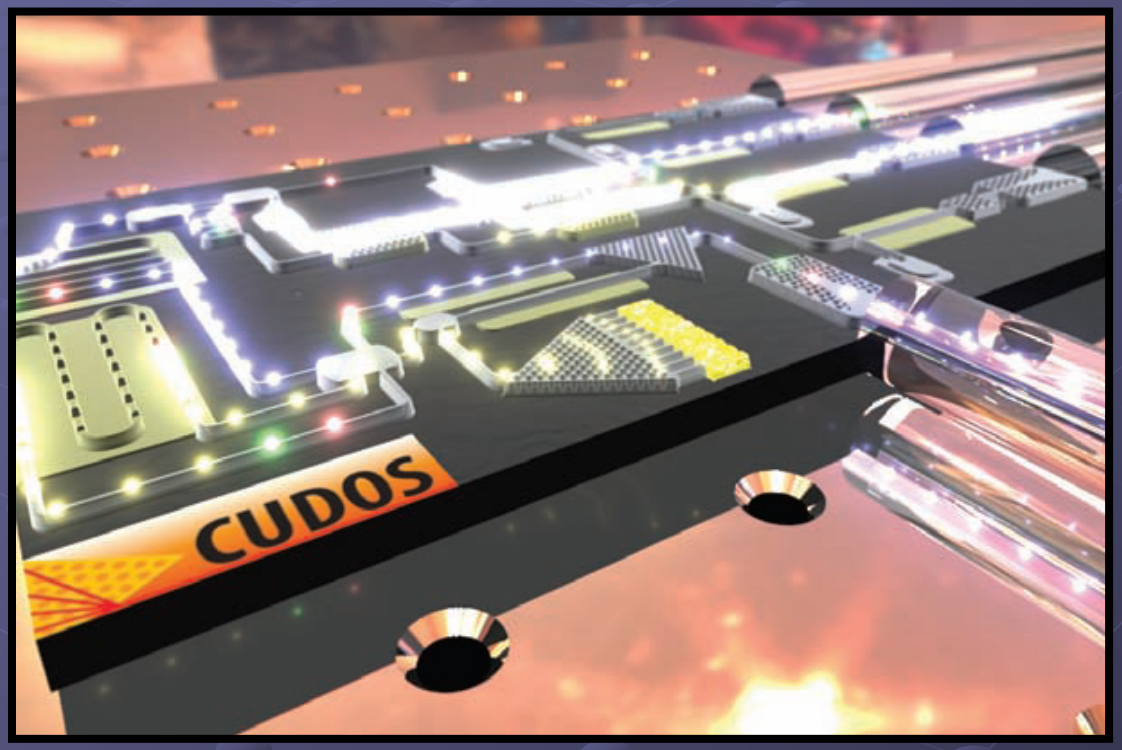
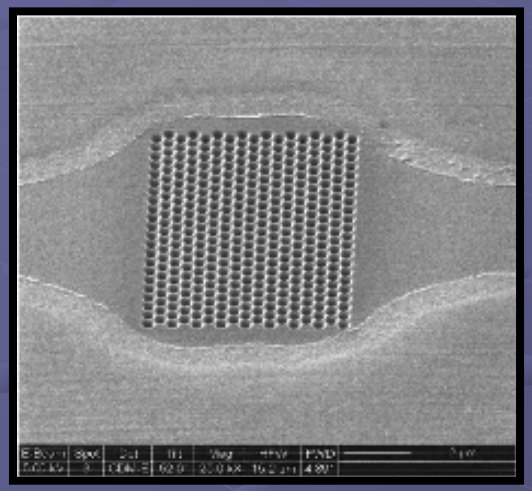


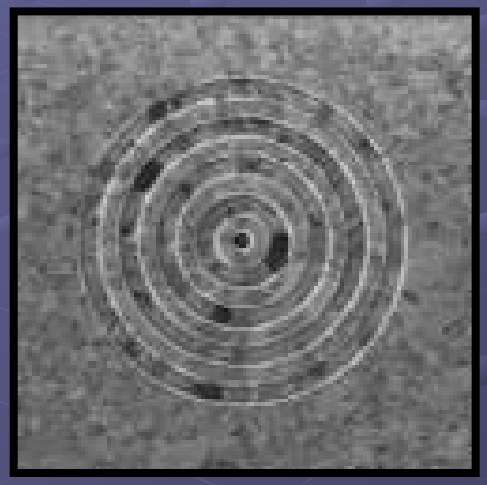
Lithium Niobate as the basis of future optical microchips

MOTIVATION:

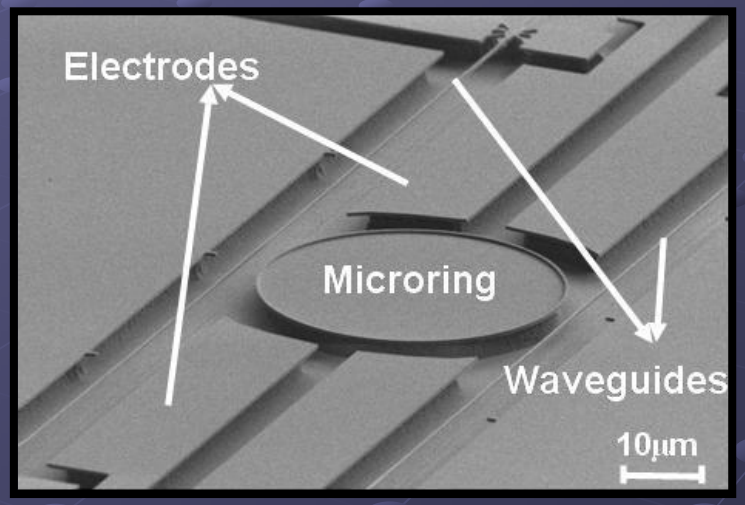
Micro-structuration techniques already demonstrated in LNB



Focused Ion Beam



Ferroelectric switching



Ion implantation
+
Selective etching

Difficult to get sub 100 nm structures

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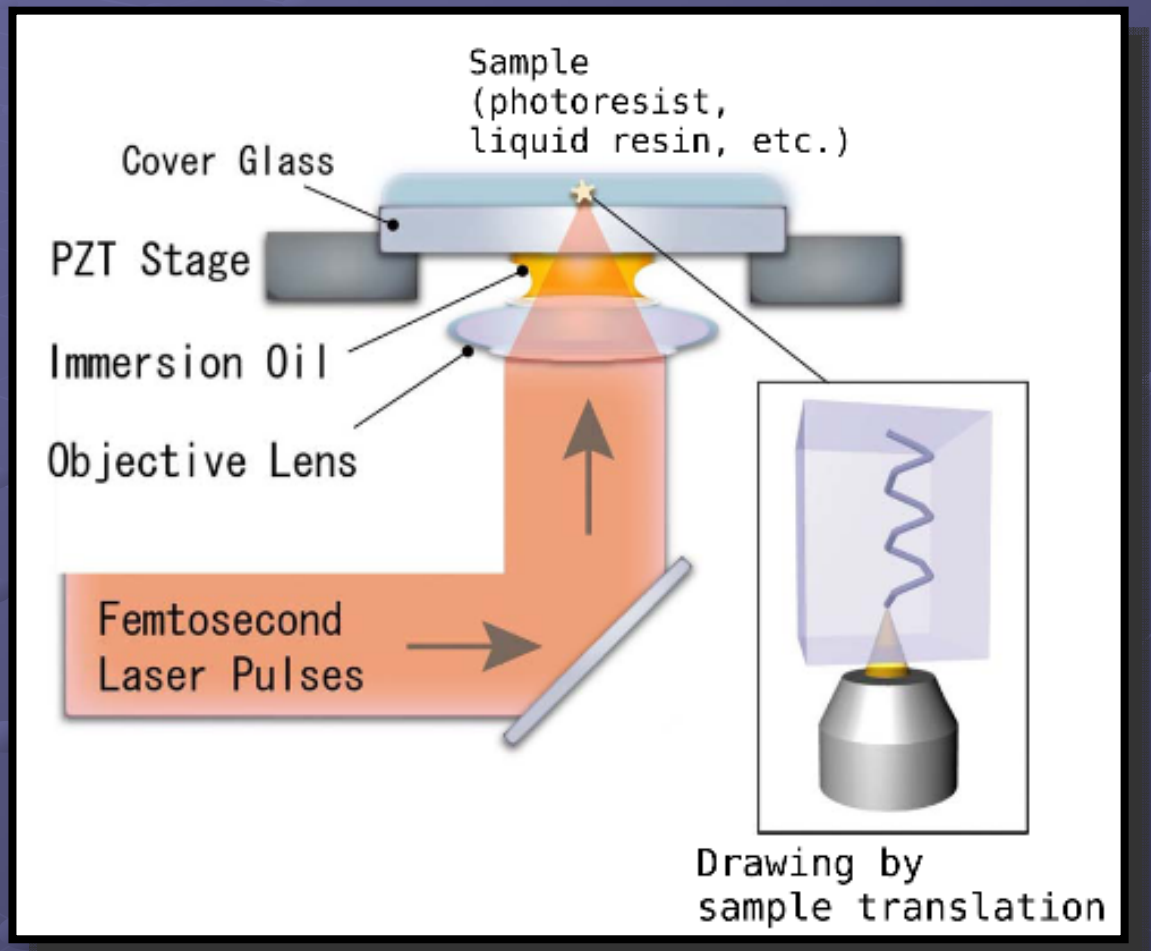
Fundamentals of ultrafast laser ablation



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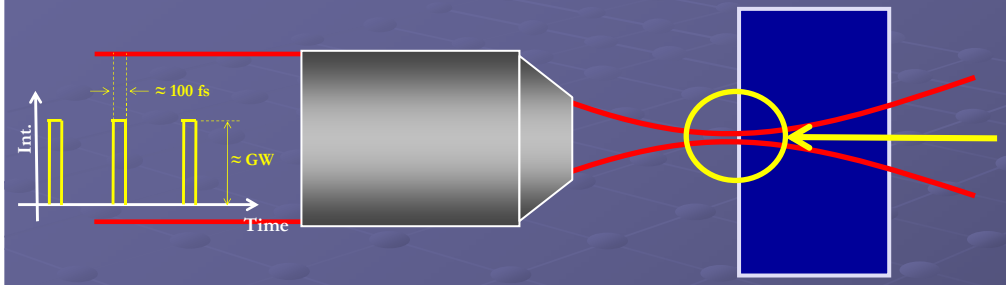
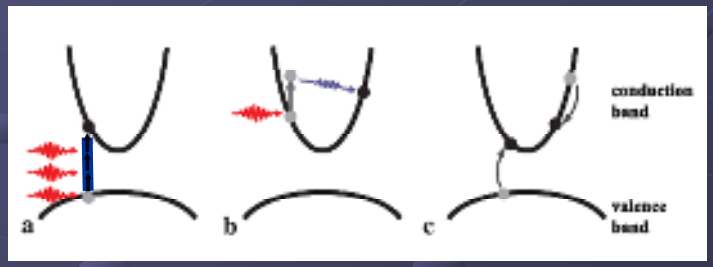


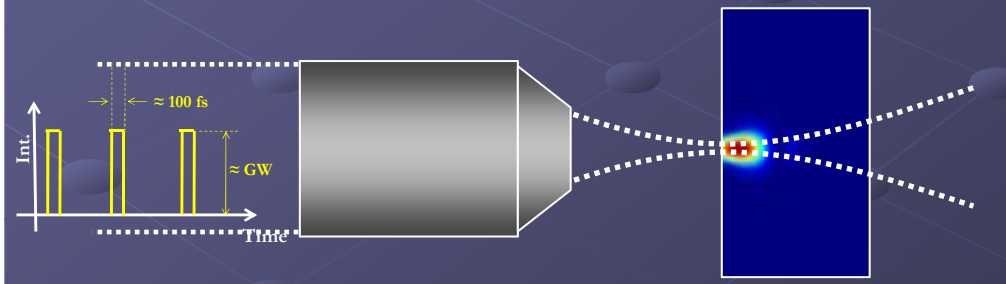
Lithium Niobate crystal
(Almost perfect Medium)

Very high photon densities (10^{17} W/cm^2)

NONLINEAR ABSORPTION/EXCITATION IS ACTIVATED



Multi-photon absorption + **Free carrier absorption** + **Impact ionization**



Very high free electron densities at focus

Fundamentals of ultrafast laser ablation:
The importance of pulse duration

ps pulses

Ablation + Melting

fs pulses

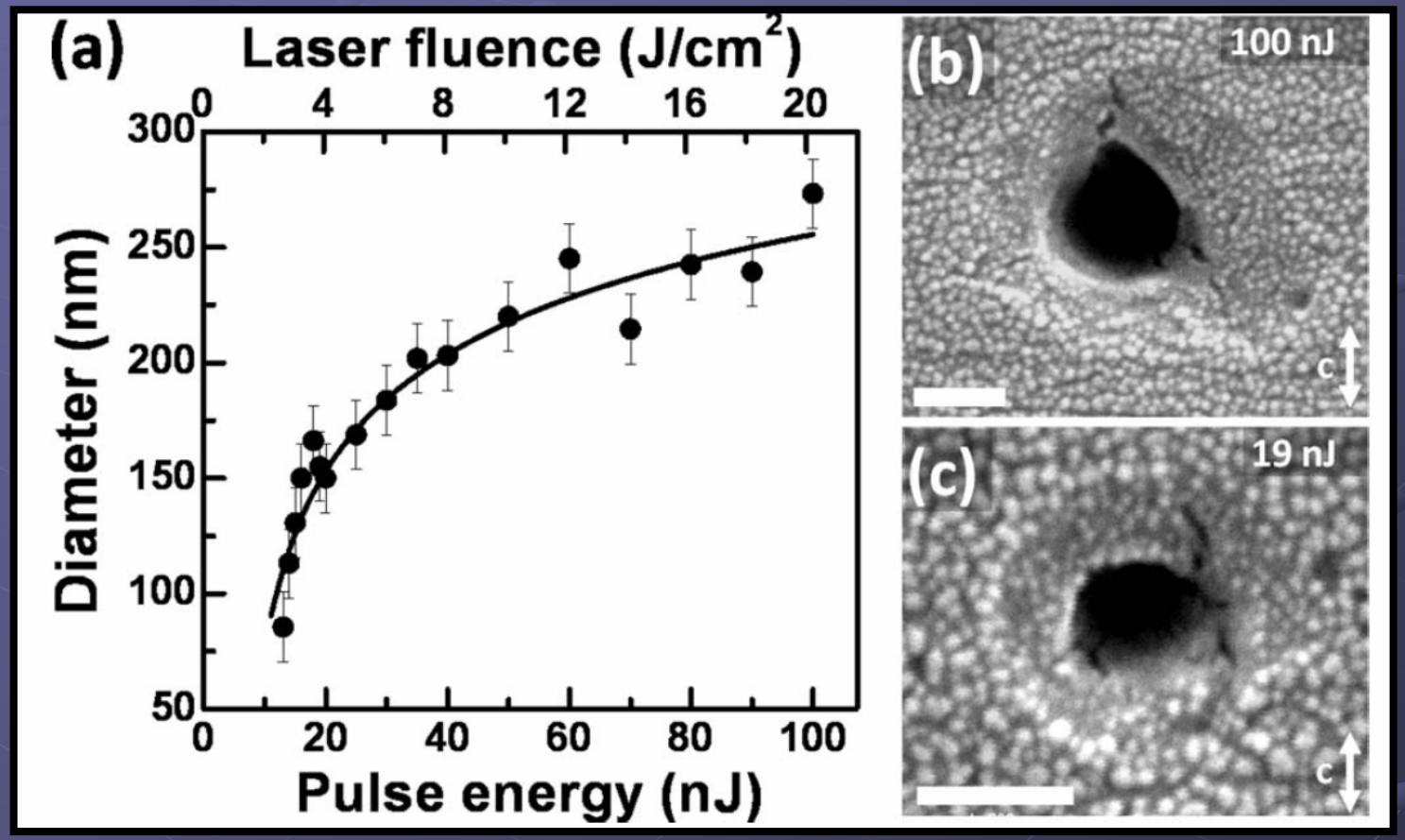
Ablation

$$\tau_{heating} \approx \tau_{pulse}$$

$$\tau_{elec-phonon} \approx 1\ ps$$

$$\tau_{relaxation} \approx 200\ ps$$

Fundamentals of ultrafast laser ablation:
Size control at the nanoscale



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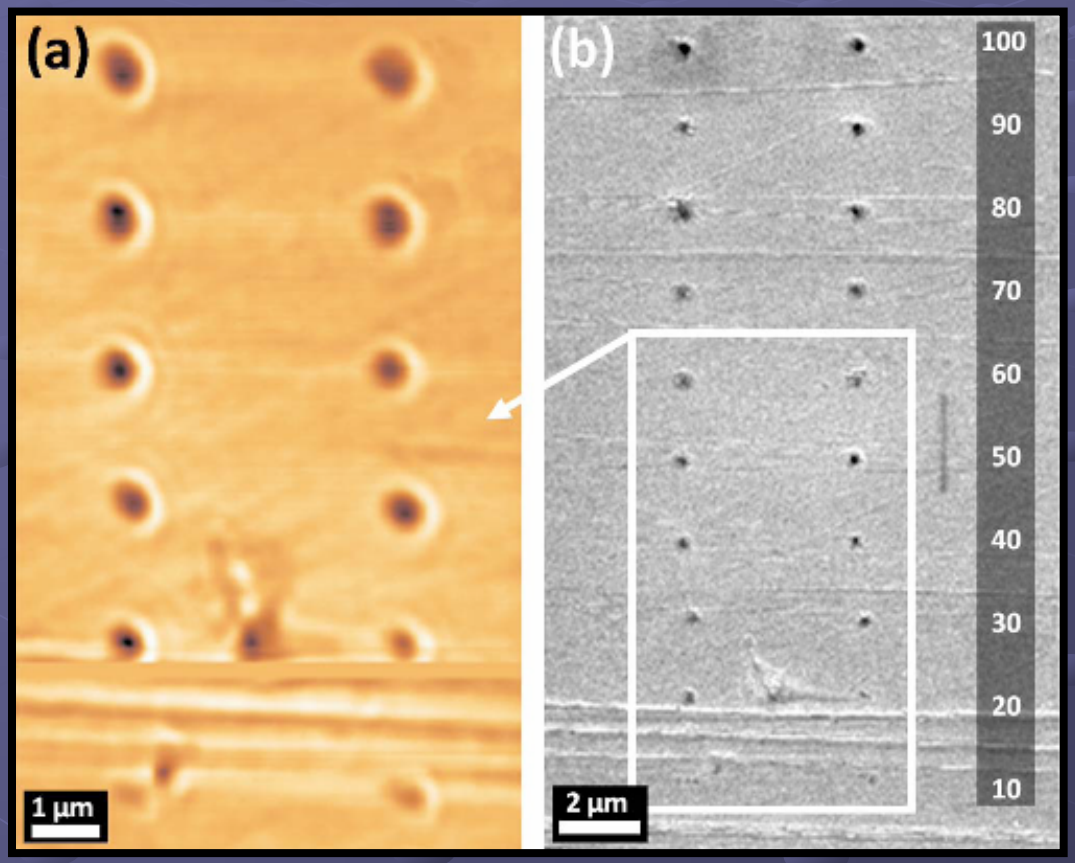
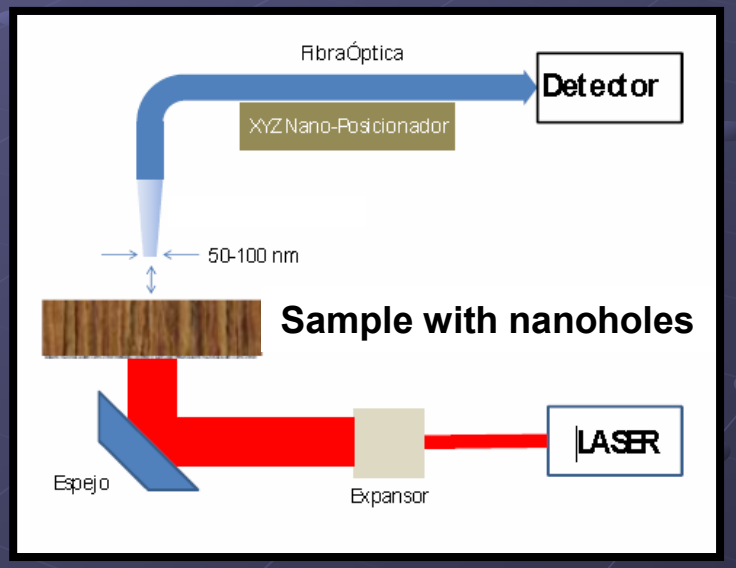
Near field transmission of single nano-holes

SNOM SEM





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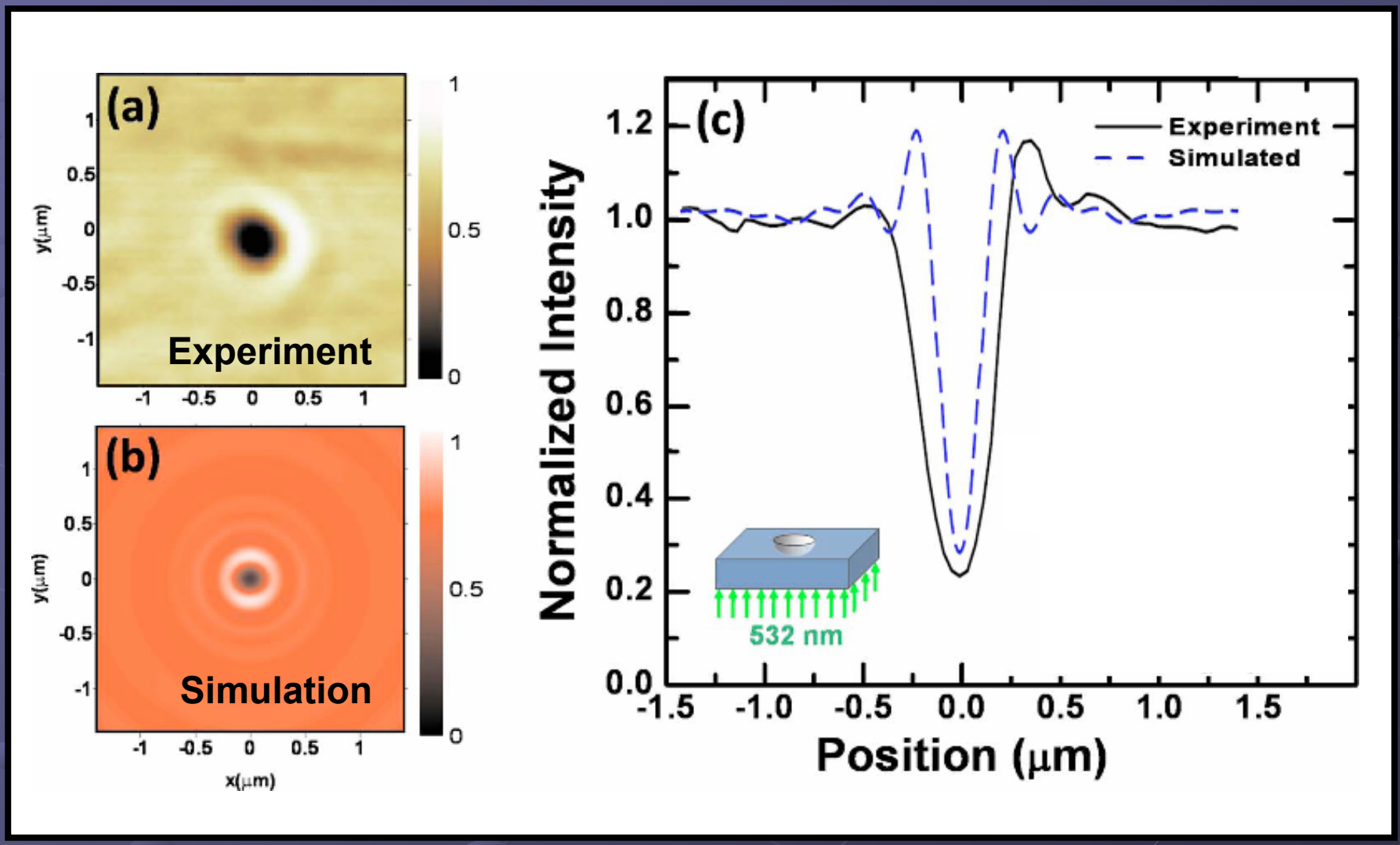

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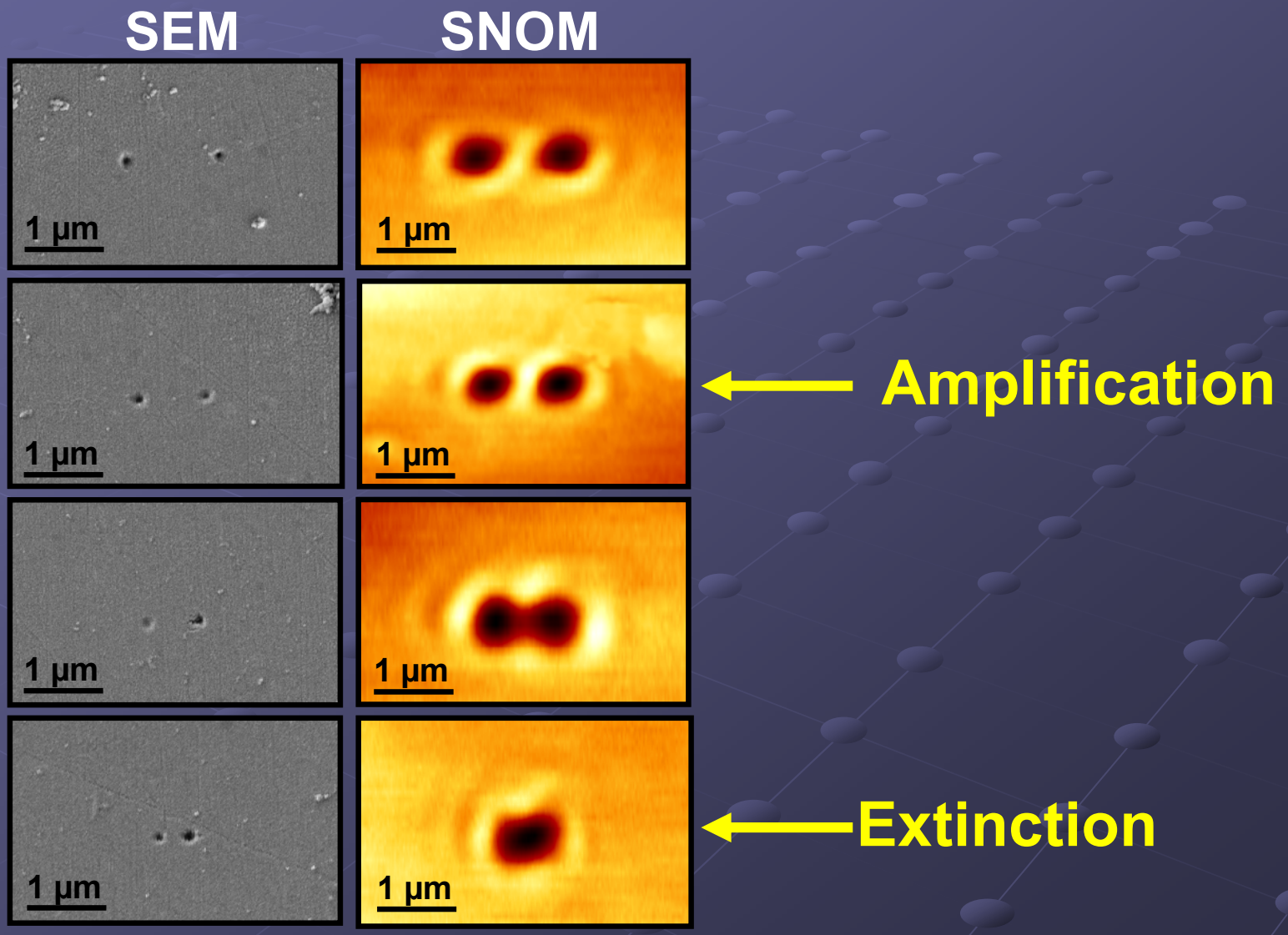
Near field transmission of a couple of nano-holes: *"cooperative scattering"*



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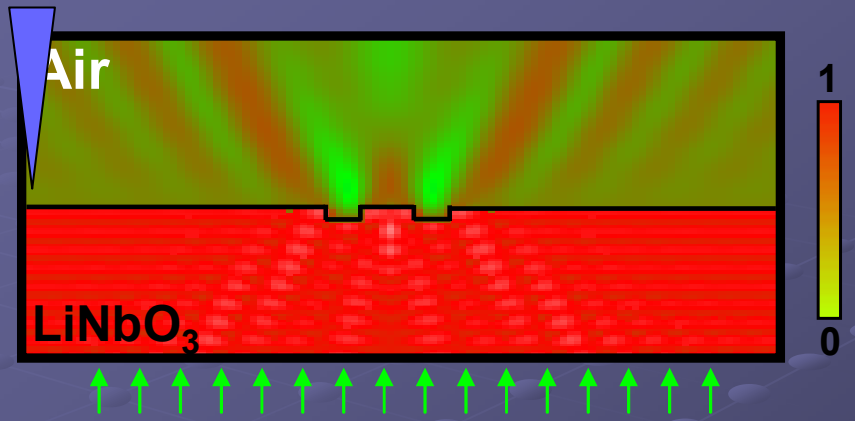

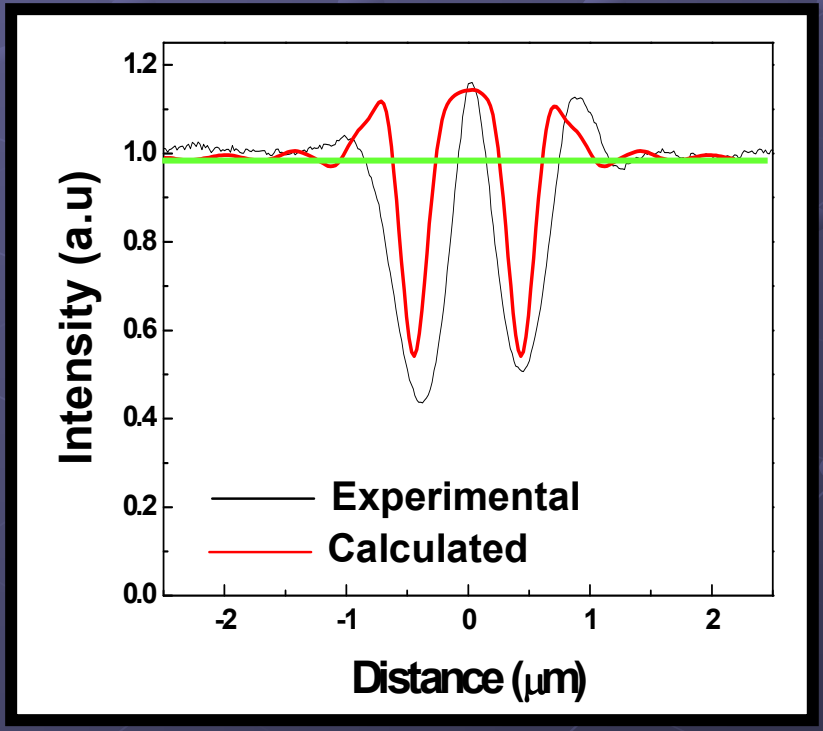

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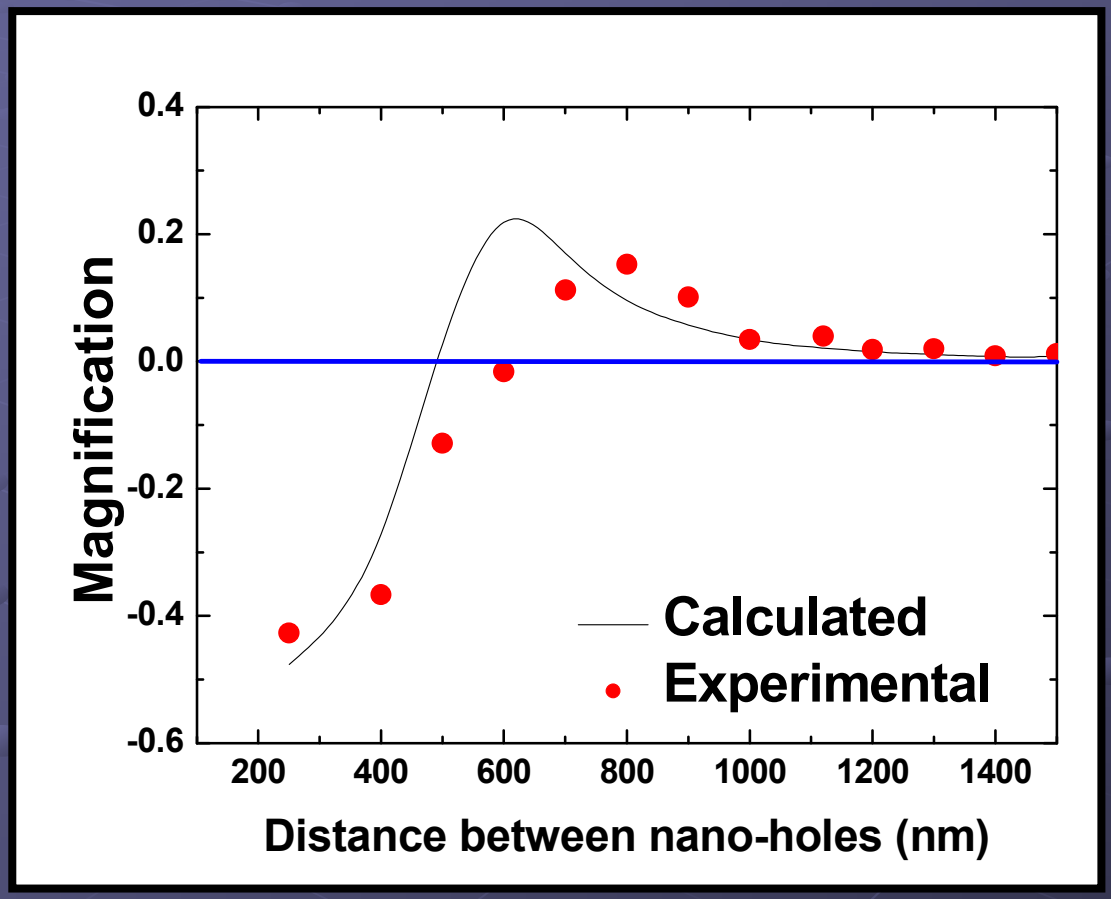

Near field transmission of a couple of nano-holes: *"Near field lenses"*