Architecture, Development and Implementation of a SWIR to Visible Integrated Up-Conversion Imaging Device

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Imaging in the infrared is usually done using expensive cooled and un-cooled thermal imaging systems that involve electronics, signal processing, image processing and algorithms to further improve image quality. Such systems are usually, expensive, cumbersome, heavy and with high power consumption. An alternative approach is to use a direct upconversion of the infrared photons into visible photons throughout the materials domain without the need of electronics and image processing.

Here we present the architecture and the progress in the development of an integrated short-wavelength infrared (SWIR $\lambda=1300$-1800nm) to visible up-conversion imaging device that is directly converts SWIR image into visible image through thin stack of nano-scales multilayers (few hundred nanometers thick each). The layers sequence starts with chemical bath-deposited-CBD on n-type GaAs substrate of the photosensitive layer that absorbs the SWIR photons and converts them into electro-hole pairs. This layer can be made of few hundreds of nano-meters PbSe or PbS nano-columns/structures, respectively. Such absorbing layer have high absorption coefficient due to the large oscillator strength imposed by the quantum size effect (due to their large Bohr radius). In addition, this quantum size effect blue shifts the absorption peak wavelength of 4.3$\mu$m(PbSe) or 2.7$\mu$m(PbS) of the bulk materials to 1.5$\mu$m in the nano-columns/spheres structure. Additional absorption in this layer is induced using a pixeledated metal layer deposited on top of the absorption layer and plasmon enhanced absorption. The photo generated charge carriers are then drifted using external bias toward the Organic Light Emitting Diode (OLED) layer that is deposited on the photosensitive layer. These holes-electrons recombination that are spatially correlated to the SWIR photon absorption generate the visible image that is transmitted through the Ca/Au, SWCNT or graphene transparent cathode thus restores the SWIR image.

An alternative approach we have demonstrated is where the photo-generated carriers are drifted toward liquid-crystal spatial light modulator (SLM) instead of the OLED layer. The induce electric field generates visible light emission (as a visible image) where its intensity is proportional to the incoming SWIR light intensity.