DOI: 10.24996/ijs.2018.59.1B.7

ISSN: 0067-2904

Polymer optical fiber sensor side-pumped with polymer clad doped lasing compounds

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Abstract
Optical fibers were produced by the system manufactured for this purpose and then, PMMA core of polymer optical fiber (POF) and PMMA doped Rhodamine B (RhB) claddings were studied and determine their UV–vis absorption and emission. The study adopted the mechanism of lateral pumping of the product polymer optical fiber by using laser with 404 nm excitation to study optical specifications of the factory fiber. It was noted that there were blue shift in maximum peak wavelength in absorption and fluorescence from the doped polymer before use it as clad. The obtained results by using the doping polymer with (RhB) for clad the amplified spontaneous emission ASE seems in fluorescence study. The side excitation shows that there were no an overlap between the excitation laser source and the RhB molecule fluorescence. The results indicate that POF can be a strong candidate for the development of optical fiber sensors.

Keywords: Optical fiber, PMMA, POFs, RhB.

متحسسات الالياف البصرية بالضخ الجانبي ذات اغلفة بوليمرية مطعمة بصبغات ليزرية

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الخلاصة
تم انتاج الالياف البصرية بواسطة المنظومة المصنعة لهذا الغرض، تمت دراسة طيف الانبعاث و الامتصاص للألياف البصرية البوليمرية في مدى uv–vis قبل و بعد اكسائها بصبغة الرودامين B. و تناولت الدراسة ميكانيكية الضخ البصري الجانبي لتهيج الالياف البصرية المنتجة باستخدام ليزر 404 نانومتر لدراسة مواصفات البصرية للالياف المصنعة.

لوحظ ان قمة الامتصاص عانت ازاحة باتجاه الازرق في كل من طيف الفلوة و الامتصاص قبل استخدامه ككساء. تضخيم الابنبعاث التلقائي من النتائج المستحصله عند استخدام كساء صبغة الرودامين ، و الذي ظهر في دراسة طيف الفلورة.

وضح التهيج الجانبي عدم حصول تراكب بين ليزر المصدر و فلورة جزيئات الرودامين . وتشير النتائج إلى كون POF هو مرشح قوي في تطوير أجهزة الاستشعار التي تعمل بالألياف البصرية.

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Introduction

Polymers are in present time considered as the very important specialty materials. This material containing azo group in the main series showed the increasing in the second order nonlinear optical efficiency. When certain polymer molecules are aligned in uniform structure, its properties can be very different from that unaligned polymer. A typical part which is fibers aligned aramid used as enhancements in high field applications, where the regular alignment molecular generates unbelievable physical properties [1]. General the polymer materials have been playing an important role in the many of fields life, the polymer is a big molecule materials prepared by the chemical synthesis method. It can be divided into several types like; poly-methyl methacrylate (PMMA), polyacrylamide (PAM), polystyrene (PS), polyvinyl pyrrolidone (PVP), polyvinyl alcohol (PVA), and deuterated polymer (DP), etc. When pulling the polymer at near the glass temperature, the time of the oriented dipolar was short for investigation maximum alignment. The polymer fibers have behavior optically, which to play an important in the bio-chemical imaging and optical sensor [2]. Many properties of (POF) when it doped by some lasing or other like quantum dots fluorescent particles or other compounds can be improved its physical or chemical properties. Dye-doped as clad of POFs can be modified the properties of POFs to obtain visible light of broad spectrum to get optical sensor [2].

The withdrawal of polymers for the production of optical fiber was possible by the manufactured system, and in addition the ability to control their nonlinear optical characteristics. With the fast implementation and making of the optical fiber longitudinal links as very cheap material that used around the world in many field like sensing or communication, telecommunication and much other field of used and its capacity used increased in unprecedented rate .The use of optical fiber (POF) in telecommunications began in the 1990s and increased this use to become the most important in this field to become the lengths of fiber optic beyond millions of kilometers. According to these specific applications, optical fibers of polymer can be classified into field of applications, sensing (photonic) and communication applications. The polymer system in any applications is very low connection cost. Many optical fibers doped by many other materials to change its optical properties and other physical properties like flexibility and elasticity. Polymethyl methacrylate (PMMA), is a large molecule produced when methyl methacrylate is polymerized and become rigid plastic, clear, colorless and transparent material [3, 4]. The fiber which used in this study analyzed by using POF whose core was undoped but its clad doped with some active material at different concentrations. It was adopted to use the fiber without cladding by pulling the optical fiber first without that layer(cladding), the withdrawn polymer core dissolved in chloroform solvent to get the same polymer in the liquid phase so that we can add lasing compound dye and used this solution as clad for the new different optical fibers in order to use this fiber as an optical sensor. In pumped doped polymer optical clad of fiber act as light source, the important behavior phenomenon can take place this phenomenon is Amplified Spontaneous Emission (ASE) [5, 6].

The study focuses on the influence of these lengths on the ASE spectrum, threshold, and efficiency obtained for each one of the fiber ends when side pumping is utilized. The study of influence of focuses of the pumping source on the length of the exposed fiber on the efficiency, spectrum of ASE and threshold was studied from J. Arrue *et. al* [7]and Illarramendi, M.A, *et. Al*. [8].

This paper measured and analyzes ASE emission and the parameters affecting on this behavior from side-pumped clade made of poly (methyl methacrylate) (PMMA) and doped with Rhodamine B.

Experiment and methods

For visual fiber pulling purposes, a simple and precise system was designed and contracted for this purpose Figure-1, the manufactured system was made of many components. The 1st one was the crucible which was made of stainless steel with a thickness of more than 1 centimeter and inner diameter of 1.5 cm, this crucible was used to heating the PMMA polymer to pulling the optical fiber. This crucible was surrounded by heater controlled by temperature controller to reach the glassy temperature was equal approximately 400C^o, which was the degree by which the polymer transition from solid to the gelatin form. For the purpose of pulling the fiber, it was necessary to using a piston in order to push the gel polymer to emerge from the exit slot to get the fiber. This piston works in both directions for the purposes of producing the fiber when its direction down word and the opposite direction for the purpose of pulling the piston from the crucible to clean it and to add the polymer to the crucible. To get precise diameters of pulling fiber, discs with specified diameters were used to in the goldsmith workshop. Also place a glass basin underneath the disk slot to receive the pulling fiber, the basin contains one of one liquid fluorine compounds and then take the fiber through the stepper motor to collect the pulling fiber.

Figure 1- contracted system for withdrawing fiber, a: the core system, b specified diameter discsc: the pulling fiber with doping clad

PMMA was the base material used to manufacture POF, it was a common polymer and possesses the following physical specifications: glass transition temperature: 114oC°, amorphous density at 25oC° is 1.17 g/cm3, and molecular weight of repeat unit is 100.12 g/mol. As mentioned in the introduction, it was transparent in the visual and UV regions. The Rhodamine B laser compound $C_{28}H_{31}N_2O_3Cl$ molecular weight 479.02 gm/mol., supplied from Lambda Physik. Rhodamine B was most efficient one the fluorescent dyes, it has been known since the beginning of the twentieth century and was used to calibrate the spectrometers for its high emission and efficiency. The chloroform Solvent (colorless, sweet-smelling, dense liquid, boiling point 61.2 °C density 1.49 g/cm^3) was used in this study to get different clad for the fiber in order to use in optical sensors. In this study, the produced fiber from system in Figure-1 was adopted for the purpose of producing the guided guides after immersion with a polymer doped lasing compound solution. The fiber was then suspended vertically in an isolated medium until it dried and then studies the photophysical properties. K-MACSV2100 Korea Material & analysis (Korea), via a fixed grating (600 lines/mm) across a linear charge-coupled device (CCD) array detector SEC2000 Spectrometer, there are two light source Tungsten-Halogen Lamp (for Visible/NIR 500-1000nm) and Deuterium & Tungsten Halogen Lamp (for UV-Visible 220-800nm) Figure-2. The doped clad of POF was side pumping by changing the spot of the laser from the circular shape to line shape by using cylindrical lens and focusing it on the POF as a stripe of 1.2 mm in width 2cm length.

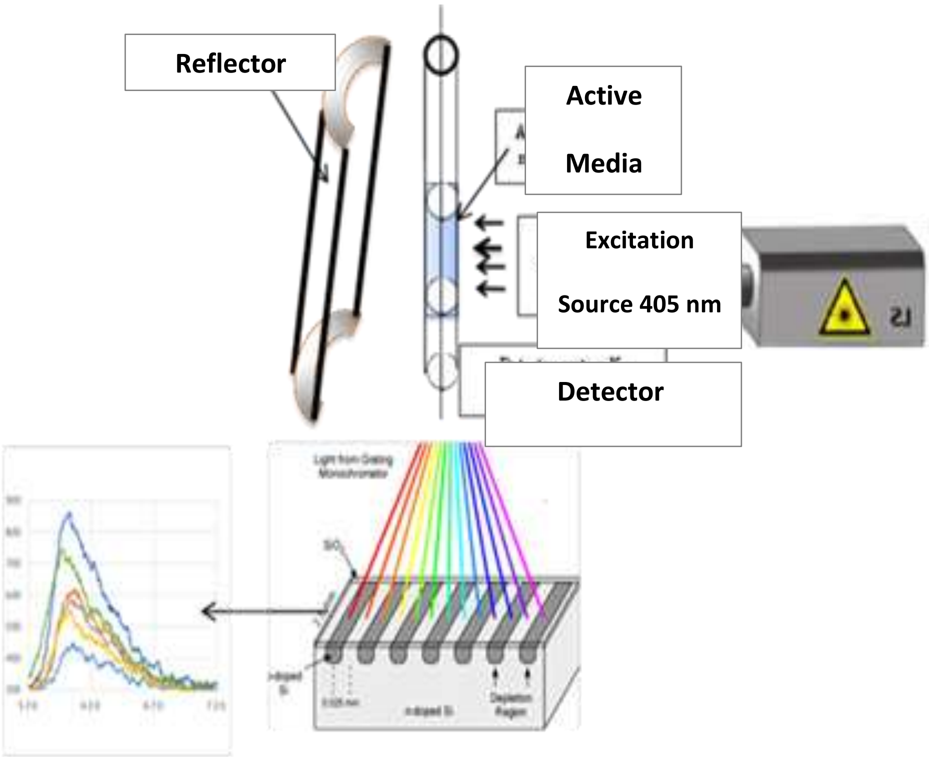


Figure (2): the experimental setup of side-pumping of POF

Result, discussion and conclusion

The properties of Rhodamine B as illustrated in experimental part doped PMMA polymer as clade preforms (absorption and fluorescence spectra) and polymer fibers as a core (attenuation, fluorescence,) was characterized. The absorption and fluorescence spectrum were recorded and measured by using K-MACSV2100 spectrometer. The laser used for excitation the fabricated POF was laser with wavelength 405 nm and power 100 mw, for the measurements; optical sensing and ASE the samples.

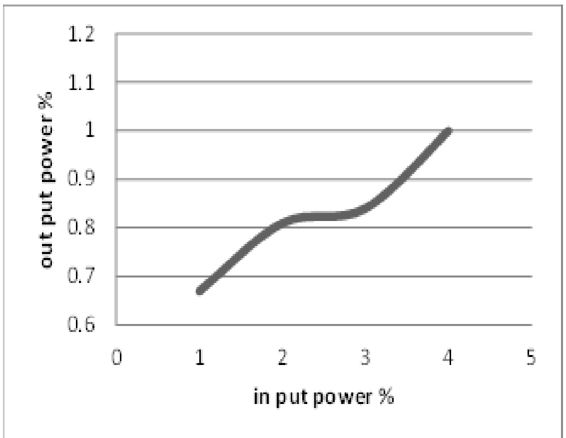
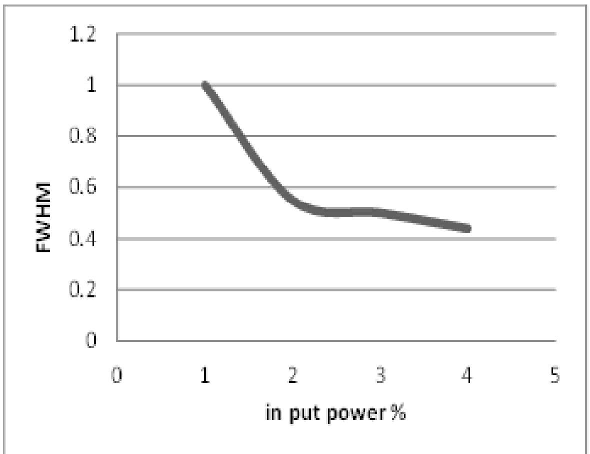


Figure (4) shows the relation between input power and the output power of OPF doped RB



Figure(5)shows the FWHM as a function of input power of OPF doped RB

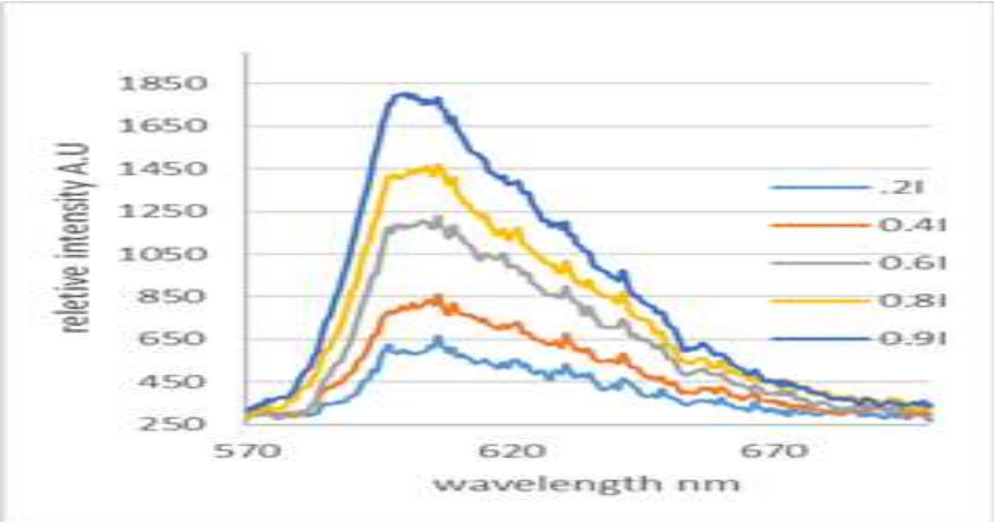


Figure 3- illustrate the fluorescence intensity as function of wavelength for POF doped RB.

Polymer optical fibers lengths of the various lengths (10–15 cm), and special cavity building for an experiment. Taking the applications of doped polymer optical fiber into account, the experimental result of the ASE and fluorescence properties doped polymer as clad. When the lines represent the fiber length which exposed to the laser one can see the narrowing of the spectral line as a function of laser pumping power of light amplification, which are plotted in Figure-3. This figure shows clear the effect of line narrowing with increasing the pump laser power.

As a result of the laser pumping to the gain media RhB doped as a clad of POF, besides the decreases of emission band spectrum (narrowing) at a given pump, the output emission intensity, increased considerably was observed in Figure-4. With this standard behavior, one can marked: the points of half spectral 50% width reduction in the curve which indicate the threshold energies [4].

The FWHM of the line of fluorescence spectra with variable (0.2 I_O to I_o) in 5 five step pumping laser power was plot in Figure-5. In figure it was clear that the spectral line narrowing from (63) to (40) nm was observed when the pump laser power was and no line sharpening was observed. This making the use of such optical fibers as optical sensors useful for the high potential of the influence of the surrounding medium due to it has high gains realizable in short distances.

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