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GaN nanocrystal formation in a SiO_2 matrix

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Abstract: The combination of ion implantation with annealing is an attractive process for the synthesis of semiconducting nanomaterials. Towards the integration of light emitting devices in Si substrates, GaN nanocrystals were fabricated *via* Ga and N implantation in a 1 μm-thick SiO_2 layer followed by rapid thermal annealing. The N and Ga atoms were sequentially implanted with energies 180 and 50 keV, respectively and fluences 6×10^{16} Ga ions /cm^2 and 7.5×10^{16} N ions/cm^2. The samples were annealed using a halogen flash lamp (rapid thermal annealing) for 30 sec in the temperature range 800 to 1300 ^{o}C. Rutherford backscattering spectroscopy, using 1.4 and 3.7 MeV He ions, revealed that Ga and N were implanted up to a depth of approximately 250 nm. Annealing at temperatures higher than 1000^{o}C causes considerable loss of Ga, as identified in the X-ray fluorescence spectra (Fig. 1). The formation of GaN nanocrystals upon annealing at 1000^{o}C is identified in the Ga-K-edge X-ray absorption fine structure spectra recorded at the KMC-II beamline of the synchrotron radiation facility BESSY-HZB (Fig. 2). Reduction in the coordination numbers is observed due to size effects. At annealing temperatures lower than 1000^{o}C, only one nearest neighbouring shell, consisting of 3 oxygen atoms at the distance of 1.88 Å, is detected. This is also the case for the sample annealed at 1200^{o}C, where middle-range order is lost. This result is attributed to loss of nitrogen which is characterized by much higher diffusion coefficient than Ga. The results suggest that ideal annealing temperature for GaN formation without considerable loss of Ga or N is 1000^{o}C.

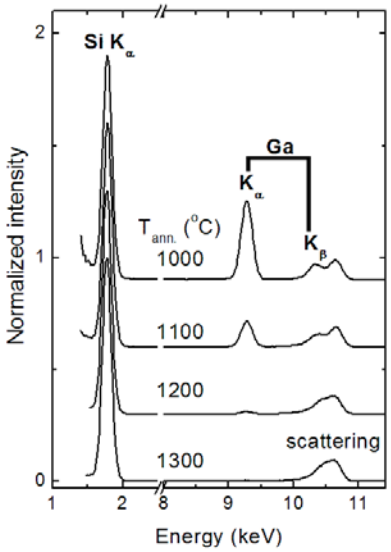

Fig. 1: *X-ray fluorescence spectra of the samples annealed at 1000 to 1300 ^{o}C for 30 sec*

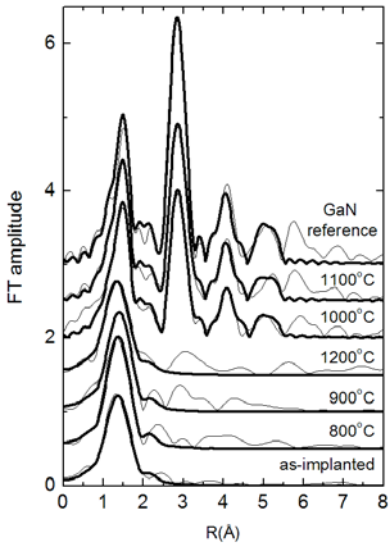

Fig. 2: *Fourier transforms of the X-ray absorption fine structure spectra of a reference GaN as well as of the as-implanted and annealed samples for 30 sec at 800 to 1200 ^{o}C.*

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