Electronic Supplementary Material (ESI) for Lab on a Chip

Supplementary material

All-optical microfluidic chips for reconfigurable dielectrophoretic trapping through SLM Light Induced Patterning

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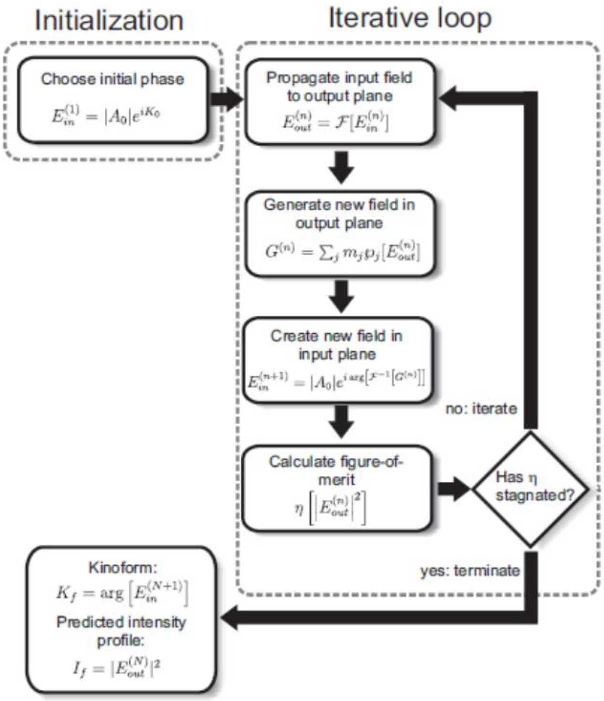
Theoretical formulation underlying the SLM-LIP

Light Induced Patterning (LIP), using Spatial Light Modulator (SLM), is realized thanks to the ability of SLM in shaping the intensity of the laser light reflected on its surface. The SLM is a reconfigurable diffractive optical element that is a matrix of 1920×1080 pixels of 256 grey levels, i.e. a phase hologram driven in real time by computer control. The phase hologram is named Computer Generated Hologram (CGH) or kinoform. The first step is the designing of the target, i.e. a matrix representing the desired ideal intensity distribution in the sample plane. The second step is the computation of the CGH that is realized by an Iterative Fourier Transform Algorithm (IFTA). The input of the IFTA is a random phase K_0 and the matrix I_o representing the ideal intensity light profile (target). A flow chart describing the IFTA is showed in Fig.1 [1]. Once the kinoform has been calculated it's send to the SLM to be displayed. The SLM is inserted in the setup in Fourier configuration (see Fig.1(b) in the paper) so the estimated intensity light pattern I_f in the sample plane is:

$$I_f = \left|fft2\{e^{iK_f}\}\right|^2 \qquad (1S)$$

where *fft2* is the 2D Fast Fourier Transform and K_f is the calculated kinoform. The light intensity pattern of Eq.(1S) activates the photorefractive (PR) effect in the Lithium Niobate crystal.



$$G^{(n)} = \sqrt{I_0}\, e^{i\arg\left[E_{out}^{(n)}\right]}$$

Fig.1: IFTA for the computing of the CGH [1].

The PR effect consist of three steps: Inhomogeneous illumination excite charge carriers, and spatially modulated currents appear. A charge density pattern builds-up and space charge fields arise. These fields modulate the refractive index via the electro-optic (EO effect). PR effect is a phenomenon typical of the EO photoconductive materials. The theoretical description of the effect is based on a kinetic model that leads to a set of nonlinear rate equations that are solved under a linear approximation [2,3].

When a sinusoidal light pattern along the z-axis is considered

$$\vec{I} = \vec{I}_0(1 + me^{i\vec{K}z}) \tag{2S}$$

where m and $\vec{I}_0$ are the modulation degree of the light pattern and its averaged value, respectively, K is the spatial frequency along the grating vector $\vec{K}$ aligned parallel to the optical axis of the crystal, the modulated space charge field for a PR and photovoltaic material (as the case of LN) and in absence of external applied field is $E^{(1)}$:

$$E^{(1)} = -m\frac{E_{PV}}{1 + \frac{irE_{PV}}{E_q}} \tag{3S}$$

where Eq is the saturation field that represent the maximum field that can be obtained and E_{PV} is the electric field due to the photovoltaic current. A schematic picture of the physical mechanism that undergoes the PR effect is depicted in Fig.2. The electric field of Eq. (3S) is responsible of DEP forces able to pattern liquid and solid matter on the crystal surface (see Eq.(1) in the paper).

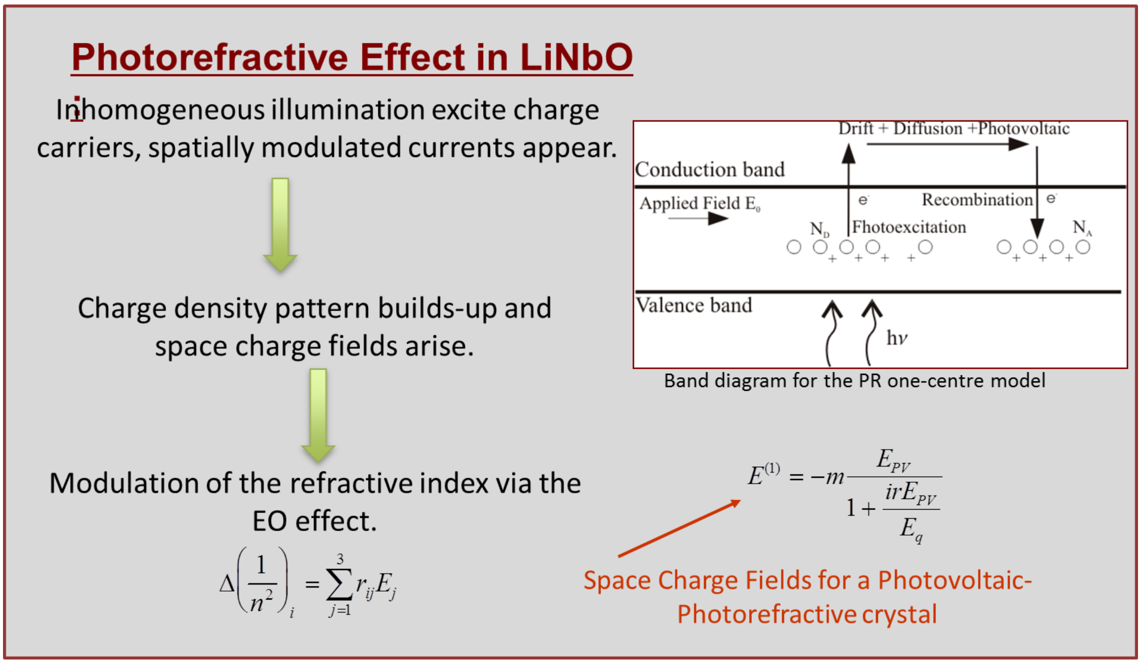


Fig.2 Schematic drawing explaining the PR effect in LN.

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