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Rare-earth (RE) impurities doped GaN are highly promising candidates for light emitting device applications due to their efficient electroluminescence properties at room temperature. Among those, Eu doped GaN has been identified as an excellent material for the red spectral region due to its strong emission at 620 nm. As a transition internal to the Eu doping atom (4f-4f), light emission originates in a much smaller complex than the more flexibly controllable quantum structures of wells, wires, and dots. This is thought to make the center less susceptible to structural defects and in particular radiation damage in the lattice host. Nevertheless, the lattice host is crucial for providing the excitation in from of free electrons and holes. In this respect, the actual lattice site Eu occupies in the host lattice, i.e. in GaN, is important. A large fraction of Eu atoms are typically inactive which must be attributed to their lattice site and local environment.

GaN films implanted with Eu to concentrations of ~10^{18} cm^{-3} were subjected to a highly directed beam of 500 keV He^+ at a dose of $5x10^{14}$ cm^{-2}. By means of a shadow mask, irradiated and unexposed regions lie very close to each other on the same sample. We used optical and structural analysis to identify the exerted radiation damage.

At the full radiation dose, photoluminescence intensity has decayed to ~0.01 of its initial value. From the dose dependence of the radiation decay we previously concluded, that this decay is in part due to the destruction of radiative Eu sites [J.W. Tringe, unpublished (2006)]. Along the transition from virgin to irradiated material we analyze the accumulated damage in terms of surface morphology (atomic force microscopy), crystallinity (x-ray diffraction), and phonon dispersion using micro-Raman spectroscopy. In addition to the well-studied E_2(high) mode, two new vibrational modes at 659 cm^{-1} and 201 cm^{-1} were observed in the Eu implanted and annealed sample, prior to He^+ irradiation. These modes are either remnants of the implantation damage or related to the Eu impurity. As such they can be indicative of the actual lattice site the Eu atom resides on. After irradiation, broad Raman modes at 300 cm^{-1} are being observed. This band indicates disorder activated Raman scattering (DARS) due to the radiation damage. An additional narrow mode appears at 672 cm^{-1}, which can possibly be due to a nitrogen vacancy related vibrational mode.

The continuous transition from irradiated to un-irradiated sample allows the direct evolution of radiation damage and its coordinated effects in structural, optical and vibrational properties. By its systematic correlation we anticipate to be able to elucidate the Eu lattice interaction and the processes of radiation damage.

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