Influence of illumination spectrum on dissociation kinetic of iron-boron pairs in silicon

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The iron-boron pair is one of the most extensively examined defects in silicon. The complex's levels, carrier capture cross-sections, kinetic models, dissociation techniques, and even ultrasound influence on pairing have been established [1-3]. However, the exact mechanism underlying the second decay phase — iron ion recharge or a recombination-enhanced defect reaction (REDR) — remains debatable. We believe that investigation of the illumination spectrum impact on light-induced dissociation may reveal which proposed model is correct. An experimental study was undertaken to explore the efficiency of FeB pair dissociation in silicon solar cells (iron concentration of 8.7×10^{12} cm^{-3}, doping level by boron of 1.4×10^{15} cm^{-3}) when different light sources are utilized. To achieve a varied illumination spectrum (see Fig.1), halogen lamps from three manufacturers — Orion, Osram, and General Electric (GE) — were used.

The characteristic time of FeB dissociation τ_{dis} was determined by measuring the dependence of the concentration of dissociated pairs on the illumination duration using a methodology referenced in [1]. It was observed that τ_{dis}, was influenced not only by the light intensity W_{ill} and the carrier generation rate but also by the light source – see Table. It was found that as the photon wavelength decreases, the dissociation rate increases. Fig. 2 shows the average photon energy for different sources, correlating with the data in Table. The findings suggest that REDR is likely to be the dominant mechanism for pair decay.

[1] O. Olikh *et al.*, *J.Appl. Phys.* **2021**, *130*, 235703.
[2] F. E. Rougieux, C. Sun, D. Macdonald, *Sol. Energy Mater. Sol. Cells* **2018**, *187*, 263.
[3] C. Sun *et al.*, *Phys. Status Solidi RRL* **2021**, *15*, 2000520.

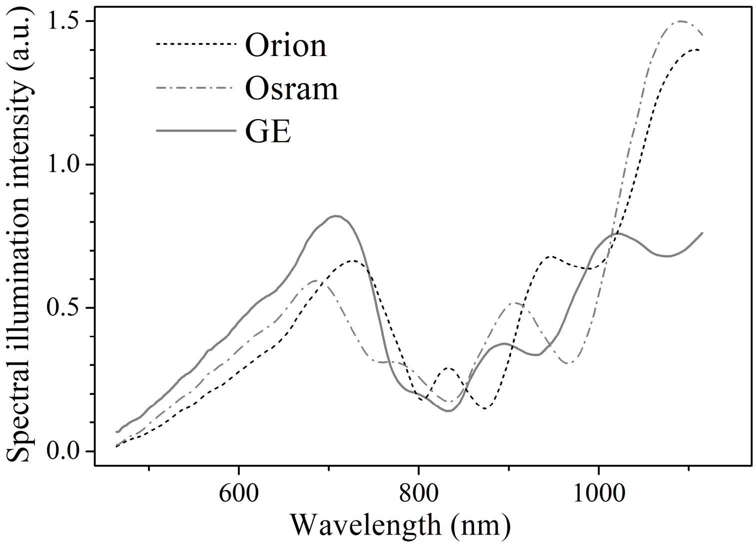

Fig. 1. The spectral composition of the sample illumination for different light sources, which is influenced by 1) the temperature of the filament; 2) the surface of the lamp reflector; and 3) the transmission characteristics of the optical fiber through which the illumination was conducted.

Table. The characteristic time of FeB dissociation for different illumination intensities and light sources

W_{ill} (mW)	τ_{dis} (s)		
	Orion	Osram	GE
200	42±3	20.0±0.7	15.1±0.5
300	15.7±0.6	12.4±0.1	6.5±0.2
400	8.8±0.3	6.1±0.3	3.6±0.3
500	5.5±0.2	4.5±0.2	
600	3.7±0.2	3.0±0.2	
700	2.4±0.2	2.4±0.2	

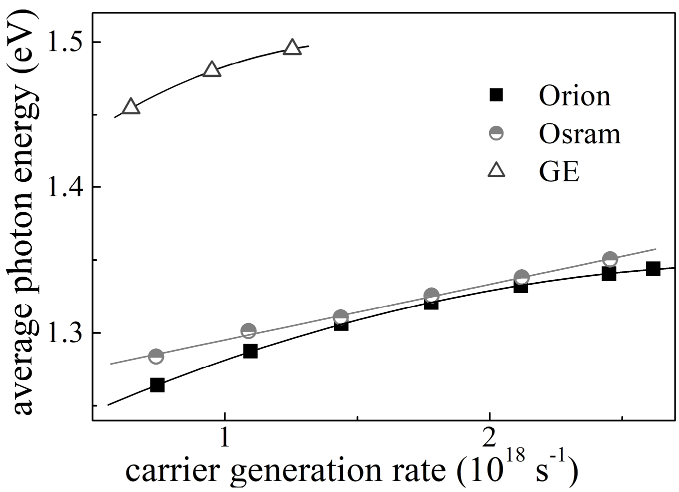

Fig. 2. Dependencies of the average photon energy on carrier generation rate for different light sources.