CFG4 Fig. 3. Current-voltage characteristics of a small area nanopost InGaN MQW p-n junction nanopost arrays, fabricated by electron beam lithography and specialized planarization and process techniques.

ciency for the patterned structures are in strong contrast to conventional III-V and II-VI semiconductors, where surface recombination at the etch-exposed vertical walls of the QW is quite detrimental on the 100 nm lateral scale and below. We have applied time resolved PL techniques to elucidate the recombination process further.

As the first step towards electrically injected subwavelength structures, light emitting diode type device structures were designed and fabricated. We overcame the challenge of these deeply etched arrayed nanoposts by using spin-on-glass coating and etchback to planarize the structure and electrically isolate the nanoposts. Transparent electrodes of indium-tin-oxide were deposited to make micron size common top contact plane to all the nanoposts. The device was working under cw current with a turn-on voltage around 4 volts, as shown in Fig. 3. The spectroscopic details and performance of these LEDs are presently being investigated further.

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CFG5 11:15 am

Ultrashort Hole Capture Time in Mg-doped GaN Thin Films

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GaN-based semiconductors have potential applications for optoelectronic devices in the UV-blue

wavelength regions and electronic devices capable of operation at high-temperature and high-power conditions. There are great efforts devoted to improve the hole properties in p-type GaN.^{1,2} Presently, p-type GaN doping is achieved mostly with Mg impurities. Defect-related transitions in GaN:Mg will strongly affect its hole behaviors in p-type GaN and are crucial for high-performance device applications. Here we report our investigation on the hole capture time into shallow Mg-related impurities. Ultrashort capture time constants of 10–80 ps depending on Mg doping concentration and excess hole energy are determined.

Our studies were performed on 0.5–1.0 μm -thick Mg-doped GaN thin films grown on top of undoped GaN substrates with doping concentrations of $0.1 - 5 \times 10^{19} \text{ cm}^{-3}$. Previous photoluminescence studies indicated that the Mg-related level is $\sim 200 \text{ meV}$ above the valence band.³ Efficient photoluminescence corresponding to conduction band to this level transition, with a wavelength of $\sim 387 \text{ nm}$ (3.2 eV) can be observed at room temperature.³ Femtosecond degenerate pump-probe experiments were performed on these p-type samples at wavelengths of 365–382 nm using 200 fs UV pulses in order to investigate their hole dynamic behaviors. Calibration experiments have also been performed on different samples in order to rule out contribution from other defects and undoped GaN substrates.

Fig. 1 shows a typical measured transient transmission trace for GaN:Mg (doping density $5 \times 10^{19} \text{ cm}^{-3}$) with pump/probe photon energy of 3.25 eV (382 nm) corresponding to conduction band to Mg-related level transition. Carrier relaxation time longer than 200 ps can be observed, indicating prolonged electron lifetime. Similar results were all observed in different doping density samples. When we tuned the excitation wavelength to band-to-band transition at 365 nm, a clear exponential-like relaxation can be observed after the transmission increased due to phase-space filling (figure 2). It is interesting to notice that this fast relaxation component occupy 50% of the observed pump-induced transmission change. We attribute this one half signal with fast relaxation time to hole dynamics while the other one-half signal with slow relaxation time to

CFG5 Fig. 1. Measured transient transmission response for p-type GaN thin films with pump-probe photon energy 3.25 eV (382 nm).

CFG5 Fig. 2. Measured transient transmission response for p-type GaN thin films with pump-probe photon energy 3.40 eV (365 nm). The dotted line is a convolution fit using a single exponential decay.

electron dynamics due to its long lifetime. This slow relaxation can be understood as the capture of photoexcited holes into the deeper bandtail and Mg-related impurity states.⁴ Through convolution fitting, a decay time constant of 10 ps was obtained. By conducting the same experiments on other samples, we have found that this hole capture time increases with decreased doping concentration, supporting the fact that the capture process is related to the Mg-related impurities. By tuning the pump/probe wavelength from 365 nm to 382 nm, the observed relaxation time becomes longer as the excess energy decreases. More details will be presented in the conference including their doping concentration dependency. This observed ultrashort hole capture time will strongly affect the hole transport dynamics on p-GaN and will have serious impact on GaN device performances.

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