

Infrared to Visible Integrated Up-Conversion Imaging Device using Nano-Plasmonic and Nano-Structures Absorber

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Abstract:

Infrared to visible up-conversion is of a real importance in-order to have a cheap light weight device, there are several group that are still investigating such phenomenon.⁽¹⁾ Here we report the concept and the progress of a Israel national nanotechnology initiative Focal Technology Area (FTA) project aimed to develop an integrated up-conversion device that will directly convert short-wavelength infrared (SWIR 1400-1800 nanometer wavelength) SWIR image into visible image via a thin layer (less than thickness of 1 μ m) composed of several nanometers thick multi-layers films (few hundred nanometers thick each). The first sub-layer is the detection layer that absorbs the SWIR photons. This layer is made of few hundred nano-meter thick PbSe nano-columns or nano-spheres having high absorption coefficient due to the large oscillator strength imposed by its quantum size effect that also blue shifted its absorption peak wavelength from 4.3 μ m of bulk material to around 1.5 μ m using the nano-columns/spheres structure. Additional absorption in this layer is obtained using surface and localized plasmon enhanced absorption techniques via a pixelated metal layer evaporated on top of the absorption layer that was grown on the heavily doped GaAs substrate which also serve as SWIR window as well as holes blocking layer. The nano-sphere exhibit three dimensional quantum confinement where the nano-columns structure exhibit only two dimensional quantum confinement due to the nanoscale size of the columns diameters but on the other hand have bulk properties along the columns axis (z-direction perpendicular to the substrate) and therefore high mobility of the charge carriers. The photo generated carriers (holes) are drifted by the external applied electric field through nearly lossless carrier transport layer toward an OLED structure grown on top of the pixelated gold layer evaporated on the photosensitive PbSe nano-structure layer. The thickness of the photo sensitive layer is around 300-400nm which allows almost collision free path from the infrared absorption location in the photosensitive layer trough the electron-hole recombination location in the OLED. This direct flow of the carried in absorption layer allows blur free image emitted from the OLED structures. The OLED structure is based on high efficiency Oligofuran molecules attached to rare-earth metals atoms. In this layer the charge carrier are recombining with electrons injected via a nanowire based transparent cathode, thus giving rise to visible photon emission through this cathode. Any visible photon emitted toward the absorption layer is reflected back by the pixelated gold layer toward the transparent cathode. Alternatively to OLED, the photo-generated carriers are swept toward liquid-crystal spatial light modulator (SLM) device that generate visible light emission where its intensity is proportional to the incoming SWIR light intensity.

References

[1] Do Young Kim, Kaushik Roy Choudhury, Jae Woong Lee, Dong Woo Song, Galileo Sarasqueta and Franky So, Nano Lett. 11, 2109-2113 (2011).