[II~10]

Formation of silicon nanocrystallites by ion beam assisted electron beam deposition

Won Chel Choi[+*], Eun Kyu Kim[+], Suk-Ki Min[+], Chong-Yun Park[*], and Jae In Jeong[**]
[+]Semiconductor Materials Laboratory, Korea Institute of Science and Technology, P.O.Box 131, Cheongryang, Seoul 130-650, Korea, ekkim@kistmail.kist.re.kr
[*]Department of Physics, Sung Kyun Kwan University, 300 Chun Chun Dong, Suwon 440-740, Korea
[**]Research of Industrial Science and Technology, Pohang 790-600, Korea

ABSTRACT

Nano-crystalline silicon (nc-Si) thin films were directly deposited by ion beam assisted electron beam deposition (IBAED) method. The visible luminescence in IBAED samples were originated from not an oxygen bond but Si nano-crystallites. And we can conclude that the ion beam would be contribute to the suppression of the Si-O bond formation.

INTRODUCTION

With increasing the interest about the emission from the silicon semiconductors such as porous silicon and nano-sized silicon crystallites, the various methods[1-3] has been attempted for fabrication of the silicon-based light emitting devices. Especially, in the case of the nano-crystalline silicon (nc-Si), it was reported that the wavelength of the emission can be controlled with respect to the size of nc-Si. Also, there are many methods for the formation of nc-Si[4-6]. The formation of the nc-Si through the post-annealing was a widely known method. In recent, a direct formation of nc-Si has been attempted by many researchers[7,8]. In this work, we introduce the new methods, ion beam assisted electron beam deposition (IBAED), for direct formation of the nc-Si. The IBAED method showed that the size and density of the nc-Si might be controlled by the various conditions of the ion beam.

EXPERIMENT

The amorphous silicon thin films were deposited by the IBAED methods on silicon substrates. The IBAED was performed at room temperature in 6×10^{-6} Torr pressure with argon ion beam, and then the growth rate of amorphous silicon film was 0.5 nm/sec. The post-annealing for the prepared samples were performed by rapid thermal annealing(RTA) and furnace annealing methods. The images of the nano-crystallites were investigated by high resolution transmission electron microscopy (HR-TEM), and the chemical binding of Si, O, H, and N were traced with Fourier transformed infrared spectroscopy(FTIR) and Auger electron spectroscopy(AES).

RESULTS AND DISCUSSION

Figure 1 shows the HR-TEM image obtained from as-deposited sample prepared by IBAED, electron beam deposition technique with argon ion beam assistance. As the result of HR-TEM measurements, we could observe the nano-sized crystallites in the ion beam assisted samples as shown in Fig.1, while nano-crystallites were not included in the sample deposited by electron beam method without ion beam assistance. However, the visible luminescence can be observed from both of the samples as shown in Fig. 2. In Fig. 2(a), the color emitted from the sample deposited by electron beam without ion beam is redish-yellow. Comparison with HR-TEM photograph(not shown here), which was not appeared any nano-crystallites, we think that this PL signal was originated from Si-O bond. After post-annealing to this IEABD sample, the PL signal was shifted to the longer wavelength (772 nm) and the PL signal related to Si-O bond was not appeared as shown in Fig. 2(b). This PL signal is compatible with the size distribution obtained from HR-TEM image (Fig.1). This change can be explained by the increase of the nc-Si size and its uniformity after the thermal treatment.

CONCLUSIONS

In the samples deposited by electron-beam without ion beam assistance, the luminescence was responsible to the Si-O bonding. However, the visible luminescence in IBAED samples were originated from not an oxygen bond but Si nano-crystallites. From these results, we can conclude that the ion beam would be contribute to the suppression of the Si-O bond formation, effectively.

ACKNOWLEDGEMENTS

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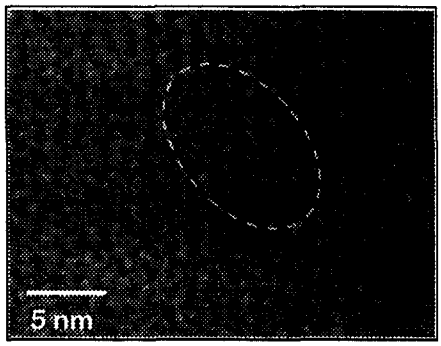

Fig. 1. Cross-sectional HR-TEM image obtained from the sample deposited by the IBAED method.

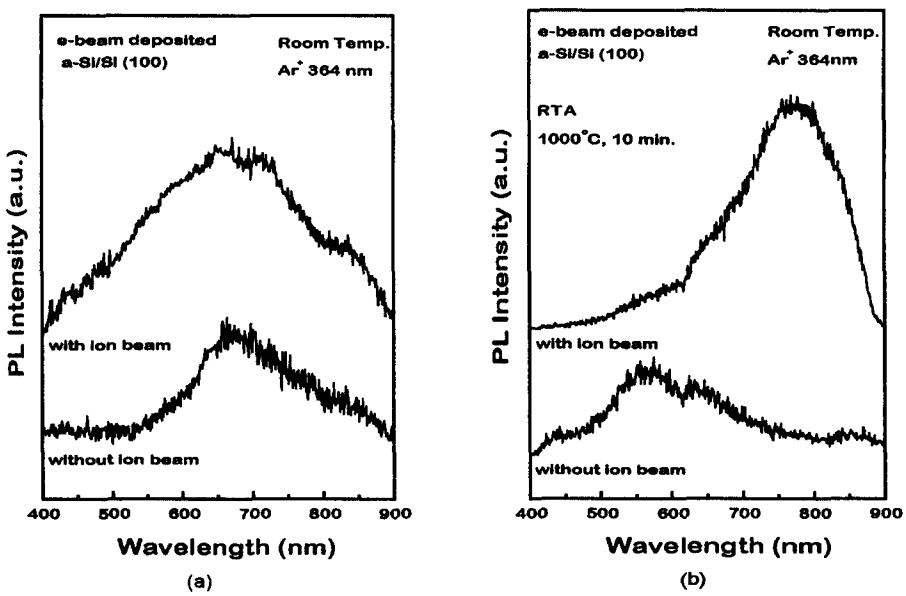

Fig. 2. The PL spectra obtained from (a) as-deposited and (b) post-annealed samples with and without ion beam assistance, respectively.

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