semiconductors appear brightest in the THz image while semiconductors with low doping levels appear darker. Our model can provide a powerful theoretical tool to aid interpretation or corroborate the results of the terahertz near-field microscopy technique. Our model is also able to calculate the 3D carrier distribution throughout the materials, not just at the surface but internally. Since carrier recombination proceeds via different channels as various powers of carrier density, it is critical to account for local variation in carrier density to accurately predict photovoltaic device performance.

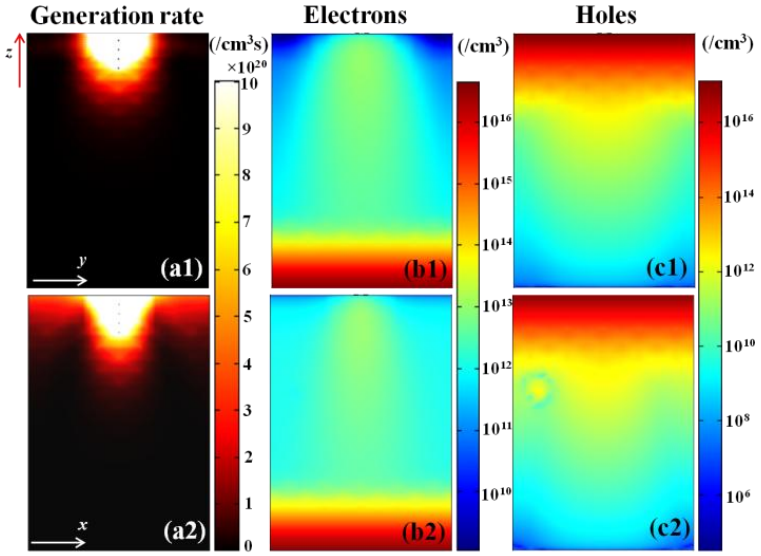

Fig. 4. Distributions of carrier generation rate [(a1) & (a2)], electron concentration [(b1) & (b2)], and hole concentration [(c1) & (c2)] inside the active layers of α-Si:H PSCs working at λ = 500 nm (in photocurrent gain region). Active layer configuration has been shown in Figs. 1(b) and 3(a1).

4. Conclusion

In summary, PSCs have been simulated using our 3D model, which calculates both the optical and electronic responses of a solar cell structure. Besides the extensively investigated optical properties, it also provides 1) a realistic measurement of the electronic performance enhancements arising from the presence of metallic nanoparticles and 2) spatial distributions of electronic parameters inside the device. Comparison between complete device simulation and optical estimation shows that carrier transport needs to be considered in a realistic SC model. Typical findings agreeing with PSC experiments and performance improvement with the incorporation of plasmonic design are verified. Since this model limits neither plasmonic nanostructure geometry nor SC configuration, it can be widely applied for the modelling of PSCs and conventional non-plasmonic SCs in 3D. Minor modifications to the model would enable light-emitting diodes and photodetectors to be modelled in a similar way.

Acknowledgments

This work was supported by EU FP7 project “PRIMA” - 248154.

#145911- $15.00USD Received 13 Apr 2011; revised 11 May 2011; accepted 13 May 2011; published 30 Jun 2011