Infrared photocurrent spectroscopy of epitaxial III-nitride materials on sapphire

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Achieving carrier concentrations at sufficient levels for effective device performance, particularly in p-type material, remains one of the pervasive challenges in compound semiconductor technology. In wide bandgap materials such as the III-nitrides, acceptor ionization energies are often too high to allow thermal ionization of significant dopant atoms at nominal device operating temperatures.

Theoretical optical absorption cross-sections of dopant atoms in wide bandgap semiconductors indicate that it should be possible to create carriers in doped material through intraband infrared optical excitation rather than thermal excitation. Besides enabling enhanced device performance, this strategy of "infrared pumping" could create a new class of integrated photonics through direct infrared optical control of III-nitride emitters.

We report transient photocurrent spectra of n–type and p-type GaN and $Al_{0.20}Ga_{0.80}N$. Metal-semiconductor-metal (MSM) test structures were fabricated using nickel-gold contacts on silicon doped n-type and magnesium doped p-type epitaxial GaN and $Al_{0.20}Ga_{0.80}N$ (~2 um thick) on sapphire (Honeywell Labs, Minneapolis, MN). MSM's biased at 5.0 V DC were top illuminated with 1.35 to 4.95 um, < 10 ns, pulses from a Nd:YAG pumped optical parametric oscillator/amplifier (OPO/OPA) (Laservision, Bellevue, WA). In our experimental setup, the biased MSM served as the input stage of a transimpedance amplifier (Terahertz Technologies, Oriskany, NY), and the transient photocurrent response, converted to a transient voltage across the feedback resistor, was measured on a digital oscilloscope.

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