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Optoelectronics: Is there anything it cannot do; Can Opto-Electronics Provide the Motive Power for Future Vehicles?

Zepler Institute International Distinguished Lecture Series

Eli Yablonovitch, Professor, Electrical Engineering and Computer Sciences Dept., University of California, Berkeley, USA

A new scientific principle has produced record-breaking solar cells. The 28.8% single-junction solar efficiency record, by Alta Devices , was achieved by recognising the importance of extracting luminescent emission. This is exemplified by the mantra: "A great solar cell also needs to be a great LED". It was essential to remove the original semiconductor substrate, which absorbed luminescence, and to replace it with a high reflectivity mirror. The solar efficiency record crept up as the rear reflectivity behind the photovoltaic film was increased, 96% reflectivity -- 97% -- 98% luminescent reflectivity;-- each produced a new world efficiency record.

In thermo-photovoltaics, high energy photons from a thermal source are converted to electricity. The question is what to do about the majority of low energy infrared photons? It was recognised that the semiconductor band-edge itself can provide excellent spectral filtering for thermophotovoltaics, efficiently reflecting the unused infrared radiation back to the heat source. Exactly those low energy photons that fail to produce an electron-hole pair, are the photons that need to be recycled.

Thus the effort to reflect band-edge luminescence in solar cells has serendipitously created the technology to reflect all infrared wavelengths, which can revolutionise thermo-photovoltaics. We have never before had such high rear reflectivity for sub-bandgap radiation, permitting step-function spectral control of the unused infrared photons for the first time. This enables conversion from heat to electricity with >50% efficiency. Such a lightweight "engine" can provide power to electric cars, aerial vehicles, spacecraft, homes, and stationary power plants.

Professor Eli Yablonovitch introduced the 4(n squared) light-trapping factor that is in worldwide use for almost all commercial solar panels. This factor, which increased the theoretical limits and practical efficiency of solar cells, is sometimes called the "Yablonovitch Limit". His startup company Alta Devices has held the world record for solar cell efficiency since 2011, now 28.8%.

Today, almost all semiconductor lasers use the concept that Yablonovitch introduced; the idea that strained semiconductor lasers could have superior performance due to reduced valence band (hole) effective mass. Everyday technologies such as DVD players and the ubiquitous red laser pointers all rely on this development. The optical telecommunication involved in almost every human interaction with the internet occurs by strained semiconductor lasers.

Yablonovitch is regarded as a Father of the Photonic BandGap concept, and he coined the term 'Photonic Crystal. He first experimentally realised Photonic bandgap, is sometimes called "Yablonovite".

Wednesday 4 November 2015, 10:30am Hartley Suite, Highfield Campus

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