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Effect of Temperature Tuning on Diode Laser Performance

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Abstract

In this work, an expermental study on wavelength tunning for diode laser adopting temperature behavior varition process is carried out .Temperature effect on the characteristics of a stripe Double Heterostructure CW (GaAlAs) diode laser is shown . For the purpose of optimum operation a collection of important information has been extracted regarding threshold current and senstivity of the laser diode as a function of temperature. It was found that the increasing in temperature (10-40)ºC resulting in an increasing in the values of forward current and the output power of the laser diode. the threshould current shows a drop in the value(48-61)mA, and increase in the differential or slope efficienecy (0.1-0.25)mW/mA.

Keywords: laser diode, GaAlAs structure ,I-V characteristic, (TEC)cooler

تاثير درجة الحرارة على عمل الليزر دايود

الخلاصة

جرى في هذا العمل ، اجريت دراسة تجريبية على تنغيم الطول ألموجي لثنائي الليزر اعتماداً على عملية تغيير درجة الحرارة و جرى استخراج مجموعة من المعلمات المهمة التي تخص تيار العتبة وحساسية ثنائي الليزر كدالة لدرجة الحرارة لغرض التشغيل الأمثل. حيث وجد ان زيادة درجة الحرارة°C(10-40)تسبب زيادة في قيم التيار الامامي وقدرة الخرج لثنائي الليزر من خلال توظيف المبرد الكهروحراري (TEC)، وقد لوحظ نقصان في قيمة تيار العتبة (61-48)mA, وزيادة في كفاءة الميل Differential or slope efficiency من(0.1-.25) mW/mA .

1.Introduction

The laser is a directed, high brightness, coherent source of light was dream come true at its first demonstration in 1960. A major new research field in physics and engineering- the development of different types of lasers, aiming to cover that part of the electromagnetic radiation spectrum that can be called "light".

As laser physics and engineering grew, so did the knowledge that real lasers have outputs that are dynamically and spectrally diverse. The dynamics refer to output power variations in time and the spectrum means the time-averged,optical -frequency-spectrum[1,2].

Almost any laser can be made to generate an output that is unstable in time by optical feedback of part of the output light back into the laser cavity. Semiconductor laser, as a subset of all lasers, represent a category in which a very broad range of the possible dynamic and spectral outputs obtainable from lasers can be achieved – from the chaotic to the narrow - linewidth, single- frequency [3].

Laser diodes are the most widely used laser ever devised. They are normally pumped directly with an injection current. Laser diodes are used in such everyday items as CD players

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and laser printers and are finding a host of new applications ranging from medical imaging to environmental sensing. The semiconductor laser is also the source which drives optical fibre communications[4,5].

The main objective of this work was to develop and experimentally in vest gate new types of widely tunable laser diodes which have a number of potential advantages over the existing concepts ; high output powers ,simple fabrication , better stability or simple tuning[6] .

2.Experimental Design

1. The experimental work

The setup and performances of the characteristics for the laser diode have been examined experimentally under various conditions as shown in Fig (1).
In this work we used the semiconductor laser type(Sharps LTO 22MC-MD – MF). Sharp laser diode is designed to assure the long life and high reliability of these devices . A 790 nm , 5 mW laser diode with single longitudinal mode (SLM) , low threshold current 50 mA . Sharp laser diode use a Gallium Aluminum Arsenide (AlGaAs) double hetero junction was Shown in Fig (2) . Optical and electrical characteristics of the laser diode is listed in the table (1).

The main characteristics of the laser diodes were measured . This included measuring the optical power as a function of drive current , the beam divergence angles , and the emission spectrum .The laser driver controlled the laser's driver current and temperature . Both the threshold current and the slope efficiency of the laser depend on the temperature. The measured also exhibit bending caused by the heating of the active region. Fig (3)shows the measurement setup . In the divergence angle measurements in Fig (4), the laser lay on the rotation stage driven by a micrometer screw .The optical power meter was set behind a 1-mm wide slit and positioned at a distance of 1.5 cm from the laser . The experimental for emission spectrum is presented in Fig (5). The laser is operating in C.W. mode before reforming measurements. It is necessary to get precise calculations about ray path of the laser . To do this the monochromator should optically matches the optical setup . In other words, its highly recommended that the laser ray enter through the narrow slit (3mm), reflect by mirrors and then pass through the grating (Transmission grating) and finally received by the detector. Otherwise the laser would be lost through the system.

3.Results and Discussion

The optical output power –forward current of laser diode is measured by supplying current in the forward direction of the laser diode and detecting the generated laser light with light receiving element that has large receiving port diameter. Laser diodes are classified into DC (CW) drive and pulse types, depending on their driver circuits. The light receiving elements in general use silicon PIN diodes. For high accuracy spectrum measurement, therefore, the temperature of the laser diode must be controlled by marinating it constant, than variety the value of injection current from "zero" and take the value of optical power corresponding the injected current, this measurement for different temperature from (10 ~ 40) C^o and display the temperature effected on characteristics curve.

Fig (6) represents the variation of optical output power, it is a function of injected current at different temperature. This curves view as forward current though the diode is increased, there is a sudden increase in laser output power, indicating laser action, at a threshold current in the range of (48 -61) mA, as the forward current is increased above threshold, the laser output power increases sharply.

Both the threshold current and slope efficiency of the laser diode change on the temperature. The rounding off of the characteristic line is the result of spontaneous emission in Fig (6). It is the cause for the oscillation of several modes next to the threshold also, at higher current the mode spectrum becomes more and more clean. Fig (7) represents the relation between Ln threshold current with temperature, by this it can determined the laser sensitivity as temperature (To =106 ºC) .

Differential efficiency η**D**): The mean value of the incremental charge in laser power output for an incremental charge in forward current.

A large sloping efficiency causes the optical output, current characteristic curve to become steeper which reduces the separation between the rated oscillation initial current and the rated operating current as show in Fig (8).

For a lower efficiency, the curve become gentler causing a larger separation between initial and operation currents necessitating a larger operating current for the rated optical output.

Laser diode with intensity profiles following a Gauss curve and a beam profile which is only limited by diffraction are called **Diffraction Limited Laser**. As Fig(9) show the intensity distribution in perpendicular junction at constant temperature (T=25 ºC) with power(3.6mW), the figure illustrated the intensity uniform Gausses distribution and increasing with different power . The same figure are show for the parallel junction in Fig(10) from this fig ,the intensity distribution is non-uniform for (T=25ºC) ,P(3.6mW).

This result from the photo emitted by stimulated emission will be increase, so the gain and power emitting will be increase too [7]. But in perpendicular angle in Fig (11) and parallel angle in Fig (12) with different temperature at constant power ,from these figures the intensity are Gausses distribution. Also display the intensity reduce with temperature increasing and this caused by internal and external loss increasing at active region when temperature increases ,carrier leakage and nonradiative recombination at defects in the active layer [8]. The active layer is made sufficiently thin that the laser operates in its fundamental transverse mode with linear polarization parallel to the active layer. Because the thickness of the active layer is so small, diffractive effects are significant.

4.Conclusions

The threshold current increases with the increasing of temperature while the differential efficiency reduces as the temperature in weaves.

5. References

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Table (1) The optical and electrical characteristic of the laser diode[1].
Tc=25 ◦C

Parameter		Symbol	Condition	Ratings MIN.	TYP.	MAX.	Units
Wavelength		λ_p	*Po = 3mW*	*770*	*780*	*790*	*nm*
Threshold Current		I_{th}	____	___	*50*	*80*	*mA*
Operating Current		I_{OP}	*Po = 3mW*	___	*65*	*100*	*mA*
Operating Voltage		V_{OP}	*Po = 3mW*	___	*1.75*	*2.2*	*V*
Radiation characteristics Angle	*Parallel*	θ''	*Po =3mW*	*8.5*	*11*	*16*	*deg*
	Perpendicular	$\theta\perp$	*Po=3mW*	*20*	*33*	*45*	*deg*
Differential efficiency		η	*2mW/I(3mW)-I (1mW)*	*0.1*	*0.25*	*0.6*	*mW/mA*
Monitor Current		*Im*	*Po = 3mW VR = 15 V*	*0.3*	*0.9*	*1.6*	*mA*

Absolute Maximum Ratings

Parameter	Rating	Unit
Optical power output	*5*	*mW*
Operating temperature	*-10 ~+ 60*	*℃*

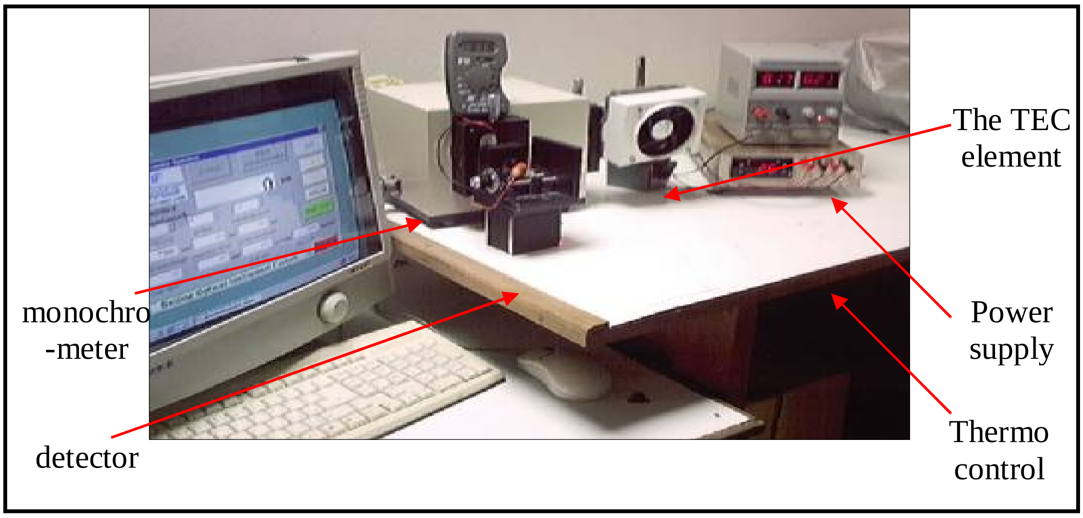


Fig (1)A photograph of the layout on the optical table

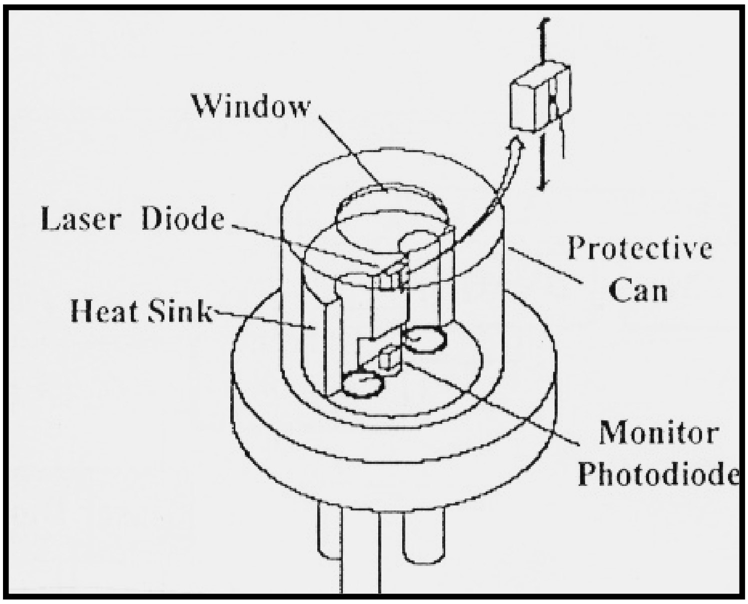


Fig (2) structure of laser diode.

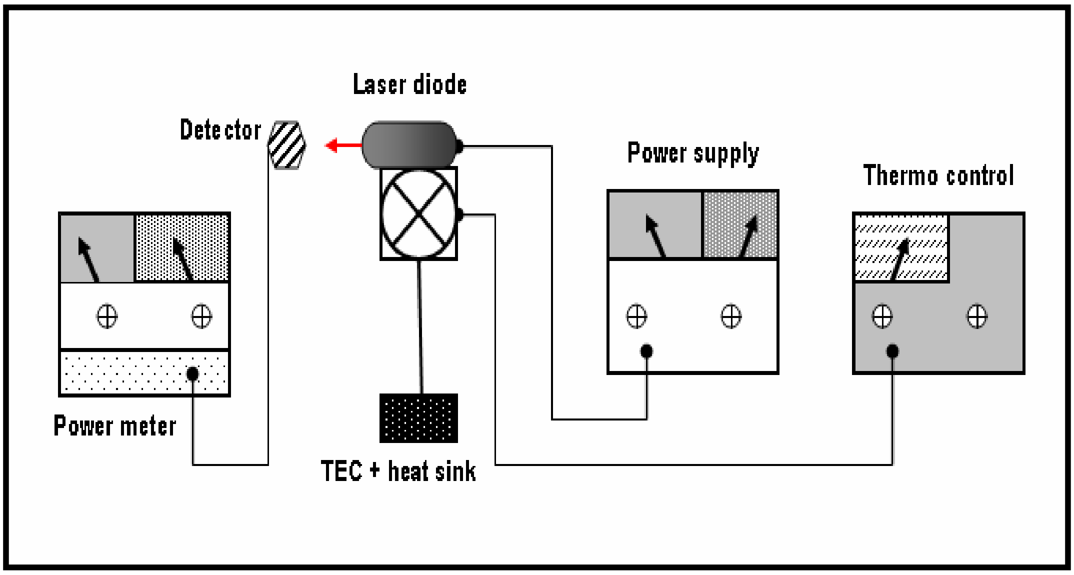


Fig (3) The Measuring of optical power as a function of forward current.

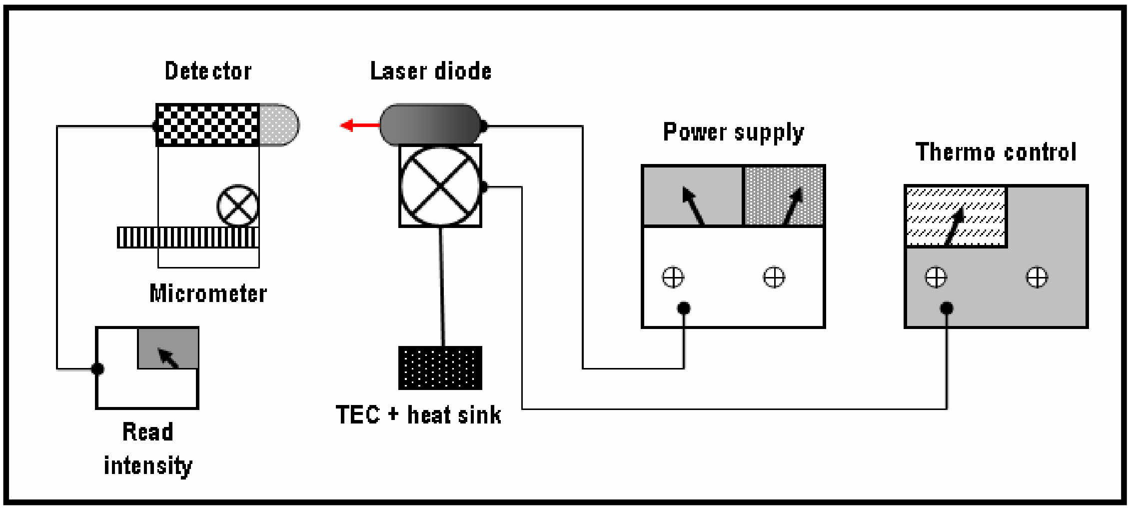


Fig (4) The Measured beam divergence angle.

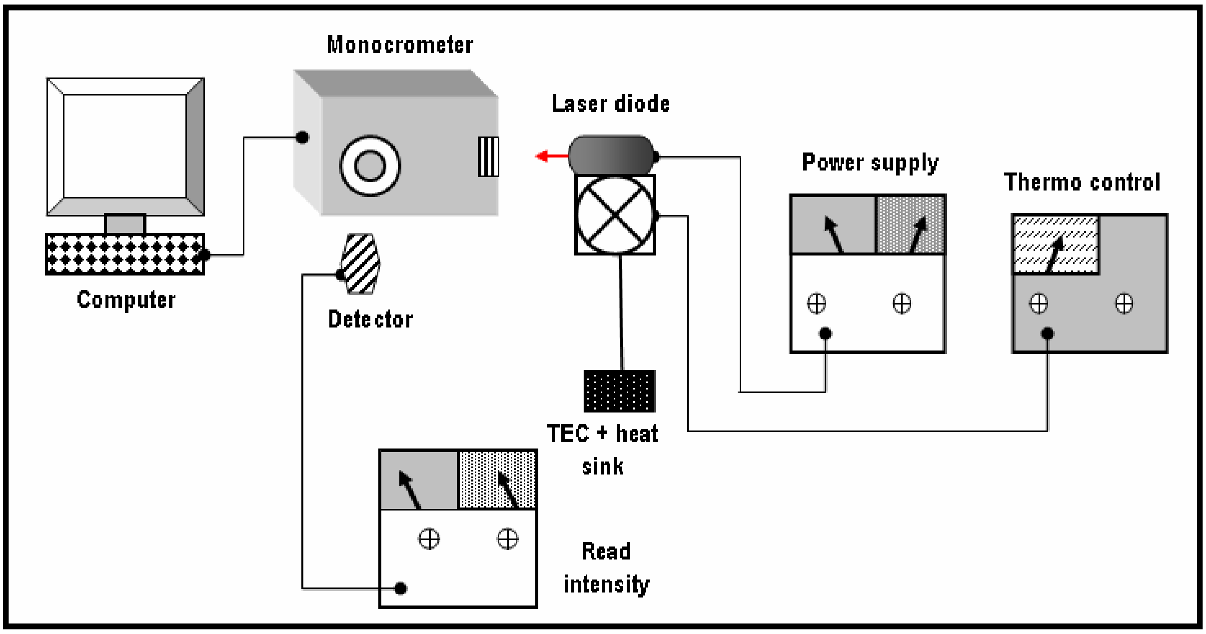
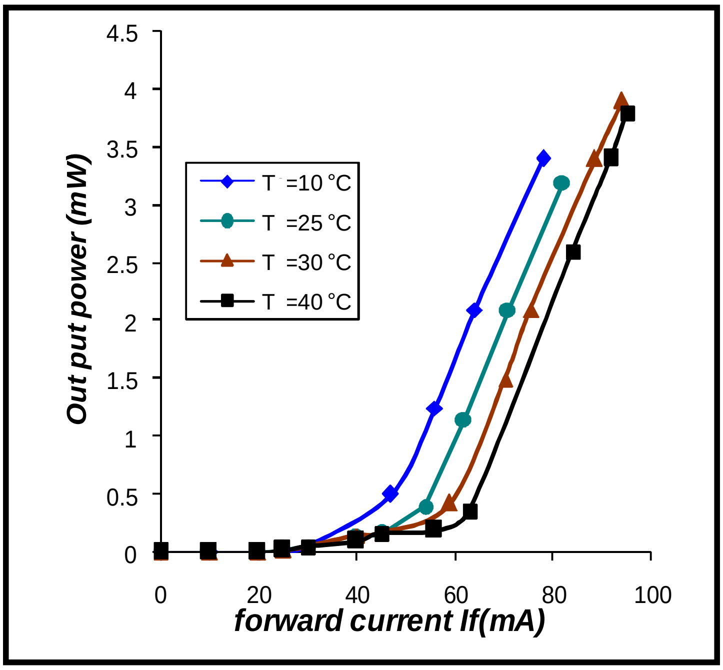


Fig (5) Measured the emission spectrum for laser diode



Fig(6) Output power of the laser diode as a function of the injection current at different temperature.

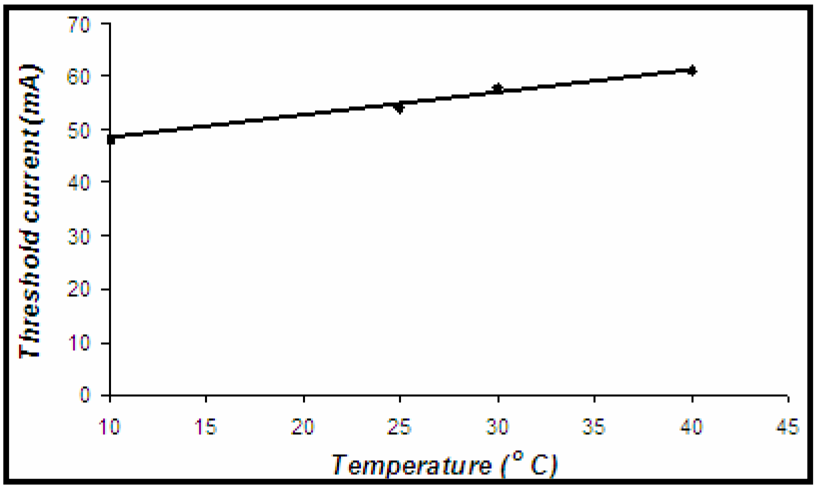


Fig (7) The threshold current as a function of the temperature

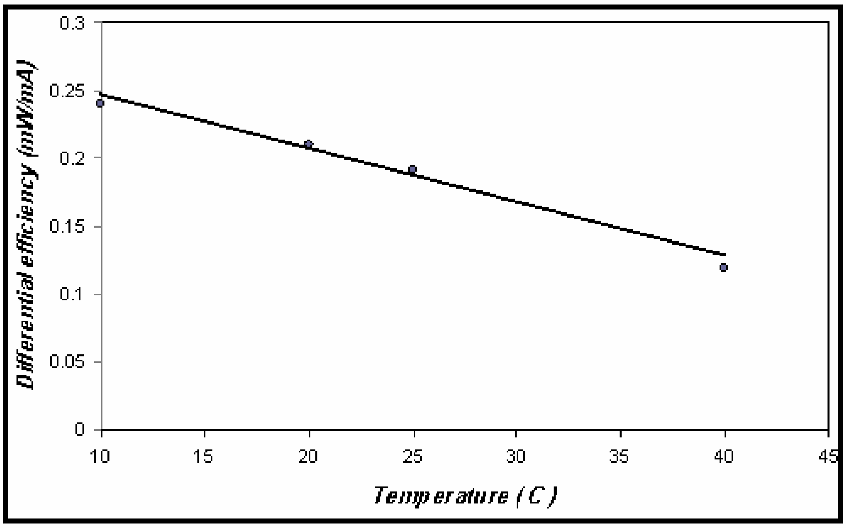


Fig (8) Differential Efficiency &Temperature Characteristics

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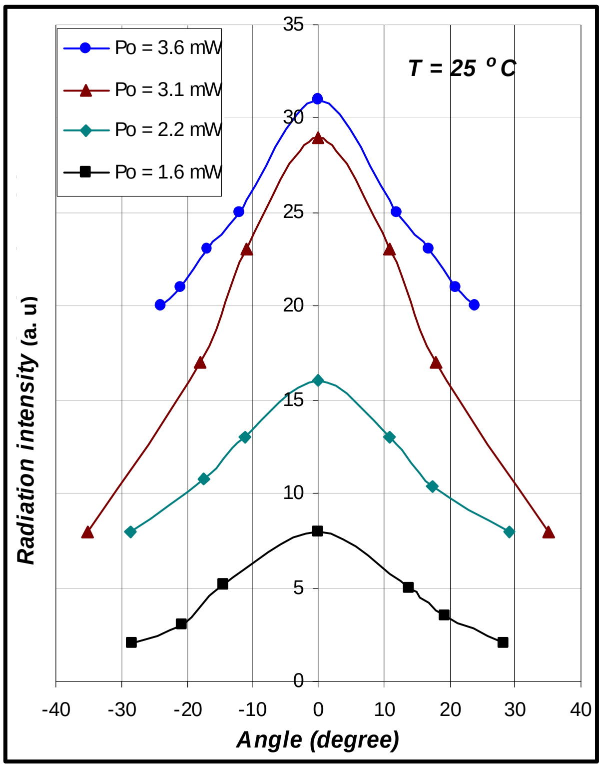

Fig(9) Power dependence of far field pattern (perpendicular to junction)

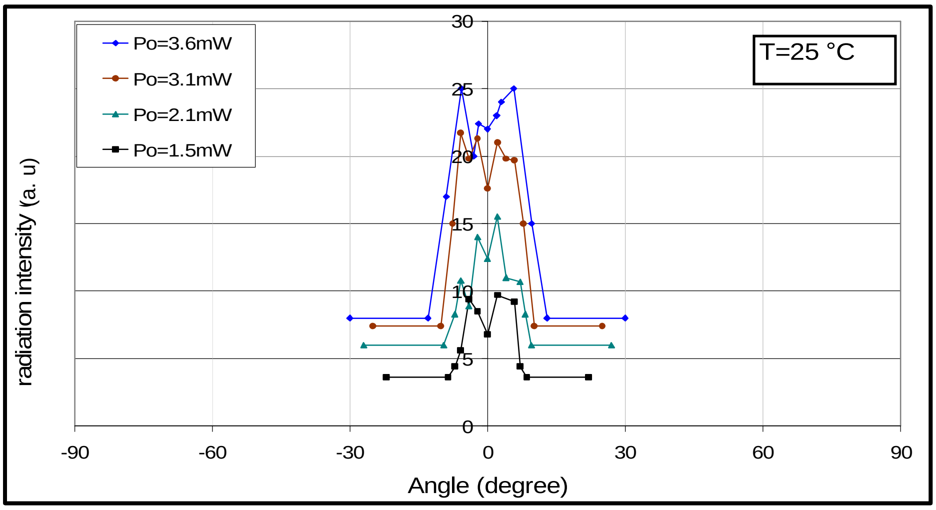

Fig (10) Power dependence of far pattern (parallel junction)

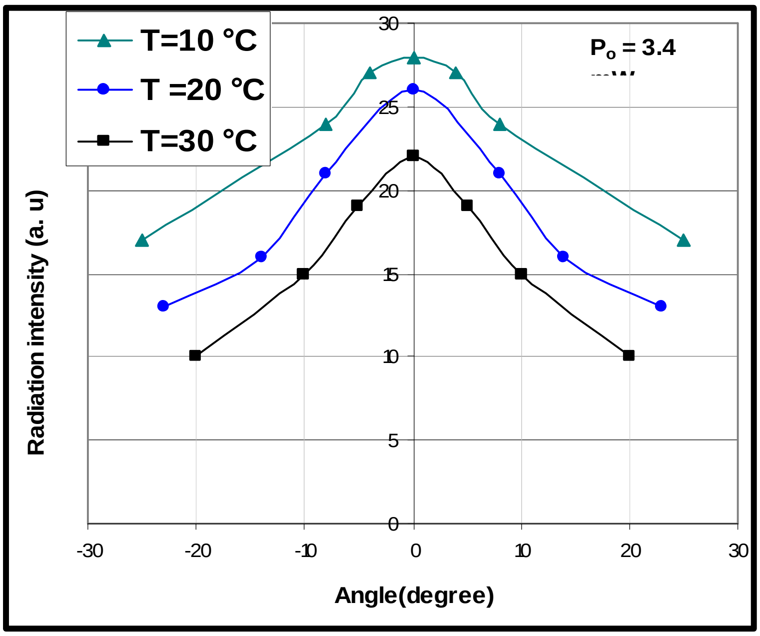

Fig (11) Temperature dependence of far pattern (perpendicular to junction)

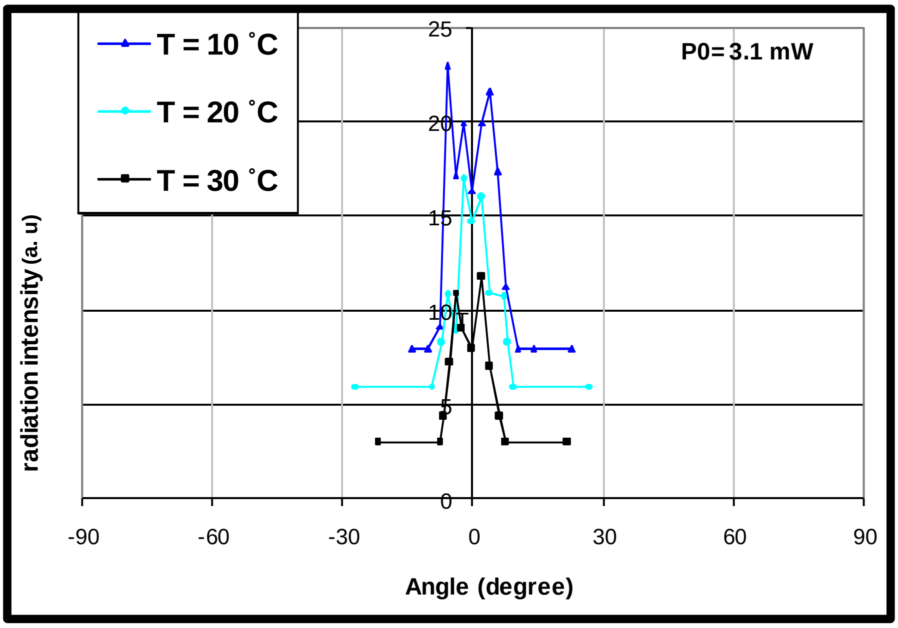

Fig (12) Temperature dependence of far pattern (parallel junction)