A movable light emitting area in resonant tunneling diodes

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The ability to spatially localize and move on a micrometer scale the emitting region in a light emitting diode (LED) is relevant for a variety of applications, such as Lab-On-a-Chip experiments, bio-imaging, optoelectronic integrated circuits, etc. Such control has been achieved, recently, in organic LEDs and transistors [1], but with performances that are presently limited by the properties of the employed organic materials –such as low quantum efficiencies, low carrier mobilities, and temporal instabilities– and by uncertainties in the physical mechanisms underlying carrier recombination and light emission in these material systems. These drawbacks can be overcome in an inorganic LED, as shown in this work [2].

We report on the realization of a movable micrometer light emitting area in a resonant tunnelling LED (RTLED) containing a GaAs/AlAs quantum well (QW). This is achieved via post-growth hydrogen passivation of C-dopants on the *p*-type layer of the *p*-*i*-*n* RTLED. The resulting increase of resistivity combined with the resonant injection of carriers in the QW leads to an unusual spatial localization of the QW electroluminescence (EL) emission along a *ring*, whose size and position are controlled by the applied voltage; see Fig. 1. The formation of the ring is observed for temperatures up to T = 100 K with characteristics indicating a real possibility for this movable LED to be used up to liquid-nitrogen temperatures. An additional, important outcome of tailoring the resistivity of the *p*-type contact layer with hydrogen is the possibility of achieving *simultaneous resonant injection of both electrons and holes* under given bias conditions. This results in a tenfold increase of the QW EL intensity and a threefold increase in the peak-to-valley QW EL intensity ratio versus applied voltage, a figure of merit of a RTLED.

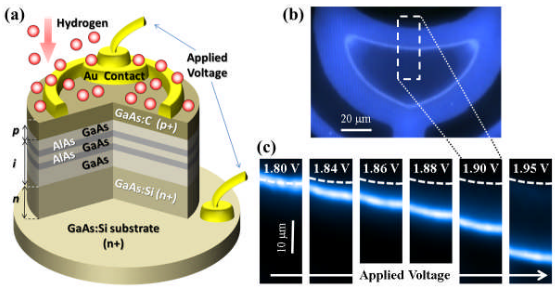

Figure 1. Sketch of a 200 µm-mesa *p*-*i*-*n* RTLED **(a)** and digital camera image of the EL emission intensity (at T = 9 K and V_{app} = 1.9 V) after post-growth hydrogen incorporation **(b)**. The neutralization of C-dopants in the region of the mesa exposed to hydrogen results in a localization of the QW EL emission along a ring, whose size and position are controlled by the applied bias **(c)**.

The successful realization of a movable micrometer-size LED in a compact and versatile solid state device will foster the development of innovative applications. Also, the controlled simultaneous resonant injection of carriers in the QW could be exploited for creating coherent excitonic states in electrically pumped quantum devices [3].

[1] B.B.Y. Hsu *et al.*, Adv. Mater. **24**, 1171 (2012).
[2] G. Pettinari *et al.*, *manuscript submitted for publication* (2013).
[3] A.J. Shields, Nature Phot. **1**, 215 (2007).