Department of Electrical and Computer Engineering
University of Rochester, Rochester, NY

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Electrical Properties and Infrared Luminescence of Er:SiO_2/nc-Si Multilayers under Lateral Carrier Injection

(Karl) Shih-Kai Ni

Supervised by
Professor Philippe Fauchet

The work described in this thesis presents investigations of Er-doped SiO_2/nc-Si multilayers operating under a novel lateral electrical pumping geometry. The motivation for this study is to design and prototype an efficient Si-based light emitting p-i-n device working at 1535 nm, in the forward bias regime.

The first part presents the electrical properties of Er-doped SiO_2/nc-Si multilayers where each layer is a few nm thick. The current – voltage characteristics taken from samples fabricated under various depositions as well as annealing conditions are presented. It is also demonstrated that lateral current can flow through multilayers with nm-thick layers. Space charge limited current model was applied to explain the collected I-V relations.

The next part of this work is focused on investigations of infrared electroluminescence (EL) from Er-doped multilayers. When electrons and holes are injected in the intrinsic region of a p-i-n device, they can excite the Er ions in the SiO_2 layers via energy transfer mechanism from the Si layers. The precisely defined Er-Si distance guaranteed by the very good controllability of deposition method is one of the most crucial parameters to achieve an effective energy transfer from nc-Si to Er. The major advantage of the proposed lateral carrier injection approach, compared to vertical carrier injection though multiple SiO_2 layers, is that transport is much easier and more efficien. The infrared electroluminescence (EL) and photoluminescence (PL) spectra show identical features, which lead us to the conclusion that the mechanisms of Er excitation via energy transfer and relaxation are similar in these two experiments. The observed strong PL under Er off-resonance excitation and EL under forward bias are very promising for Si-based light sources - the missing link in an all-silicon on-chip optical interconnection system.

The final left of the work focuses on optimizing parameters of the structure to design a stable, strong and efficient infrared electroluminescent device. The final goal of this work is to achieve electrical gain from the proposed device. Increased inferred transmission at 1535nm under electrical pumping indicates that gain has been achieved for TM polarized light.