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The effect of thermal anneal on luminescence and photovoltaic characteristics of B doped silicon-rich silicon-nitride thin films on *n*-type Si substrate

Se-Young Seo[1], In Yong Kim[1,2], Seung Hui Hong[1,3], and Kyung Joong Kim[1]

[1]Division of Industrial Metrology, Korea Research Institute of Standards and Science (KRISS), Korea.
[2]Department of Physics, Korea Advanced Institute of Science and Technolgy (KAIST), Korea.
[3]Department of Applied Physics, Kyung Hee University, Korea.

The effect of thermal anneal on the characteristics of structural properties and the enhancement of luminescence and photovoltaic (PV) characteristics of silicon-rich silicon-nitride films were investigated. By using an ultra high vacuum ion beam sputtering deposition, B-doped silicon-rich silicon-nitride (SRSN) thin films, with excess silicon content of 15 at. %, on P-doped (*n*-type) Si substrate was fabricated, sputtering a highly B doped Si wafer with a BN chip by N plasma. In order to examine the influence of thermal anneal, films were then annealed at different temperature up to 1100 ^{o}C under N_2 environment. Raman, X-ray diffraction, and X-ray photoemission spectroscopy did not show any reliable evidence of amorphous or crystalline Si clusters allowing us concluding that nearly no Si nano-cluster could be formed through the precipitation of excess Si from SRSN matrix during thermal anneal. Instead, results of Fourier transform infrared and X-ray photoemission spectroscopy clearly indicated that defective, amorphous Si-N matrix of films was changed to be well-ordered thanks to high temperature anneal. The measurement of spectral ellipsometry in UV-visible range was carried out and we found that the optical absorption edge of film was shifted to higher energy as the anneal temperature increased as the results of thermal anneal induced formation of Si_3N_4-like matrix. These are consistent with the observation that higher visible photoluminescence, which is likely due to the presence of Si-N bonds, from anneals at higher temperature. Based on these films, PV cells were fabricated by the formation of front/back metal electrodes. For all cells, typical I-V characteristic of *p-n* diode junction was observed. We also tried to measure PV properties using a solar-simulator and confirmed successful operation of PV devices. Carrier transport mechanism depending on anneal temperature and the implication of PV cells based on SRSN films were also discussed.