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Infrared detection with colloidal quantum dots based on interband and intraband transitions

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While much research on colloidal quantum dots is focused on their potential as visible emitter or light harvester, this talk will cover our investigations of the mercury chalcogenide colloidal quantum dots in the thermal mid-infrared ranges of 3-5 microns and 8-12 microns where the atmosphere is transparent. HgTe is a zero-gap semiconductor. As a result, colloidal quantum dots (CQD) of sizes between 10 and 20 nm readily lead to infrared gaps tuning between 3 and 12 microns respectively. It is also very promising that infrared photodetection using dried films of these CQDs has now been demonstrated up to 12 microns. Further improvement through chemistry are likely and will be required to raise the detectivity to the level required to transform thermal infrared detection technology. In contrast to HgTe CQDs which tend to be intrinsic, beta-HgS and HgSe CQDs are naturally n-doped, in the first such instance with CQDs. Furthermore, the doping is modulated by modifying the surface composition, and this effect is attributed to the tuning of the energy level with respect to the environment, via the surface electrostatics. With controlled doping, both HgSe and HgS CQDs have now led to the first operation of mid-infrared CQD photodetector based on the intraband absorption. This is a breakthrough in the field of colloidal quantum dots where interband transitions had been exclusively used for the past 30 years. One challenge with both interband and intraband infrared CQDs will be to reduce the nonradiative recombination, which will improve the detectivity as well as allow to use their infrared luminescence.