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Production And Investigation About Structural Properties Of Silicon Layers

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Abstract: Silicon thin layers were deposited on glass substrates with the thickness of 100 nm. The layers were produced by electron gun method, under high-vacuum condition at room temperature. The structural details are determined by AFM method. The optical spectra were obtained by spectrophotometer in the spectral range of 400 −800 nm wave length range. Silicon clusters produced at 100 nm thickness and room temperature. Produced Silicon layers are not homogenous and don't have good conductivity because of low voltage profile. There is a peak at 3.4 eV in optical curves that depends to intrinsic property of silicon. At least there were a good agreement between optical and structure of produced layers.

Key words: Silicon; AFM; Spectrophotometer; thin films

INTRODUCTION

Periodically structuring a dielectric material in the sub-micrometer range can strongly modify its dispersion relation for optical wavelengths, allowing the control of light propagation and emission in ways not conceivable with its unstructured counterpart (Belotti *et al*., 2008). Such periodic dielectrics, commonly termed photonic crystals (PhC), have brought a great interest in both fundamental research and advanced applications (Belotti *et al*., 2008). Photonic crystals (PhCs) are an attractive sensing platform because they provide strong light confinement. Unlike many sensing platforms that utilize the interaction between the small evanescent tail of the electromagnetic field and the analyte, PhCs can be designed to localize the electric field in the low refractive index region (*e.g.* air pores), which makes the sensors extremely sensitive to a small refractive index change produced by bio-molecule immobilization on the pore walls (Lee and Fauchet, 2007). Extremely high-*Q* photonic crystal based cavity structures have been demonstrated in Silicon (Ndi *et al*., 2006). Silicon is the preferred material for various applications including switches, modulators, delay lines and on-chip interconnects due to its optical properties and the potential for integration with electronics (White *et al*., 2008). Silicon is transparent in the near infrared regime, and is heavily used for telecommunication purposes near the wavelength of 1.5 µm. However, silicon absorbs heavily in the visible wavelength range, and would be difficult to employ in light emitting and waveguiding devices at the visible wavelengths (Gong and Vučković, 2010). Silicon is non-toxic, relatively inexpensive, easy to process, and has quite good mechanical properties (Filios *et al*., 2009). The aim of this work is to produce silicon thin layer by electron gun method on glass substrate at room temperature from silicon powder and investigate about nano structure and optical reflectance and transmittance of produced layers.

Experimental Details:

Silicon films were deposited on glass substrates (18× 18 × 1 mm, cut from microscope slide) by using electron gun evaporation method, from tungsten boats, at room temperature. The evaporated material was a circle piece of pure silicon. An ETS160 (Vacuum Evaporation System) coating plant with a base pressure of 1×10^{-6} mbar was used. Prior to deposition, glass substrates were ultrasonically cleaned in heated acetone first and then in ethanol. The substrate holder was a disk of 36.5 cm in diameter with adjustable height up to 45 cm and also adjustable holders for placing any kind of substrates. Thicknesses of layers were determined by quartz crystal microbalance technique. Thickness of layers were 100 nm. The surface physical morphology and roughness were obtained by means of AFM (Dual Scope ^{TM} DS 95-200/50) analysis. The transmittance of films was measured using UV-VIS spectrophotometer (Hitachi U− 3310) instrument. The spectra of layers were in range of 400−800 nm wavelength (UV-VIS).

RESULTS AND DISCUSSION

Figure 1 shows, two dimensional AFM image of 100 nm thickness Silicon/glass layer, on 2 µm × 2 µm area. As it can be seen there are big clusters of silicon with less voids on glass substrate.

Figure 2 shows, three dimensional AFM image of produced layer in this work. In agreement with figure 1, there are big clusters of Silicon with less black colored voids on surface. Area of the image is 2 µm × 2 µm and the thickness of layer is 100 nm.

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Figure 3 shows, two dimensional phase image from same area of Silicon/glass layer. As it can be seen layer is not homogeneous and there are two different colors in this figure, cross section of the voids are black and cross section of Silicon clusters are lighter. Figure 4 shows, three dimensional phase image of produced layer in this work, difference between colors are more clear in this figure, that depends on production of a heterogeneous layer. Figure 5 shows, two dimensional AFM image of Silicon/glass 100 nm layer with an identified length by arrow. In this length as it can be seen from figure 5, there are big Silicon clusters and less voids between them. Figure 6 shows, the image profile of identified length, that clearly depends to kind of clusters (Silicon clusters) the average height of the Silicon cluster is about 107.5 nm and average wide is about 800 nm. Figure 7 shows, two dimensional phase image of Silicon/glass with a signed arrow. Figure 8 shows, the image voltage profile of signed length in figure 7. As it can be seen voltage of produced layer is very low (-8 up to -7.5) and this layer doesn't have good conductivity property that is because of high thickness of produced silicon layer. Figure 9 shows, two dimensional AFM image with identified area. Figure 10 shows the image height distribution of signed area in figure 9, that is in agreement with configuration Silicon clusters and thickness of the produced layer. Figure 11 shows, two dimensional phase image with identified area. Figure 12 shows, voltage image height distribution of signed area in figure 11, that is in agreement with other structural analysis.

Figures 13 and figure 14 show, Reflectivity and Transmittance curve of Silicon/glass of 100 nm thickness at room temperature, respectively. There is an increase in reflectance and a decrease in transmittance at about 3.4 eV energy that depends to structural intrinsic property of Silicon layers. As it can be seen from figures 13 and 14, for produced layer with 100 nm thickness we are encountered with about 50% reflectance and 50% transmittance.

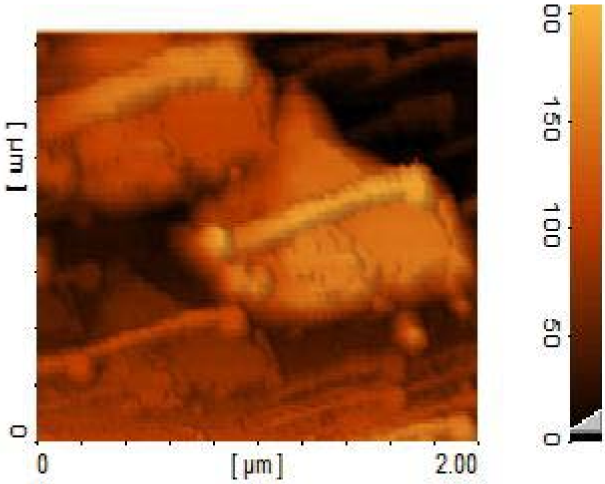

Fig. 1: two dimensional AFM image of 100 nm thickness Silicon/glass layer, on 2 µm × 2 µm area.

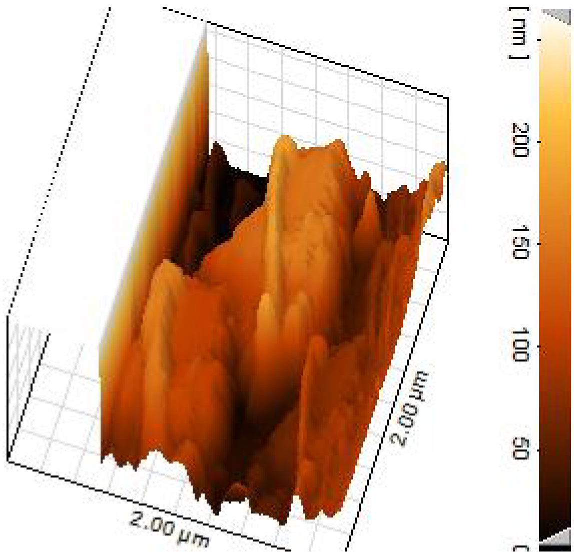

Fig. 2: three dimensional AFM image of 100 nm thickness Silicon/glass layer, on 2 µm × 2 µm area.

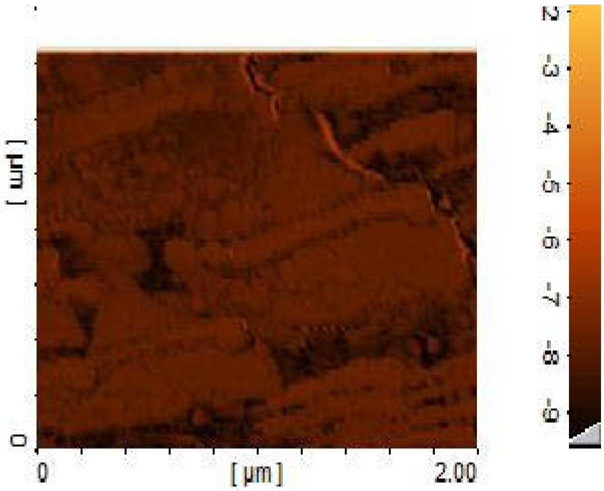

Fig. 3: two dimensional phase image of 100 nm thickness Silicon/glass layer, on 2 μm × 2 μm area.

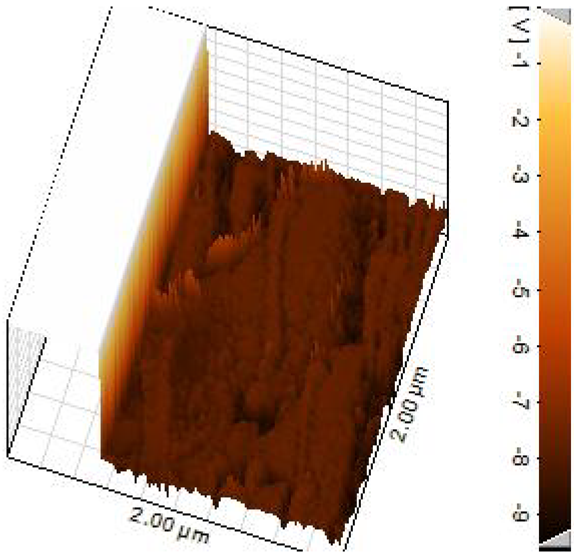

Fig. 4: three dimensional phase image of 100 nm thickness Silicon/glass layer, on 2 μm × 2 μm area.

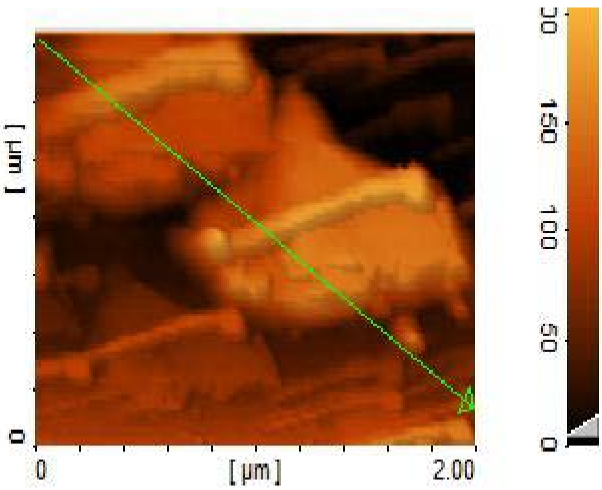

Fig. 5: two dimensional AFM image of Silicon/glass 100 nm layer with an identified length by arrow.

Fig. 6: image profile of Silicon/glass 100 nm layer with an identified length.

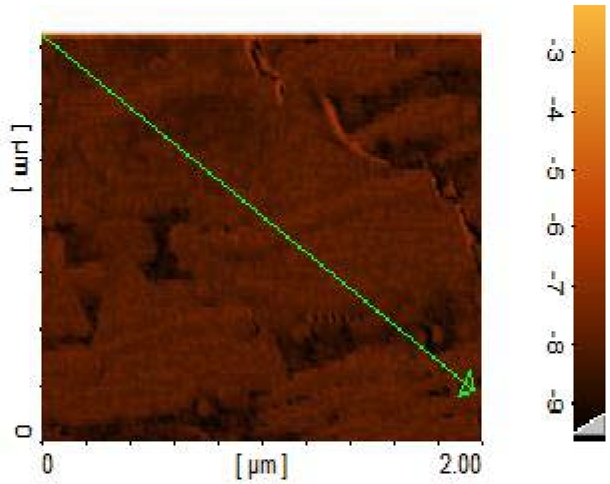

Fig. 7: two dimensional phase image of Silicon/glass with a signed arrow.

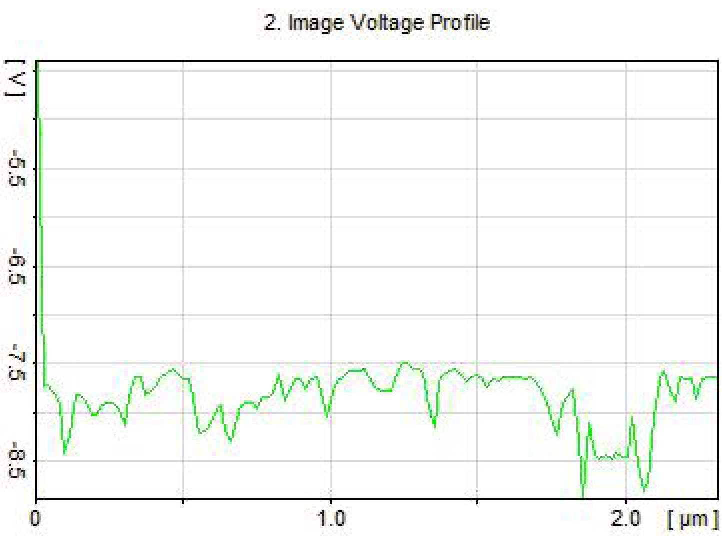

Fig. 8: The image voltage profile of signed length in figure 7.

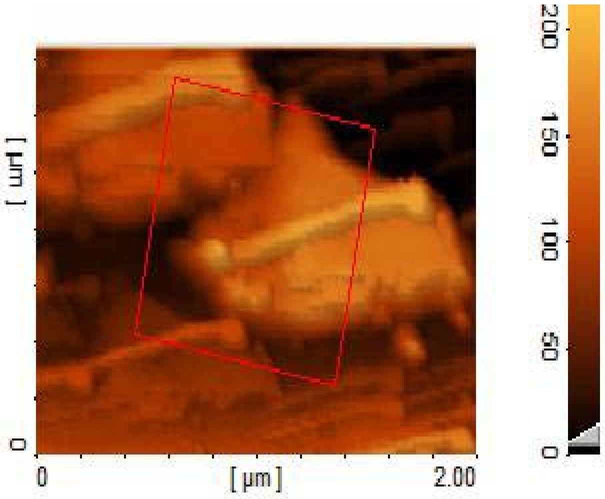

Fig. 9: Two dimensional AFM image with identified area.

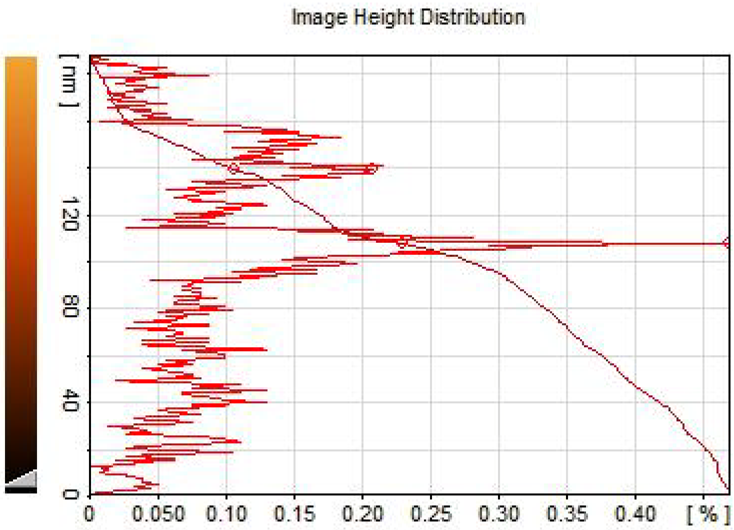

Fig. 10: The image height distribution of signed area in figure 9.

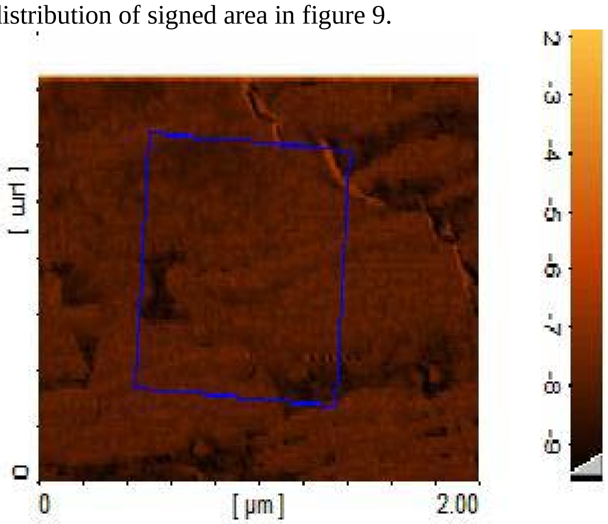

Fig. 11: Two dimensional phase image with identified area.

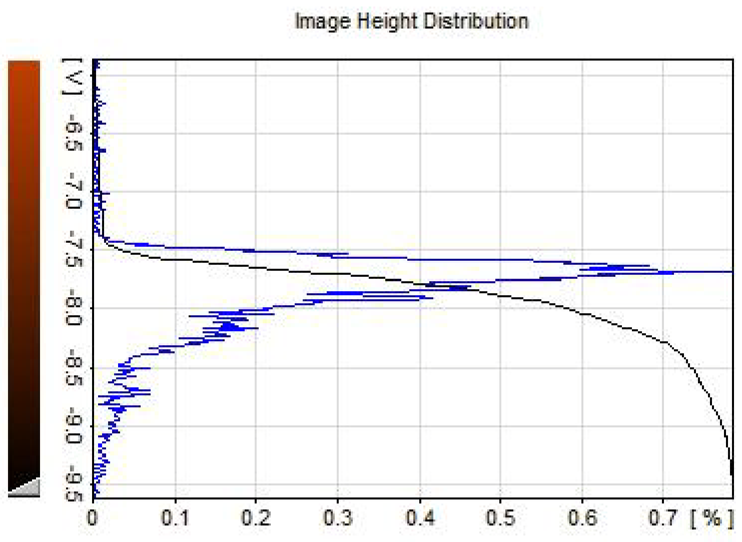

Fig. 12: voltage image height distribution of signed area in figure 11.

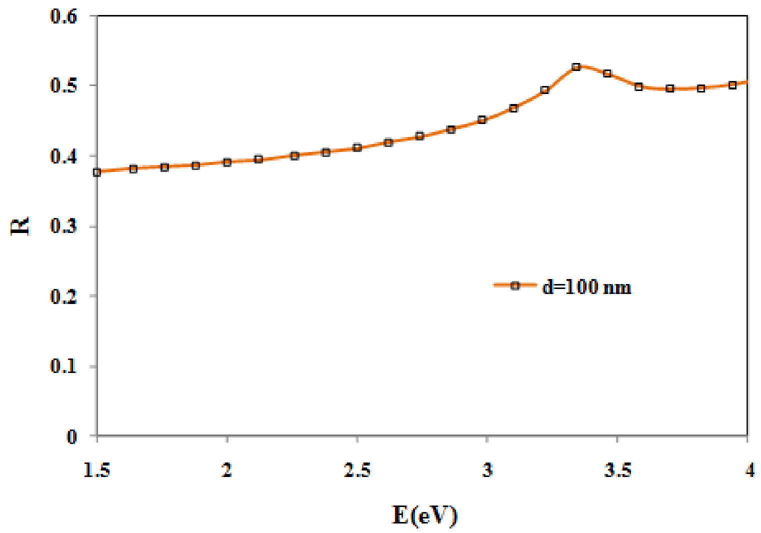

Fig. 13: Reflectivity curve of Silicon/glass of 100 nm thickness at room temperature.

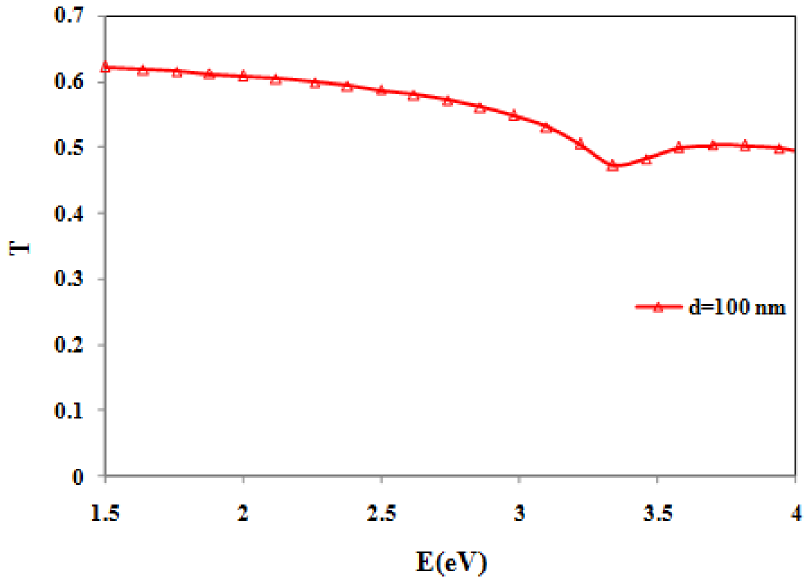

Fig. 14: Transmittance curve of Silicon/glass of 100 nm thickness at room temperature.

Summery:

Silicon layers of 100 nm thickness on glass substrate at room temperature and HV conditions were produced by electron gun evaporation method. Structural properties, voltage image, grain size and height distribution of produced layers were investigated by AFM method. There are clusters of Silicon on glass substrate with less voids between them. Silicon clusters have a low value of voltage and this layer acts as an insulator. Optical reflectance and transmittance were obtained by spectrophotometer at visible light wave length range. An increasing peak on reflectivity and a decreasing peak on Transmittance curves at 3.4 eV were appeared, that depends to intrinsic property of Silicon. For 100 nm silicon layer produced in this work, reflectance and transmittance of light were half and half percents.

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