NON-LINEAR OPTICAL MATERIAL FOR LIGHT PROCESSING AND AMPLIFICATION

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Abstract

The need for fast transmission of large amounts of data as well as processing and storage of increasing amounts of information is the reason for the search for new materials showing not only linear but also non-linear optical properties. In linear optics, the refractive index is a constant value for a given material (depending only on the wavelength of the radiation). The variable value of incident light intensity does not affect the linear optical properties of such a material (optically isotropic). At the same time, the polarization of the medium caused by the electric field of low intensity is a linear function of the field strength. When a polarized light beam of high intensity, carrying a strong electric field (corresponding to the binding energy of such a medium) is incident on such a medium, its electric polarization no longer depends linearly on the electric field strength, and the refractive index changes with increasing light intensity. The non-linear optical properties enable the fabrication of optical devices such as optical modulators, switches, frequency doublers, etc.

An optical modulator is a device that can be used to modify the properties of an electromagnetic wave, e.g. a laser beam. Depending on which property of light is controlled, there are modulators of intensity, phase, polarization of light, etc. The change in the optical characteristics of the material, manifested by a change in such parameters as: transmittance, reflection coefficient or refractive index, occurs in response to an externally controlled electric field or light (electromagnetic wave).

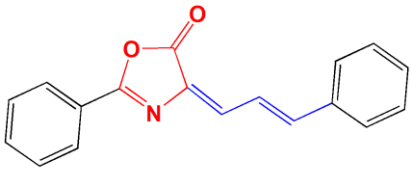
It is known that organic compounds containing a delocalized π electron system can exhibit a non-linear optical response, which in many cases is much greater than that of inorganic compounds. In addition, the properties of fully organic hybrid systems containing an organic non-linear optically active medium embedded in a polymer matrix can be freely modified to optimize other desirable properties. These are: mechanical and thermo-oxidative stability, and a high laser damage threshold while maintaining electronic interactions responsible for non-linear optical effects.

Thin films made of organic materials (including polymers) showing high non-linear optical susceptibility of the second order are used e.g. for the production of modulators, sensors, for the generation of electrical impulses in the THz range, for the generation of the second harmonic of light, for raising or lowering the frequency in lasers with tunable frequency.

From a practical point of view, equally important in non-linear optical processes are third-order non-linear optical effects, such as: generation of the third harmonic, optical Kerr effect - forced birefringence, self-focusing, mixing of four waves (optical phase conjugation), or forced Brillouin effect. Many of them have found application in the processing of optical information or the production of optoelectronic integrated circuits.

Research is also conducted on the search for new organic compounds that exhibit valuable optical non-linear properties, necessary for the manufacture of devices adapted to switching and modulation of light, information control in optical circuits and optical communication.

The invention relates to a non-linear optical material for light processing and amplification, which is an organic guest-host hybrid system comprising a transparent polymer (PMMA) and a photoisomerizable dye based on the 5-(4H)-oxazolone and a stilbene derivative of the formula:



acronym: **Ox**–π,π–**Ph**

This material reveals effective refractive index manipulation and multimode lasing action, respectively. It is a thin film with a thickness of 14.0 - 17.0 micrometers, where the photoisomerizing dye has a concentration of 0.5 - 5.0% in relation to the weight of the polymer. It is a potentially valuable active medium component in all-optical and electro-optical switches and optical amplifiers for optoelectronics and photonics since: (a) light modulation is repeatable and stable, also in the hundreds of Hz regime, (b) amplified optical signal can be easily generated by an external optical pumping source, (c) signal control, as well as read-in and read-out of the information in real time, is fully available, (d) generation of third-order, nonlinear, optical phenomenon is also observed using a third harmonic generation technique, (e) optical or non-linear optical response is observed only by changing the energy and time regime of the supplied optical signal.

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The innovativeness of the invention consists in particular in the fact that:

- it is a completely organic non-linear optical material
- it is an organic guest-host hybrid system containing a photoisomerizing dye (according to the formula) embedded in a polymer matrix
- exhibits optically induced birefringence, which makes it capable of processing light by creating optical anisotropy of the medium
- it has the ability to generate Boltzmann energy inversions (these are multi-level, minimum 3-level systems), which results in stimulated/stimulated emission
- shows the presence of optical resonators in which amplification takes place (multiplying the number of photons in a specific range of laser modes)

The innovativeness of invention can translate into the following benefits:

- Maximum photoinduced optical birefringence (Dn) of about 5.5×10^{-4} and process reversibility close to 85% classifies the material as one of the best active media for currently available organic optical switches.
- The system allows for the production of efficient feedback emission, known in the literature as random lasing.

Applications/Markets:

- Optoelectronics
- Photonics
- Potentially valuable active medium component in optical switches and amplifiers