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Room Light Anodization of N-Type Silicon and Study of Its Photoluminescence

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Abstract: **N- type Porous Silicon(Porous-Si) has been fabricated using electrochemical anodization etching technique in presence of room light. The formation of pores and crystallinity of Porous layer is confirmed through XRD investigation. PL measurements reveals the blue luminescence of P-Si layer formed. FTIR results authenticate the presence of Si-O-Si and Si-H bends which could be one of the reason for blueluminescence.**

***Index Terms*: Blue Luminescence, FTIR, Porous silicon (P-Si), and XRD**

I. INTRODUCTION

Discovery of luminescence from Porous Silicon, a form of silicon having nanoporous holes in its microstructure, rendering large surface to volume ratio and exhibiting quantum confinement effects, has stimulated a lot of interest in exploting this unusual property of Porous-Si to promote silicon as a versatile material for application in the field of photonics and optoelectronics [1-2]. But silicon is an inefficient light emitter due to its indirect bandgap and thus limits its use in light emitting applications. And thus, predominantly III-V group compounds are used for fabrication of light emitting devices as they are direct band gap materials making them efficient light emitters. But these materials are much expensive than silicon and are difficult to integrate with the most dominating technology in electronics i.e., silicon microchips. Thus it would be advantageous to fabricated silicon based light emitters. This could be achieved using porous silicon. Many studies have been reported for synthesis of N-type porous silicon in under illumination and under no illumination [3]. In this paper N-type Porous-Si is synthesized using anodic electrochemical etching under room light i.e., no external light assistance is provided. And its photoluminescence is studied without any post treatments.

II. EXPERIMENTALSECTION MATERIALS:

All chemicals were obtained from commercial sources and used as received. N-type Si wafer <100> containing no dopant was purchased from sigma Aldrich. Hydrofluoric acid (40%) was procured from CDH. Platinum wire was used as cathode. Ethanol and acetonewere purchased from ChangshuYangyuan Chemical China and CDH respectively.

Synthesis of PorousSilicon(P-Si)

An N-type Si wafer, single side polished containing no dopant and having orientation along <100> , diameter 2 inches and thickness of 0.5 mm were etched. Teflon made etching cell was assembled having inner diameter 19 mm. Si wafer was cleaned prior to etching by sonicating it in DI water for 10 min and further in acetone for 15 min. Wafer was then placed into the etch cell with aluminum sheet as the backside contact. The aluminum sheet covers the entire back side of the wafer. The anodization was performed in the electrolyte of 40% aqueous HF and ethanol with a ratio of 1:2 at room temperature and in the presence of room light. Constant DC potential of 5V was applied across two electrodes of cell using METRAVI RPS-

3010. Here Si wafer serves as anode and Pt grid act as cathode. Reaction was carried out for 6 mins. After fabrication of porous samples, cell was unmounted and sample was rinsed in ethanol for 2-3 times and then was left fordrying.

Characterization

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X-ray diffraction (XRD) patterns were obtained from BRUKER D8 advance(CuKα radiation, λ = 1.5406 Å) diffractometer , FTIR spectroscopy was conducted using BRUKER ALPHA FTIR spectrophotometer in ATR mode. The Photoluminescence spectra were recorded on Hitachi F-7000 FL Spectrophotometer.

III RESULTS ANDDISCUSSIONS

The structural analysis of Porous silicon was achieved using **X-ray diffraction (XRD)** Analysis. The XRD pattern of Porous-Si is shown in Fig. 3.1 (a). Spectra shows a peak of intense crystallinity at 2θ = 69.2° similar to that of the silicon substrate **[JCPDS No. 75-0589]**, confirming good Porous-Si crystallinity even after anodizing. A new intensity peak appears at 2θ = 33.03° corresponding to 200 crystalline peak. This new intensity peak signifies formation of porous layer at the surface of (100) silicon. The sharpness of this new peak is an indication of crystalline nature of porous.

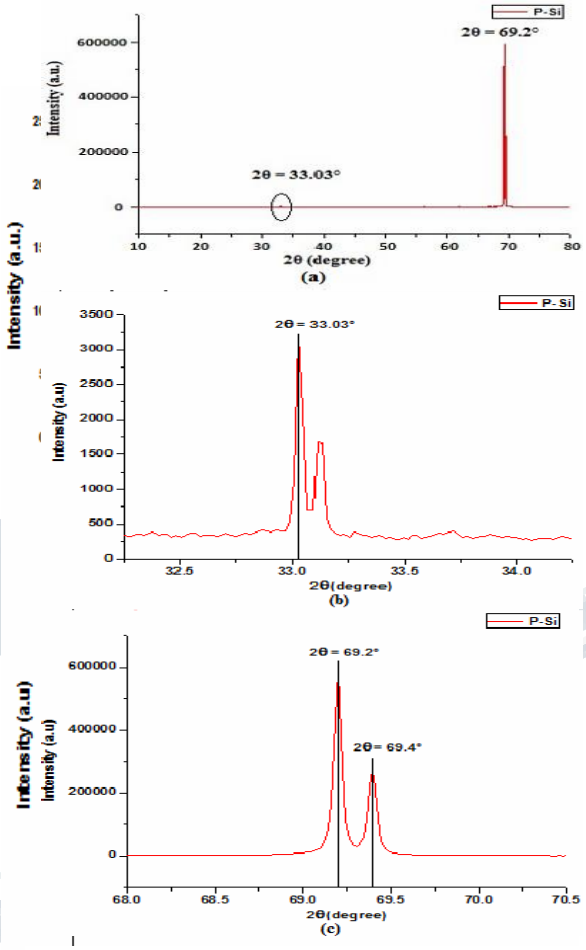

Fig. 3.1 (a) XRD spectra of as-prepared P-Si sample (b) zoom view of XRD peaks at 2θ = 69.2° and (c) zoom view of XRD peak at 2θ = 69.2°

Fig. 3.2 (a) PL spectra of P-Si corresponding to 325 nm excitation, (b) PL spectra of P-Si corresponding to 390 nm excitation.

layer . Fig 3.1 (b) and (c) shows zoom view of peaks at two angles. The crystallite size obtained using Scherrer formula is 35 nm. Particle size was also confirmed from AFM and TEM Analysis (images not shown).

Photoluminescence spectra of as-prepared P-Si are shown in Fig. 3.2. The PL spectra reveals a sharp peak at 426.8 nm corresponding to an excitation wavelength of 390 nm and a peak at 382 nm corresponding to an excitation wavelength,

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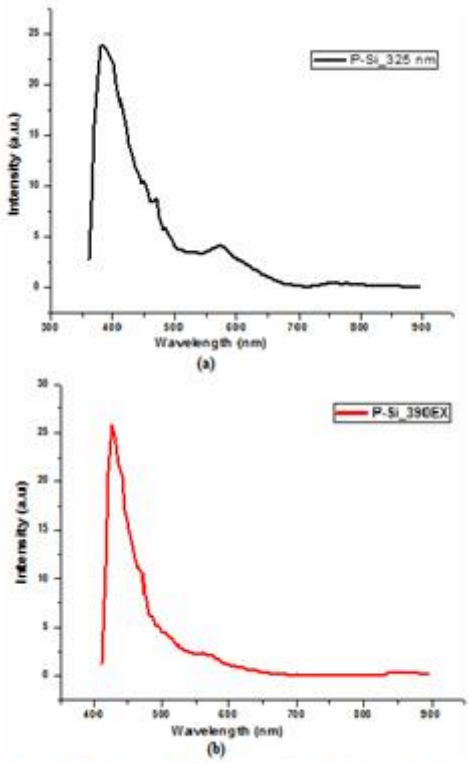

Fig. 3.2 (a) PL spectra of P-Si corresponding to 325 nm excitation, (b) PL spectra of P-Si corresponding to 390 nm excitation.

Of 360 nm. The luminescence obtained from as-prepared sample lies in the blue band which is quite rarely expected of porous silicon. This blue luminescence can be attributed to i) Remarkable increase in the size of the pores in silicon resulting in more confinement of Si leading to an increase in the energy band gap of silicon to the blue light region [4] . ii) Another reason might be the presence of hydrides (Si-H_X) formed during electrochemical reaction and presence of oxygen (Si-O-Si bonding) in the sample due to its ambient oxidation[5,6,7]. Further the presence of Si-O-Si and Si-H_X was confirmed from **FTIR spectra** (image not shown). FTIR transmittance spectra were performed in the range 500 - 4000 cm^{-1}. The peak present at 641.82 cm^{-1} corresponds to Si-H_2 scissor mode. Peak at 705.21 cm^{-1} can be assigned to Si-OH. The peaks at 811.40 cm^{-1} and 933.02 cm^{-1} shows existence of Si- H_2 wagging mode and Si-H_2 scissor mode respectively. The transmittance peak at 1180.67 cm^{-1} is an evident to the presence of Si-O-Si asymmetric stretching.

IV CONCLUSION

N-type porous silicon has been successfully fabricated under room light with appreciable crystallinity. XRD spectra confirmed P-Si formation with characteristic peak at $2\theta = 33.03°$. Crystallinity was justified by an intense peak in XRD at $2\theta = 69.2°$. Crystallite size calculated using sherrer formula is ~35 nm. Blue luminescence quantum confinement of silicon and to the presence of Si-O-Si and Si-H_X(x=1,2) bonds as confirmed by FTIR spectra. This blue emission of porous silicon can be used to fabricate blue LEDs.

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