The surface morphology of photo- 
luminescent porous silicon has turned the much 
attention to its electronic and optical properties1-2. 
The discovery of photoluminescence in porous 
silicon3 at room temperature generated its use in 
optoelectronic industries. The increasing use of 
silicon in integrated circuits and their techniques 
have been developed. The restriction on silicon over 
GaAs in making optoelectronic devices is due to 
indirect band gap of silicon. So efficient light emitting 
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been going on since last decade. Rather 
photoluminescence, electroluminescence4 is 
achieved at room temperature from porous silicon 
based optoelectronic devices. The formation of 
porous silicon in hydrofluoric acid electrolyte under 
anodic bias was reported first by Turner5 and Uhlir6. 
The anodic oxidation is widely used technique for 
preparation of porous silicon7-9. However 
electrodeless (stain-etching) techniques10-12 can also 
be used to grow porous silicon layers. Both thickness 
and structure of pore size can be controlled with 
anodic oxidation technique. This controls the 
electrical and optical behaviour10 of porous silicon 
layers. In this letter, we present a novel nano 
engineering technique of porous silicon preparation 
and optical properties of the formed porous silicon 
films. This new technique enable us to grow PS from 
vapors etchant instead of anodic oxidation. This 
technique can be used for etching the selective 
area of surface of semiconductor. It is an 
electrodeless technique for making less thicker layer 
compared to anodic oxidation. This technique 
presents a new nano structure for optical and 
electrical properties of interest of porous silicon. 
The capability of fabricating electroluminescence 
and photoluminescence devices, the pattern of 
nano-structured silicon is very important for 
application in flat panel display devices and 
monolithic integration. The electroluminescence is 
reported from stain-etched (HF:HNO3:H2O mixture) 
optical devices by Xu11. In this paper we present 
green and blue emission under direct UV light 
ilumination.

**INTRODUCTION**

Visible light emission is reported from boron doped p+ type porous silicon films. These films 
were prepared by stain etched method. In this method KOH pallets were used in de-ionized water 
at 75°C for etching silicon samples. Blue and green light area observed from these porous silicon 
samples. The visible photoluminescence originate from direct transitions between energy levels in 
the quantum wells.

**Key words**: Porous silicon(PS), photoluminescence (PL), 
Quantum Wells, quantum wires, stain-etching.

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$\Omega$-cm were used in 80% KOH solution (100 ml denozed water + 80 gm KOH pallets). The whole system is kept in temperature controlling bath at 75°C. A telfon cell used in order to expose silicon wafer surface to vapors evaporating from KOH solution as shown in fig. 1.

![Schematic diagram of a gas etchant cell. In this silicon surface is etched by fumes.](image)

Fig. 1: Schematic diagram of a gas etchant cell. In this silicon surface is ethed by fumes.

So after being exposed to silicon surface, vapors are constantly exhausted from the surface. The growth rate is about 50nm per minute. A UV lamp (365 nm) is kept at 30cm distant. During of porous silicon, the UV light exposure makes PL intensity stable. On decreasing the percentage of KOH solution, a monhomogeneous porous film is obtained. So to require a homogeneous layer of porous silicon the percentage of KOH solution can be increased. In this method the etching rate is less but a smooth and homogeneous PS layer is achieved. The samples were then rinsed in de-ionized water and dry with nitrogen. All measurements were carried out at room temperature under-ambient atmosphere.

RESULTS AND DISCUSSION

A weak photoluminescence of green (546nm) and blue (450nm) from porous silicon wafers were observed under excitation of UV lamp at the end of porous silicon formation. The formation mechanism of both samples was identical. The peak maxima of both samples are found at 546nm and at 450nm, which presented in fig. 5 and fig. 6. It is expected that the origin of these photoluminescence is from ‘S’ shaped quantum wires spread over the exposed surface. These ‘S’ shaped structure, called quantum wires, are observed to run perpendicular to surface and a morphology of interconnected pores and quantum wires is found. The transition energy ($\Delta E$) for green colour is $\sim2.27$ eV with 70% measured porosity while transition energy ($\Delta E$) for the colour with 80% porosity is $\sim2.8$ eV. It is also expected that the photoluminescence originates from transition in degenerate energy levels in the quantum wires. The direct transition dominated mechanism is believed. It is known that the different wavelengths are emitted from samples of different porosities and size of quantum wires in porous silicon. Table - 1 shows the combination of photoluminescence and quantum wells with porosity. The dimensions of the observed surfaces are summarized in the table 1. The dimension of sample-1 and sample-2 are compared, the quantum wells of small width are observed form sample-2 and it is noted that the quantum wells of 150 nm width are observed for sample-1, and quantum wells of 50 nm width are for sample-2. However the lateral extension of the surface remain almost constant.

<table>
<thead>
<tr>
<th>Porous silicon samples</th>
<th>Porosity (%)</th>
<th>Emitted wavelength</th>
<th>Quantum well width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample -1</td>
<td>70</td>
<td>546</td>
<td>450 nm</td>
</tr>
<tr>
<td>Sample -2</td>
<td>80</td>
<td>450</td>
<td>50 nm</td>
</tr>
</tbody>
</table>

Table 1: The summary of different wavelength for corresponding porosity and quantum well width is presented.

A blue of shift is observed as porosity is decreased. The photoluminescence spectrum taken from porous silicon films under UV (365) excitation has emission bands peaked at $\sim546$ nm and at $\sim450$nm. The recombination mechanism of luminescence is proposed by almost everyone. On the basis of experimental studies of photoconductive properties of porous silicon as anodized PS excited with UV light emit efficient visible photoluminescence and emission of electroluminescence at room temperature is
observed by applying forward bias voltage, so there exist a correlation between the porosity of porous silicon and photoluminescence. The results indicate that some carries are influenced by UV illumination and also, it enhances the PL intensity of emitted light to some extent. This silicon nano structure is obtained by gas etchant, core radius ionic cell is ~5 nm and therefore possibility of defect generation is negligible. This indicates that both green and blue emission might come from quantum wires via transition in conduction band.

However photoluminescence intensity could be enhanced. Although radiative recombination centers can be generated during illumination but these have no effect on photoluminescence intensity. It remains almost constant during experiment as shown in fig.1. The intense blue emission from carbon-plasma implanted porous silicon reported silicon reported by Liu et al., but a sustainable and stable intense photoluminescence is questionable. However the photoluminescence are confirmed by quantum wire model. To the best of our knowledge direct monochromatic visible light silicon sources are not present. A need of novel quantum wire engineering is to be developed to achieve low visible wavelength.

CONCLUSION

We reported porous silicon films fabricated with KOH fumes as etchant by exposing silicon wafer surfaces. The prepared films exhibit weak intense
green and blue emission. This emission of visible light is due to transition mechanism among the energy levels in quantum wires. The high porous surfaces show the blue shift. If emission of stable and intense visible light would be achieved from porous silicon, the crystalline silicon become the heart of optoelectronic industries. For this a quantum mechanical study is under way and would be presented in future.

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REFERENCES