Band edge silicon electroluminescence in amorphous-crystalline silicon heterostructures

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Band edge silicon electroluminescence (EL) was observed at room temperature for an amorphous-crystalline silicon heterostructure which is normally used as a high efficiency solar cell. The EL intensity rises with the temperature from liquid nitrogen to room temperature. The dependence of the intrinsic EL of silicon on current is superlinear both for liquid nitrogen and room temperature.

Analysis of the emission properties of the heterostructure based on the model of a planar p-n junction shows that the emission comes mainly from the less doped p side and its intensity is determined by radiative recombination coefficient and the lifetime of electrons in the p side. The increase of the EL intensity with the rise of temperature is explained by the fact that efficient lifetime of the electrons injected in the p side can significantly increase in the same temperature range due to reverse ejection of the carriers captured by deep recombination centers in a metastable state. An estimate of the internal quantum efficiency of the heterostructure gives the value on the order of one percent. A further increase of the doping level of the crystalline silicon substrate can rise the internal quantum efficiency up to several percent with the modulation frequency on the order of 50 kHz.

The EL properties are correlated to capacitance measurements as a function of bias, temperature and frequency, that give indications on the defects in the region of the amorphous to crystalline interface.

Our El results can be compared to results recently obtained on high efficiency crystalline silicon solar cells (1) and other crustalline silicon p-n junctions operated under forward bias.

References

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