Laser writing of hydrogen containing III-N-Vs

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The incorporation of a small concentration of N-atoms into the anion sublattice of a III-V compound induces a large reduction of the band gap energy. On the other hand, H-atoms tend to neutralize the electronic activity of N by forming N-H complexes [1]. Here we exploit these unique properties and a focused laser beam to profile the band gap of III-N-Vs [2-3].

We show that the N-H complex can be dissociated by light due to a resonant photon absorption. This is a local process that depends on the photon energy (Fig. 1a) and can be activated at temperatures as low as 4.2 K, significantly smaller than those required for thermal dissociation (> 200 °C). The photon-assisted N-H dissociation provides a means of profiling the band gap energy of a III-N-V alloy: nanoscale light emitting spots in the visible and near infrared region are laser-activated in Ga(AsN), (InGa)(AsN) and Ga(PN); profiles of different shapes are patterned in the growth plane with submicron spatial resolution and high energy accuracy (Fig. 1b). Moreover, the patterned profiles are erasable and the samples can be re-hydrogenated making any nanoscale in-plane band gap profile rewritable (Fig. 1c).

The versatility of hydrogen makes this laser writing technique of general interest and relevant to the development of fast fabrication approaches to nanotechnologies. Non-thermal (photonic) laser writing may also offer an alternative route to non-destructive band gap profiling of temperature sensitive material systems.

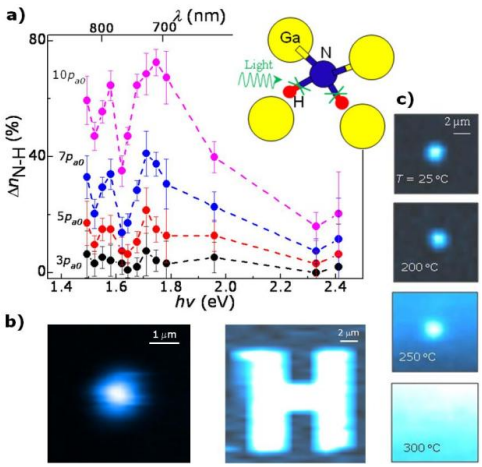

Figure 1. (a) Percentage change in the concentration of N-H complexes, Δn_{N-H}, dissociated by laser in a Ga(AsN) quantum well (QW) versus photon energy, $h\nu$, and wavelength, λ, at various power densities, p_a (p_{a0} = 10^5 W cm^{-2}). The inset sketches the photon-assisted dissociation of a di-hydrogen N-H complex. **(b)** Micro-photoluminescence maps of dot-like (left) and H-shaped (right) profiles at T = 300 K for an hydrogenated Ga(AsN) QW created by a focused laser beam. **(c)** Light emitting dots created by laser writing in Ga(AsN) and mapped following an annealing in a furnace at T = 200 °C, 250 °C, 300 °C for 1 hr.

[1] R. Trotta et al., *Adv. Funct. Mat.* **22**, 1782 (2012).
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[3] N. Balakrishnan et al., *Appl. Phys. Lett*. **99**, 021105(2011).