**Optical acceptor ionization in III-nitrides**

Steven F LeBoeuf
Edward B Stokes
Andrew Cao
Aba Ebong
Peter Sandvik

General Electric Corporate Research & Development
Schenectady, NY 12301

One of the fundamental limitations in development of wide bandgap light emitting devices is the ability to achieve suitable electron and hole carrier levels for radiative recombination. This limitation is especially strong with p-type dopants in the III-nitride system. For example, the Mg acceptor level in GaN is reported to be 150-165 meV [1] above them valence band, severely limiting the number of ionized acceptors at room temperature. Mg acceptor ionization levels are even larger in AlGaN than in GaN. [2]

The equilibrium condition for wide-band gap materials $\left[ n_i^2 = n_0 p_0 = e^{E_g/2kT} \right]$ combined with the relatively large unintentional background carrier density in typical AlGaN epilayers, hinders the realization of high p-doped AlGaN. One way to circumvent this problem is through “optical pumping”: steady state continuous optical ionization of acceptors. This process seeks to use long wavelength photons to excite electrons from the valence band into acceptor levels, and is distinct from the process of optical pumping of e.g. solid state lasers, whereby valence electrons are excited into the conduction band.

Ni-Au Metal-Semiconductor-Metal (MSM) devices were fabricated on Mg-doped GaN, Zn-doped GaN, and Mg-doped AlGaN. Photoconductive structures were also fabricated on Si-doped GaN. Devices were exposed to incoming red or near-infrared radiation (wavelength 0.6 to 3 um) at room temperature, and changes in conductivity were measured both with and without external bias.

In Mg doped GaN, it is found that roughly $1 \times 10^{17}$/cm3 holes can be generated for every 2.5 mW of incident 1.06 mm radiation; see figure 1. These results are quite encouraging for the development of 280-nm III-nitride emitters, where free hole densities are low at equilibrium. Indeed, since light generation in a quantum well (QW) LED is directly related to the injected carrier density, over an order of magnitude higher light generation can be fancied by IR-pumping 280-nm UV emitters.

This work was supported in part by DARPA contract # N66001-01-C-8589

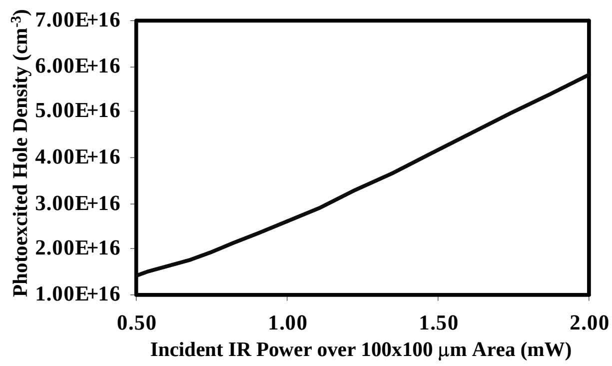


Figure 1 - Photoexcited hole density vs. IR Power density: Test was performed on Mg-doped p-GaN MSM photoconductors using 1.06 um light as the excitation source. For every 2.5 mW of IR light, about $1 \times 10^{17}/cm^3$ holes are generated.

References:

1 - I Akasaki, H Amano, M Kito, and K Hiramatsu, J Luminescence, **48/49**, 666 (1991).
2 - A Saxler, W Mitchel, P Kung, and M Razeghi, App Phys Let, **74**, 2023 (1999).