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(71) Applicant *(for all designated States except US)*: **FACULDADES CATÓLICAS (PUC-Rio)** [BR/BR]; Rua Marquês de São Vicente, 225, Gávea, CEP: 22451-900 Rio de Janeiro (BR).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **CARVALHO, Isabel, C.S.** [BR/BR]; Rua Marquês de São Vicente, 225, Gávea, CEP: 22451-900 Rio de Janeiro (BR). **FOKINE, Michael** [SE/SE]; Sjönas Bonderiyd, S-SE599 92 Ödeshog (SE). **MONTEIRO DE BARROS CORDEIRO, Cristiano** [BR/BR]; Rua Jasmim, n° 180/102, Chácara Primavera Campinas, SP (BR).

(74) Agent: ATEM & REMER ASSESSORIA E CONSULTORIA DE PROPRIEDADE INTELECTUAL LTDA.; Praça Floriano, 19/28° Andar, CEP:20031-050 Cinelândia, Rio de Janeiro - RJ (BR).

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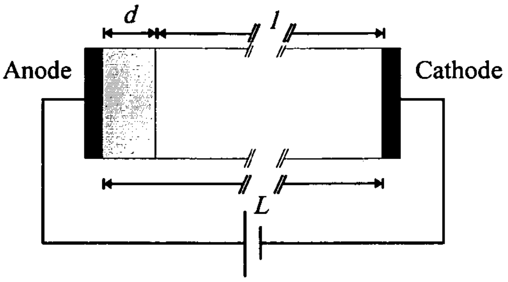
(54) Title: OPTOELECTRONIC DEVICE AND PROCESS FOR ITS PRODUCTION

Figure 1



(57) Abstract: The present invention provides optoelectronic devices and processes for obtaining same. In the process of the invention, glass is submitted to processes in which the current dynamics during thermal poling shapes the formation dynamics of charges and/or of the ion-deficient region (depletion region) in said glass. Consequently, the devices containing glass modified by the process of the invention may serve, among other applications, as ionic RC circuits.

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Specification of Patent of Invention

Optoelectronic Device and Process for its Production

Field of the Invention

The present invention is related to optoelectronic devices and to processes for its production. More specifically, it refers to modified glass devices and to thermal poling processes for obtaining same. In the process of the invention, glass is submitted to processes in which the electric current dynamics during the thermal poling shape the formation dynamics of mobile charges and/or of the ion-deficient region (depleted region) in said glass. In the process of the invention, said formation dynamics are closely related to second order induced optical non-linearity and, consequently, the glass modified by the process of the invention can be understood to be ionic RC circuits.

Background of the Invention

Glass is a center-symmetrical material having macroscopic inversion symmetry, and as such has no second order non-linearity (SON) or other even-order non-linearities. However, it is possible to break the inversion symmetry by special processes usually called poling. An efficient optical poling process on optical fibers was originally described by Osterberg & Margulis, followed by the description of thermal poling by Myers et. al., and subsequently by irradiation poling using ultra-violet (UV) laser or femto-seconds (fs), or else by special thermal treatment. Thermal poling is a means of inducing second order non-linearities in different types of glass that typically have macroscopic inversion symmetry. Thermal poling generally consists of applying high voltage through a glass sample, under high temperature for a given time, after which the temperature is reduced while maintaining the voltage through the sample. Most glass, such as silica, is an excellent insulator and does not conduct electrons. Yet, in the high temperatures used for thermal poling, typically between 200-300°C, ionic types of sodium or alkaline metals presents as impurities or dopants, show increased mobility. Applying voltage under high temperature results in the displacement of said positive ions, leaving in their wake a region of negative charges near the anode. The negative charges are typically non-bridging oxygen, i.e., charged oxygen bridged to a silicon unit (Si-O^-). When the temperature is reduced, the ionic mobility and the ion-deficient region is effectively "frozen", inhibiting the recombination of positive ions and negative charges. This ion-deficient region is generally referred to as the "depletion region". Although the interaction mechanisms for the different types of glass are not fully understood, the generally accepted theory is that the SON is located in the depletion region and is proportional to a "frozen" electric field (E_{dc}) and the intrinsic third order non-linearity. The result is an effective SON given by equation 1:

$$\chi_{eff}^{(2)} = 3\chi^{(3)} \cdot E_{dc} \qquad \text{Eq. (1)}$$

Patent literature comprises some documents related to the objects of the present invention.

International patent application WO 9410601, filed by the University of Southampton and entitled "Electro-Optic Modulators and Optical Frequency Convertors in Glass Waveguides", was published on May 11, 1994. Said document discloses a method for creating second order non-linearities in glass by exposing glass to an electron or ion beam.

International patent application WO 9529425, filed by the University of Southampton and entitled "A Method for Forming Electrets In Optical Fibers", was published on November 2, 1995. Said document discloses a method of forming electrets in optical fibers, comprising thermal poling of the optical fibers in the absence of air.

North American patent US 6,801,356, filed by the University of Southampton and entitled "Optical parametric devices and methods for making same", was published on October 5, 2004. Said document describes a device based on a parametric process involving first and second frequencies ω_1 and ω_2 that are different to each other. Said device comprises:

- an optical fiber comprising a core and a cladding, the optical fiber being poled lengthwise with a non-linearity profile having a period that satisfies a quasi phase matching (QPM) condition including the first and second frequencies;
- in which the optical fiber cladding comprises a micro-structure of holes to provide waveguiding confinement of at least one optical mode in the core.

North American patent US 6,831,776, filed by the University of Southampton and entitled “Periodic thermal poling of waveguides for quasi phase matching”, was published on December 14, 2004. Said document discloses a method of creating a varying second order non-linearity profile along a waveguide. Said method comprises:

- providing a waveguide structure with a waveguiding core and a surface adjacent to the waveguiding core;
- structuring the surface to produce a structured surface defining a varying distance between the structure surface defining a varying distance between the structure surface and the waveguiding core along the waveguide; and
- thermally poling the waveguide structure to generate a varying second order non-linearity profile along the waveguide derived from the varying distance between the structure surface and the waveguiding core.

North American patent US 6,839,495 of the University of Sydney and entitled “Poled waveguide structure with stabilized internal electric field”, was published on January 4, 2005. Said document discloses a waveguide structure prepared for submission to poling, comprising:

- a portion of the structure being received or acting like an electrode; and
- a region of the structure comprising a material capable of maintaining the charge , wherein said material is disposed near or adjacent to said portion, to inhibit the decay of the space charge between the positively charged region and the negatively charged region induced by poling, thus establishing the internal electric field.

North American patent US 6,684,013 of NEC Co. and entitled “Optical waveguide device to be optically poled, method of manufacturing optical waveguide device to be optically poled, and method of optically poling optical waveguide device", was published on January 27, 2004. Said document discloses an optical waveguide comprising:

- a waveguide whose refraction index changes can be controlled by an electro-optical effect; and
- a waveguide for coupling or applying an ultraviolet radiation to the waveguide directly to a pre-set area of said waveguide, wherein said pre-set area is not an entry door of said waveguide.

Scientific literature also comprises references circumscribing the invention, but without predating or suggesting it. Some such references are listed below.

U. Osterberg and W. Margulis, "Dye laser pumped by Nd:YAG laser pulses frequency doubled in a glass optical fiber" Opt. Lett. **11**, 516-518 (1986).

R. A. Myers, N. Mukherjee, S. R. J. Brueck, "Large second-order nonlinearity in poled fused silica" Opt. Lett. **16**, 1732-1734 (1991).

T. Fujiwara, D. Wong, Y. Zhao, S. Fleming, S. Poole, and M. Sceats, *"Electro-optic modulation in agermanosilicate fibre with UV-excited poling,"* Electron. Lett. **31**, 573-575 (1995).

C. Corbari, J. D. Mills, O. Deparis, B. G. Klappauf, P. G. Kazansky "Thermal poling of glass modified by femtosecond laser irradiation" Appl. Phys. Lett., **81**, 1585-1587 (2002).

M. Fokine, K. Saito, A. J. Ikushima *"Thermally induced second-order nonlinearity in silica-based glasses"* Appl. Phys. Lett. **87**, 171907 (2005).

Y. Quiquempois, P. Niay, M. Douay, and B. Poumellec, *"Advances in poling and permanently induced phenomena in silica-based glasses"* Current Opinion in Solid State & Materials Science, **7**, 89-95 (2003).

N. Mukherjee, R. A. Myers, S. R. J. Brueck, *"Dynamics of second-harmonic generation in fused silica"* J. Opt. Soc. Am. B **11**, 665- (1994).

P.G. Kazansky, P.St.J. Russell, "Thermally poled glass: frozen-in electric field or oriented dipoles?" Optics Comm., **110**, 611-614 (1994).

A. Kudlinski, G. Martinelli, Y. Quiquempois, *"Time evolution of second-order nonlinear profiles induced within thermally poled silica samples"* Opt. Lett., **9**, 1039-1041 (2005).

A. Von Hippel, E. P. Gross, J. G. Jelatis, and M. Geller, *"Photocurrent, space-charge buildup and field emission in alkali crystals"* Phys. Rev., **91**, 568-579 (1953).

D. Schults, *"Transient Response of Variable Capacitor Diodes"* IRE Trans. Comp. Part., **7**, 49- 53 (1960).

H. C. Lin, *"Step Response of Junction Capacitors"* IRE Trans. Circuit Theory, **9**, 106- 109 (1962).

Paul M. Sutton, *"Space charge and Electrode Polarization in Glass: I"* J. Am. Ceram. Soc., **47**, 188-194 (1964).

R. Ongaro, "Contribution to current transient analysis including space-charge build-up and dipolar relaxation" Science, Measurement and Technology, IEE Proceedings, **137**, 97-110 (1990).

Y. Quiquempois, N. Godbout, S. Lacroix, *"Thermal poling of thin silica glass films: Design rules for optical fibers and waveguides"* Phys. Rev. A, 71, 063809 (2005).

The present invention was developed from experiments performed on borosilicate glass and demonstrated the formation of color on glass submitted to thermal poling using Teflon near the anode. Initially, it was thought that this was due to the incorporation of carbon after the ionization of Teflon. However, further research demonstrated that in fact the consequences of poling were other, providing new and thus far undisclosed applications of the present invention. In the process of the present invention, descriptions are provided of processes of thermal poling and formation of space charge, as an ionic RC circuit having non-linear capacitance. The process of the invention provides the production and use of electro-optical or optoelectronic devices based on thermal poling and the formation of space charge.

Summary of the Invention

It is one of the objects of the present invention to provide an optoelectronic device in which at least part of the structure comprises a material having low ionic mobility under processing conditions, acting as an electric or ionic capacitor.

In a preferred aspect, the present invention provides an optoelectronic device in which at least part of its structure comprises glass, said glass containing mobile ionic charges.

In another aspect, thus being another object of the present invention, the device of the invention has ionic resistor property.

In another aspect, thus being yet another object of the present invention, the device of the invention has ionic conductor property.

In another aspect, thus being yet another object of the present invention, the device of the invention has non-linear electronic or ionic capacitor property.

In another aspect, thus being yet another object of the present invention, the device of the invention additionally comprises a means of guiding light through the same.

It is also another object of the present invention to provide a process to improve the non-linear properties of an optical device. In a preferred aspect, said process consists of the thermal poling of optical devices by applying an electric field through said devices, in which at least part thereof comprises a material containing ionic charges that can become mobile. In an even more preferred aspect, the conditions that provide the mobility of the ionic charges are selected from among thermal and/or electromagnetic radiation.

It is also another object of the present invention to provide a process of obtaining optoelectronic devices.

In one aspect, thus being another object of the present invention, the process of the invention comprises the steps of:

- submitting at least a glass material to the application of voltage through said glass; and

- during the application of said voltage, maintain the temperature high, followed by a substantial reduction in temperature, so as to reduce the mobility of the ionic charges of said glass while the voltage is kept in the glass sample.

These and other objects of the invention shall be better understood and appreciated by reading the detailed description of the invention and the appended claims.

Brief Description of the Drawings

Figure 1 presents a schematic representation of the glass during the thermal poling process, showing: the electrodes (dark area), the depleted region of mobile charges (*depleted region*) having thickness d (cross-hatched area below "d"), and the core of the glass sample. L is the total length of the glass sample.

Figure 2 presents equivalent electric circuits (a) as soon as the depleted region reached stability and (b) equivalent electric circuit to shape the formation dynamics of the depletion layer.

Figure 3 presents a schematic representation of the thermal poling of a light guiding region showing: in a) the dummy capacitor DC, the central region CR, the substrate S and the electrode E; while b) shows a central region CR that should preferably be doped with a maximum concentration of impurities to a depletion layer size of the CR diameter.

Figure 4 is a schematic representation of the thermal poling of a light guiding region, showing: the EA electrode anode, the DC dummy capacitor (low conductivity material), the RD depletion region (non-linear capacitor), the RC central region (bulk material which is an ionic conductor), and the EC electrode cathode. Compare with Figure 3 a: here the depleted region will be formed by the light guiding region, i.e, the waveguiding structure should be placed where the depleted region will be formed.

Figure 5 shows a graph with lin-log/log-log scale plotting of the decay times measured in the experiments performed. a) shows the decay times of the silica material with 7.4 μm of Kapton (1kV/1mm); c) shows the decay times of the silica material without dummy capacitor (1kV/1mm) (the data of a) and c) are plotted in the right-hand ordinate, which shows the current in nA); and b) shows the decay times of the Infrasil material with 12.7 μm of Teflon (2kV/2mm) (the data of b) are plotted in the left-hand ordinate, which shows the current in nA). The abscissa (horizontal axis) shows the time in minutes.

Detailed Description of the Invention

For the purposes of the present invention, the term “electro-optical”, or “optoelectronic” device refers to devices comprising at least part of its glass structure, said glass containing mobile ionic charges.

Typically, the poling process is monitored by measuring the current through the system, based on which valuable information can be obtained on the dynamics of the charge during the poling process and when the process should be stopped. In the process of the invention, the current dynamics are strongly related to the dynamics of forming the depletion region, which is related to SON by eq. 1. The process of the invention provides the production of ionic RC circuits by the thermal poling of glass.

A schematic representation of the configuration of the thermal poling process is shown in Figure 1, wherein the region devoid of positive ions (of length d) is positioned below the anode and the length of the glass sample is L, while the neutral region of the glass has length $l=L-d$. When a voltage is applied, the region below the anode becomes devoid of positive ions, which causes an increase in resistivity in various orders of magnitude, since conductivity is related to the presence of mobile ions. The equivalent electric circuit can be seen as two serial resistors, where almost all the voltage falls through the resistor near the anode $R_{(DL)}$, as shown in Figure 2a. The voltage in the remainder of the glass sample, $R_{(Bulk)}$, is significantly reduced to cause further ionic migration, interrupting any additional growth of the depletion region. This approach takes into account that the voltage drop through the depletion region and the ionic conductivity are different processes. However, since the voltage drop in $R_{(DL)}$ is the direct result of the charge displacement in $R_{(Bulk)}$, a better equivalent circuit to describe the dynamics of thermal poling would be a capacitor and a serial resistor, as demonstrated in Figure 2b. In this context, the accumulated charges in the depletion region represent the capacitor, while the remainder of the glass represents an ionic resistor. Due to the dynamics of forming the depletion region during thermal poling, the capacitance also has to change over time, i.e., a non-linear capacitor is obtained.

Although the vision of the thermal poling as an ionic RC circuit does not change the underlying physics of the current or the dynamics of the depleted layer, the device and process of the invention provide certain advantages when considering the development and/or production of materials and structures suitable for efficient poling. The preferred case is that of the production of maximum overlapping between the internal electric field recorded and the optical path, when optical waveguides and optical fibers are used. The use of non-capacitative, non-conductive layers as cladding structure enables the development of a buried depleted region for maximum concentration of ionic dopants (impurities), i.e., maximizing the internal electric field and the optimizing overlapping with the light guiding region. An overlapping of 100% between the depleted region and the optical mode can be obtained with buried waveguides.

The use of low refraction index Teflon film as cladding layer provides the placement of electrodes much nearer to the light guiding region without inducing significant losses, providing greater flexibility for the obtainment and performance of optimized devices.

Poling processes in UV or fs-laser regimes can be improved by using a dummy capacitor as a blockage electrode, since the migration of the charges can be controlled better, i.e., it is possible to choose/manipulate blockage or non-blockage electrodes.

Example 1

In a preferred embodiment of the process of the present invention, described in detail ahead, the thermal poling process was performed with the use of stainless steel (SS304) electrodes, circular and optically polished, having a diameter of 10 mm. The device was heated in an oven at a temperature of

280°C. As soon as the temperature stabilized (variations less than ±0.5°C) the voltage was turned on, at a preset value. The glass samples used in the device of the present example were silica glass (Infrasil® 301) having dimensions of 40x40x2 mm^3, containing a concentration of sodium impurities of approximately 1 ppm, according to the manufacturer. Teflon® and Kapton® films were chosen for the dummy capacitor by virtue of their low ionic and electronic conductivities, as well as their dielectric strength and thermal properties suitable for the thermal poling process. The thickness of the Teflon and Kapton films was d_C=7.6 μm. The thermal poling was performed by placing the dielectric film between the anode and the glass sample to be submitted to the poling process. The experiment results are shown in Figure 5.

Details of the underlying physics of the results of the invention

Although a full understanding of the mechanisms involved in the process of the present invention has not been elucidated thus far, not that such elucidation is essential for a person skilled in the art to reproduce the invention, the inventors carried out more in-depth studies on said mechanisms with a view to developing the best conditions for obtaining devices and their respective processes.

In order to simplify an equivalent ionic RC circuit model, and for a more comprehensive view of the thermal poling processes, the following simplifications have been made: the anode acts as a blockage electrode (no injection of charges in the glass); the cathode partially blocks effectively neutralizing positive ions, i.e., all the neutralized ions in the cathode contribute to the current measured through the circuit; the initial concentration of mobile ions is homogeneously distributed along the glass volume, with a charge density of $c_0=|q|N_0$ m^{-3}, wherein q is the ion charge and N_0 is the volume density of charge carriers. To simplify this general process even further, a single charge carrier is involved, for example, assuming they are sodium ions (Na^+). The depletion region can be estimated with a step-by-step profile. Additionally, it is considered that the ideal case in which the electronic conduction or dielectric rupture of the depletion region does not occur during the process, although there are known cases of dielectric rupture during long-duration thermal poling processes.

For a linear RC circuit, the charge and current dynamics are given by the exponential decay with a time constant.τ = RC, wherein R is the resistance and C is the capacitance. The capacitance and the resistance, assuming a geometry of parallel plates, is given by:

$$C = \varepsilon_r \varepsilon_0 \frac{A_C}{d}, \quad R = \rho \frac{l}{A_R}, \qquad \text{(Eq. 2 \& 3)}$$

wherein ε_r is the dielectric constant of the material and ε_0 is the dielectric permissivity of the free space, ρ is the resistivity, *l* is the length of the resistor given by *l=L-d* (see Figure 1), and A_C and A_R are the area and the crosswise section of the resistor (i.e. the glass substrate), respectively. Assuming that A_C = A_R, the decay time can be defined as a plate separating function:

$$\tau_d = RC = \rho \frac{l}{A_R} \varepsilon_r \varepsilon_0 \frac{A_C}{d} = \varepsilon_r \varepsilon_0 \left(\frac{L}{d} - 1 \right) \qquad \text{(Eq. 4)}$$

However, since this is a non-linear capacitor, a single *time constant* does not precisely describe the current dynamics. Instead, a variable decay time can be expected over time. The thickness of the depletion layer before the thermal poling process is d=0, which would imply an infinite capacitance and subsequently an infinite decay time. This, however, has no physical significance, since no voltage is applied to the circuit. Yet, as soon as the voltage is applied, mobile positive ions will quickly move towards the cathode, creating a depletion region below the anode, thus rapidly increasing d, effectively reducing the capacitance in the system and the decay time. In an ideal system, as assumed above, there will be a saturation depth d_∞ of the depletion layer thickness. The maximum thickness value, determined by the dielectric constant, charge density and voltage applied (V), is given by:

$$d_\infty = \lim_{t\to\infty} d = \sqrt{\frac{2\varepsilon_r\varepsilon_0 V}{c_0}} \qquad \text{(Eq. 5)}$$

As the limit of the depletion layer approaches, the decay time also approaches a value limit, τ_∞. Except in the case of thermal poling of very thin films and fibers, it is established that L>>d. It is therefore possible to simplify Eq. 4, which combined with Eq. 5 results in the decay time limit (τ_∞) given by:

$$\tau_\infty = \rho L\sqrt{\frac{\varepsilon_r\varepsilon_0 c_0}{2V_0}}\,. \qquad \text{(Eq. 6)}$$

Assuming that the resistivity can be expressed by:

$$\rho = \frac{1}{\sigma} = \frac{1}{\mu\cdot|q|\cdot N_0}, \qquad \text{(Eq. 7)}$$

wherein σ is the conductivity, μ is the mobility of the charge carrier and $/q/=e$ the charge, and $c_0=/q/N_0$, Eq. 6 can be written as follows:

$$\tau_\infty = \frac{L}{\mu}\sqrt{\frac{\varepsilon_r\varepsilon_0}{2eN_0 V}}, \qquad \text{(Eq. 8)}$$

which is identical to the decay time derived by Von Hippel *et. al* when analytically solving the formation dynamics of the depletion layer. The dynamics of the system was given by:

$$I(t) \cong \frac{I_0}{\cosh^2(t/2\tau)}, \qquad \text{(Eq. 9)}$$

instead of a single expontential function.

It is also possible to note the very capacitance of the depletion layer. Using equation 2, wherein d can be estimated using eq. 5, the capacitance is then given by:

$$C = \sqrt{\frac{q\varepsilon_r \varepsilon_0 c_0}{2V_0}} \qquad \text{(Eq. 10)}$$

This is equivalent to a capacitance of a reverse-biased one-sided step junction, if it is established that $V_0=V_{bi}+V_r$, wherein V_{bi} is the intrinsic potential of junction and V_r is the reverse-bias. In the case of thermal poling, V_{bi} can be overlooked. The dynamics of non-linear capacitors cited previously has been given by:

$$I(t) \cong I_0\left(1 - \tanh^2(t/2\tau)\right), \qquad \text{Eq. 11}$$

wherein τ=RC, which is identical to Eq. 10.

According to Eq. 8, the decay time of the circuit is proportional to the thickness (*L*) of the sample, which can be recognized as the R change in the RC circuit. In order to carry out more in-depth testing of the equivalent ionic RC circuit for thermal poling, it is not only possible to change the response time of the circuit by the change in length of the sample but it is also possible to change the capacitance of the circuit. This can be done by placing a dielectric film between the anode and the glass sample, resulting in an initial capacitance different to zero in the circuit, i.e., a dummy capacitor.

In synthesis, the present invention bears concrete experiment results and also theoretical support to explain them. The process of the present invention provides the thermal poling of glass, resulting in the devices of the invention, which are useful, among other aspects, as ionic RC circuits. In the present invention, the depleted region of ions (negatively charged) associated to the second order optical non-linearities, corresponds to a non-linear capacitance, while the remainder of the glass corresponds to an ionic resistor. The process and the device of the invention provide various advantages in the development, obtention and use of optoelectronic devices by controlling the dynamics of the depletion layer.

The poling and separation of charges in dielectrics, and specifically in glass, has been the topic of discussions for decades, but no precise analytical solution has been achieved, nor has it even been possible to provide devices and practical processes to control the electro-optical properties of glass to the extent that they can be used in ionic RC circuits, for example. The process and device of the invention solves this difficulty by providing, besides the practical ways of embodying the invention, the entire theoretical framework on which it is based. Consequently, persons skilled in the art will immediately appreciate the important benefits resulting from the use of the present invention. Variations in the embodiment form of the inventive concept exemplified herein shall be understood to be within the spirit of the invention and the appended claims.

Claims

Optoelectronic Device and Process for its Production

1. Optoelectronic device characterized by comprising at least one material containing ionic charges, said ionic charges made mobile by applying thermal and/or electromagnetic radiation.

2. Device, according to claim 1, characterized by comprising at least part of its glass structure, said glass containing mobile ionic charges.

3. Device, according to claim 1, characterized by the fact that the mobile ionic charges make said device have an ionic resistor property.

4. Device, according to claim 1, characterized by the fact that the mobile ionic charges make said device have an ionic conductor property.

5. Device, according to claim 1, characterized by the fact that the mobile ionic charges make said device have a non-linear electronic or ionic capacitor property.

6. Device, according to claim 4, characterized by the fact that said capacitor comprises a material selected from the group comprising Teflon, Kapton, Mica, SiO_2, SiON, BN, or combinations thereof.

7. Device, according to claims 1-6, characterized by additionally comprising a means of guiding light through same.

8. Device, according to claim 7, characterized by the fact that said means of guiding light is an optical fiber with and/or without holes.

9. Device, according to any of the prior claims, characterized by being a PCF.

10. Process for improving the non-linear properties of an optical device characterized by comprising the thermal poling of optical devices by applying an electric field through said devices, in which at least part thereof comprises a material containing ionic charges that can become mobile.

11. Process, according to claim 10, characterized by the fact that mobility of the ionic charges is provided by thermal and/or electromagnetic radiation.

12. Process of obtaining an optoelectronic device, characterized by comprising the steps of:

- submitting at least a glass material to the application of an electric field through said glass;
- during the application of said electric field, maintain the temperature high, followed by a substantial reduction in temperature, so as to reduce the mobility of the ionic charges of said glass.

13. Process, according to claims 10-12, characterized by additionally comprising the use, as a dielectric between the anode and the glass, of a material selected from the group that comprises Teflon, Kapton, Mica, SiO_2, SiON, BN, or combinations thereof.

DRAWINGS

Figure 1

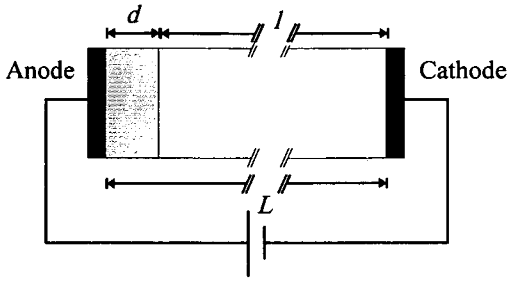


Figure 2

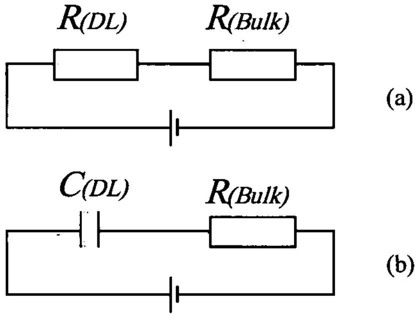
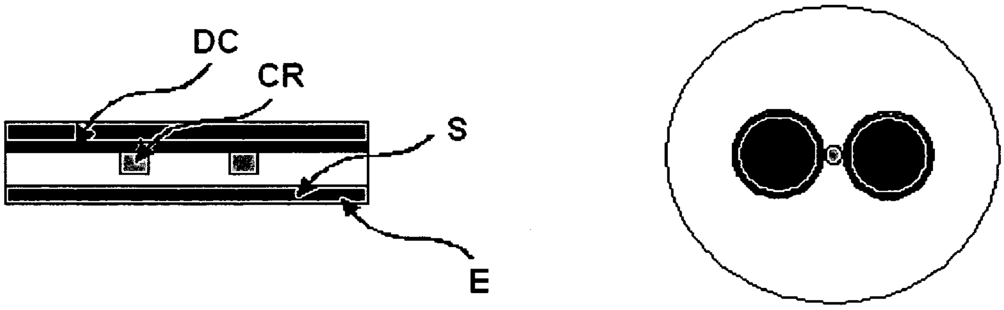


Figure 3



a) b)

Figure 4

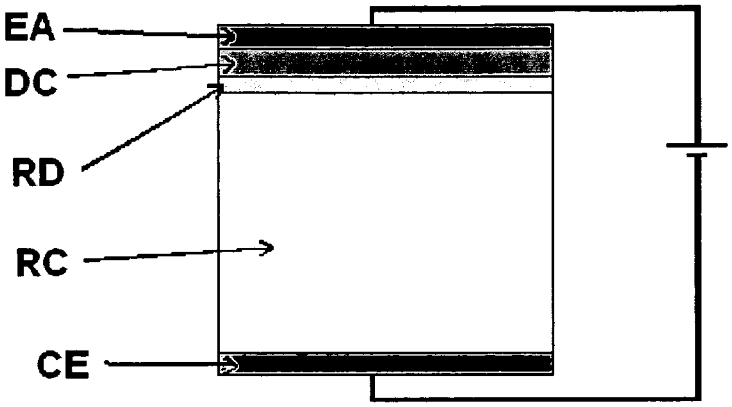
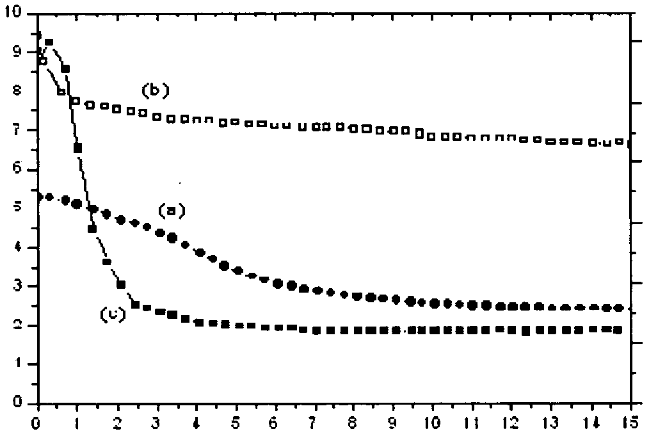


Figure 5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/BR 2008/000268

A. CLASSIFICATION OF SUBJECT MATTER
IPC^8: ***G02F 1/355*** (2006.01); ***G02F 1/377*** (2006.01)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC^8: G02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPI, EPODOC, X-FULL, PAJ, IEEE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2001/020389 A1 (UNIVERSITY OF SYDNEY), 22 March 2001 (22.03.2001) *background of the invention; summary of the invention and fig. 1 with description* --	1-7,10-13
X	EP 0794450 A1 (ANDREW A.G.), 10 September 1997 (10.09.1997) *whole document* --	1-7,10-13
X	WO 1995/029425 A1 (UNIVERSITY OF SOUTHAMPTON), 2 November 1995 (02.11.1995) *figs. 1 and 3 and description of figures* ----	1-7,10-13

☐ Further documents are listed in the continuation of Box C.   ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 21 November 2008 (21.11.2008)	Date of mailing of the international search report 17 December 2008 (17.12.2008)
Name and mailing address of the ISA/ AT **Austrian Patent Office** Dresdner Straße 87, A-1200 Vienna Facsimile No. +43 / 1 / 534 24 / 535	Authorized officer KOSKARTI F. Telephone No. +43 / 1 / 534 24 / 326

Continuation of first sheet

Continuation No. II:

Observations where certain claims were found unsearchable

(Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. With regard to any nucleotide and/or amino acid sequence disclosed in the international application and necessary to the claimed invention, the international search was carried out on the basis of:

Claims Nos.: 8 and 9 because they relate to subject matter not required to be searched by this Authority, namely:

because of Article 17(2)a)ii) no search could be established because the subject matter of claim 8 is completely unclear: where should the holes be and for what reasons? Also the subject matter of claim 9 is unclear: what means PCF, perhaps Photonic Crystal Fibre ? Both subject matters are not supported by the description or the drawings. Therefore no search could be conducted.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/BR 2008/00268

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO A 0120389		US B1 6792166	2004-09-14
		JP T 2003509720T	2003-03-11
		EP A1 1212656	2002-06-12
		CA A1 2383534	2001-03-22
		WO A1 0120389	2001-03-22
		AU A 7498900	2001-04-17
EP A 0794450		US A 6134356	2000-10-17
		US A 6041149	2000-03-21
		EP A1 0794450	1997-09-10
		NO A 970930	1997-09-08
		JP A 9243973	1997-09-19
		CA A1 2196714	1997-09-05
WO A 9529425		WO A1 9529425	1995-11-02