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Optical and Electrical study of new Surface-Optical system of monocrystalline p-type <100> Si for Si-based micro/or nano devices at room temperature

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KEYWORDS

Continuous wave PL techniques, Silicon visible emissions, surface texture, optical and electrical properties of Si-based materials, Transmissivity of Si, DBR & Si- based microdevice

A B S T R A C T

The Si-based microdevices is a promising optical device and cheap. A key motivation of this study is using a new cheap thermal method plus internal Distributed Bragg reflector to create strong visible emissions at room temperature. So, we have applied a thermal method (LN2+50C0) to produce a new surface profile of monocrystalline p-type <100> Si and designed simple optical cavity ((Air-Si- Back Distributed Bragg reflector, BDBR of Ge, ~40nm in thickness). We calculated Transmissivity of Si and Si –BDBR of Ge using a technical computing language Matlab in order to understanding the effect of BDBR of Ge on (600-700nm wavelengths) emissions profile. In this paper, we present and discuss the results concerning the optical and electrical characterizations of new surface texture using PL (Ar+ laser - 514.5nm), AFM, Ellipsometery and IV characterizations. All measurements were carried out at room temperature. Changes in: surface profile, refractive index, IV and Spectra of the luminescence in visible region were observed and recorded. Cw luminescence intensity increases with increasing excitation power (0.6-0.9 watt) using BDBR, which serves for high reflection across active region (Si). The luminescence intensity does not saturate completely with range excitation power (0.6-0.9 watt).

Introduction

Since silicon is the dominant semiconductor in microelectronics, the development of Si-based microdevice would be advantageous for integrating optical and microelectronic components on the same chip [1].

Further reduction in broad band Transmissivity can be achieved by adding additional intermediate index layers, where a single index discontinuity is replaced by a continuous transition from low (Si) to high index material (Ge) as shown in this study. If this continuous index transition occurs over several wavelengths of optical path length, broadband Transmissivity (600-700 nm) approaching zero can be achieved.

A key motivation of this work is in using a new simple cheap thermal method (LN2+50C0). to create new surface profile of monocrystalline p-type <100> Si for new applications in visible region at room temperature.

Optical-Electrical-surface characterizations of the samples were carried out by photoluminescence (PL) (Ar+ laser - 514.5nm), Ellipsometery, I&V characterizations and AFM respectively at room temperature.

We calculated Transmissivity of Si and Si /internal DBR-Ge using a technical computing language Matlab for optical cavity design (air-Si – internal DBR-Ge) working in wavelengths (600-700nm).

Result and Discussion

A new simple cheap thermal method (LN2+50C0) was applied to create new surface profile for new optical and electrical properties of monocrystalline p-type <100> Si as shown in figures (1-2).

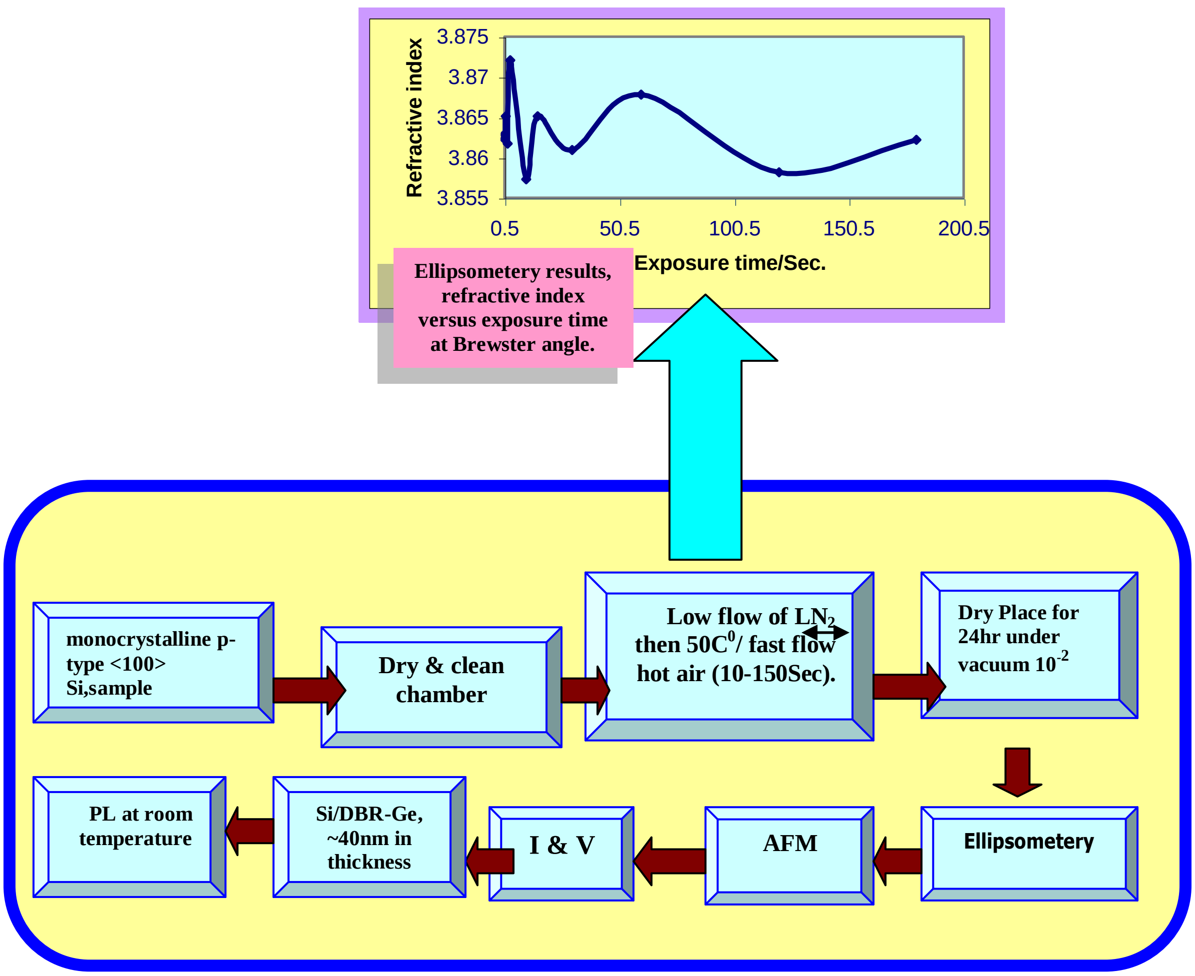

Fig.1 Schematic illustration of thermal method and measurements steps

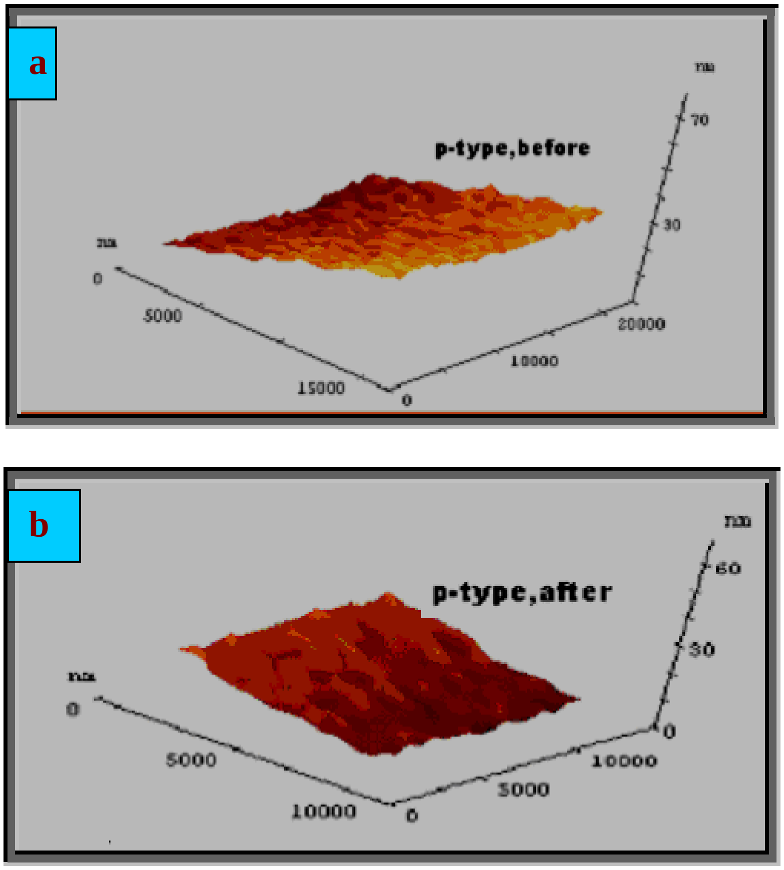

Fig.2 AFM surface morphology of monocrystalline p-type <100> Si:
a) Before treatment b) After treatment (LN2, $50C^0$)

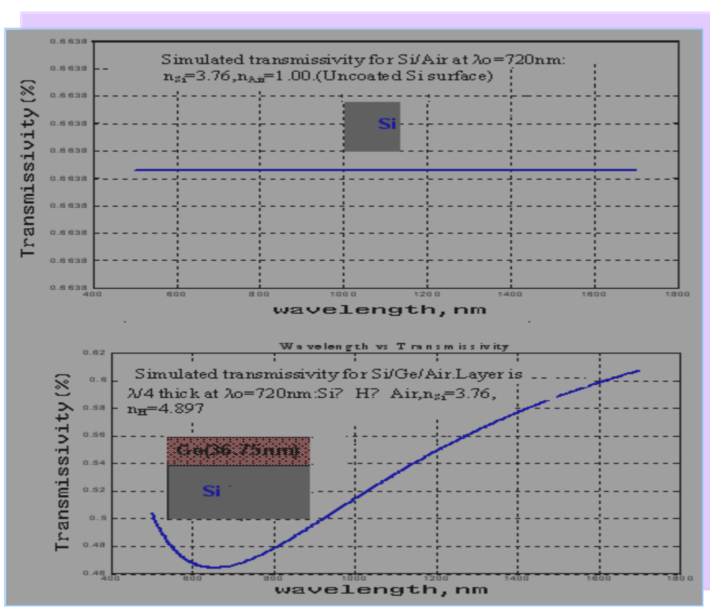

Fig.3 Transmissivity of Si and Si -BDBR-Ge using a technical computing language Matlab

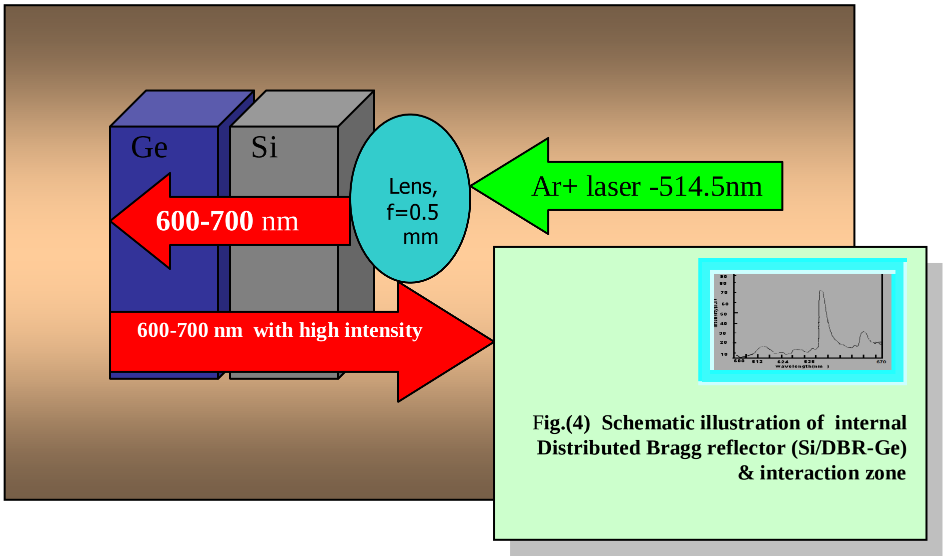

Fig.(4) Schematic illustration of internal Distributed Bragg reflector (Si/DBR-Ge) & interaction zone

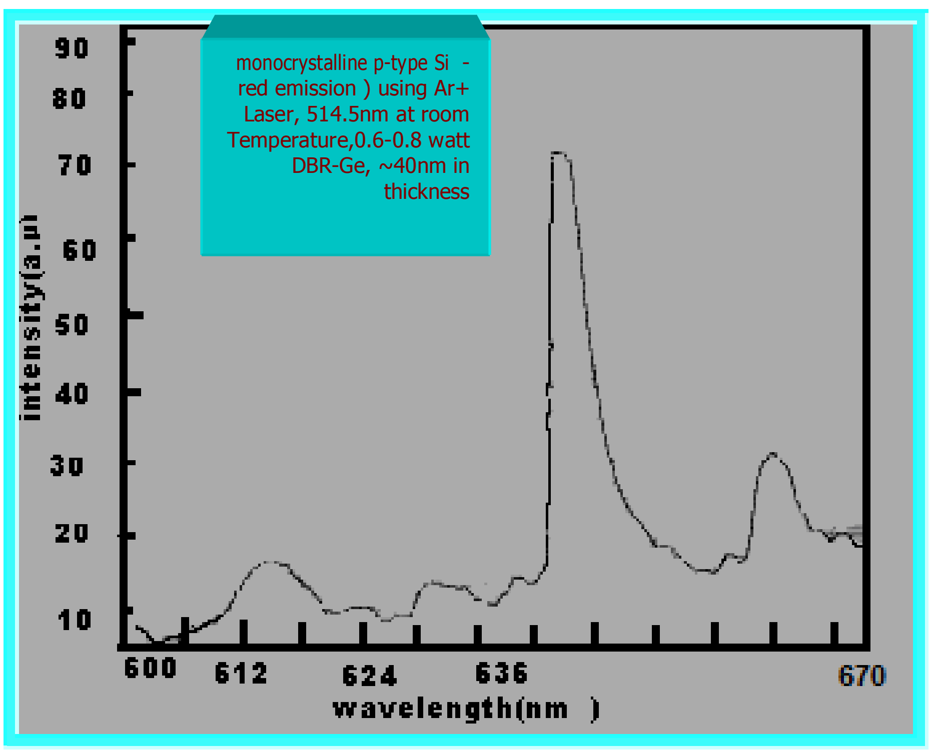

Fig.5 PL visible emissions of (treated monocrystalline p-type Si/ BDBR-Ge, ~40nm in thickness) using Ar+ Laser (514.5nm) at room Temperature

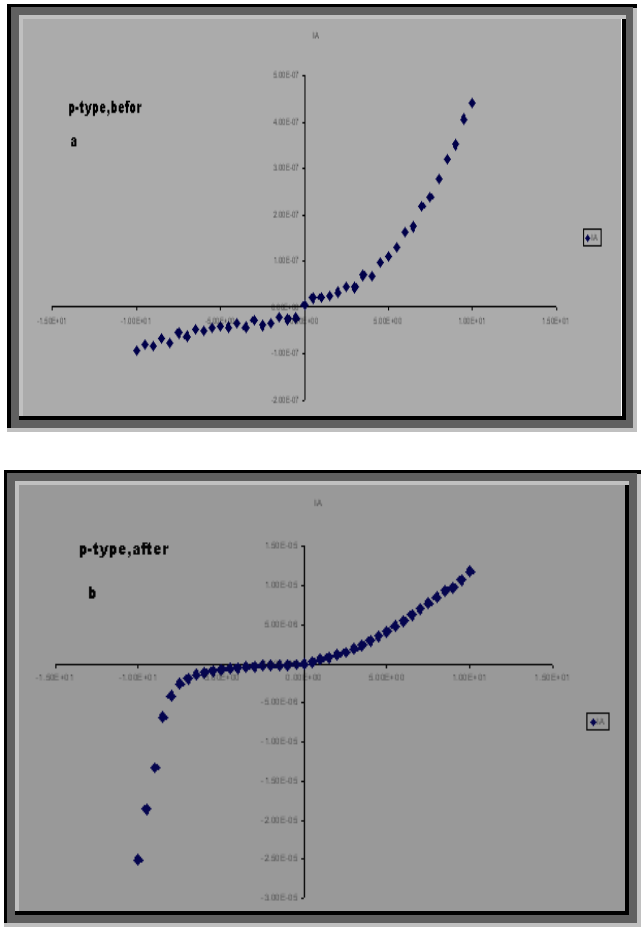

Fig. 6 I&V characterizations of new surface texture (monocrystalline p-type <100> Si) at room temperature

I&V characterizations are observed showing new Electrical properties (Fig.6) -to- new morphology (Fig.2) correspondence between wavelengths emission/or new intensity profile (Fig.5) -to- new morphology (Fig.2). New surface texture results of samples (PL, AFM, Ellipsometery and IV characterizations) are indicated that the new surface of silicon exhibit as a good physical system for selecting and controlling the radiative parameters. PL results indicate the well defined character of the new optical system using (BDBR-Ge,~40nm in thickness) for different applications. PL results of (Air-treated Si/ BDBR) were due to excitation of surface states (nanopatericals) which take its place through radiative recombination pathways.

This paper gives now the simple way to modulate the visible light emitted by the silicon. It also to improve the surface texture of the samples to further increase efficiency [2]

Conclusion

As mentioned in the introduction of this work: development of Si- based microdevice would be advantageous for integrating optical and microelectronic components on the same chip. So, new-organization of Si Surface particles with (BDBR-Ge,~40nm in thickness) in this study opens up the possibility of fabricating a whole variety of emitted photon /or Electron on silicon surface with possible applications in areas ranging from quantum optics to Electro-technology. However, further work is required to fully understand these new results which can lead to ultimate control of micro-nanodevices and its applications in different fields.

References

[1] L. Diehl et al., Appl. Phys. Lett. 81, 4700 (2002).
[2] Bull. Korean. Chem. Soc., 16, 1019 - 1023 (1995). Improved Photoluminescence from Light-emitting Silicon Material by Surface Modification.