Plasmon-excited near-field luminescence of semiconductor light sources

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On-chip integration of semiconductor light sources is hindered by the fact that the wavelength of the light is considerably larger than the physical dimensions of the emitter. Therefore, near-field handling of the emission with a deeply subwavelength spatial resolution would be of great importance. Here we present a fully near-field photoluminescence study of semiconductor light sources (CdSe/ZnS quantum dots), with a surface plasmon interference device (SPID) used for the excitation and scanning near-field optical microscopy (SNOM) for the collection.

The SPID consists of an opaque metallic layer on a glass substrate with thin slits fabricated using focused-ion-beam milling [1,2,3]. The subwavelength thickness (below 100 nm) of the slits ensures that only surface plasmon polaritons (SPP) can propagate through the slits while the far-field radiation is blocked. The SPID is illuminated from the bottom and SPP form a standing wave on the top interface, where the distribution of the field is characterized by SNOM. With a semiconductor light source positioned directly at the top interface, luminescence can be generated [Fig. 1(a)]. The luminescence near field is again characterized by a SNOM. The optical signal is collected with the aperture-type probe and guided to the spectrometer. Details of the setup are provided in Ref. [2].

We have demonstrated the plasmon-excited far-field and near-field luminescence of CdSe/ZnS quantum dots [Fig. 1(b,c)]. We have observed a rather weak effect of the excitation mechanism on the emission energy and intensity. This makes the plasmon-excited luminescence a suitable tool for the on-chip integration of semiconductor light sources, as well as a characterization technique with the subwavelength spatial resolution.

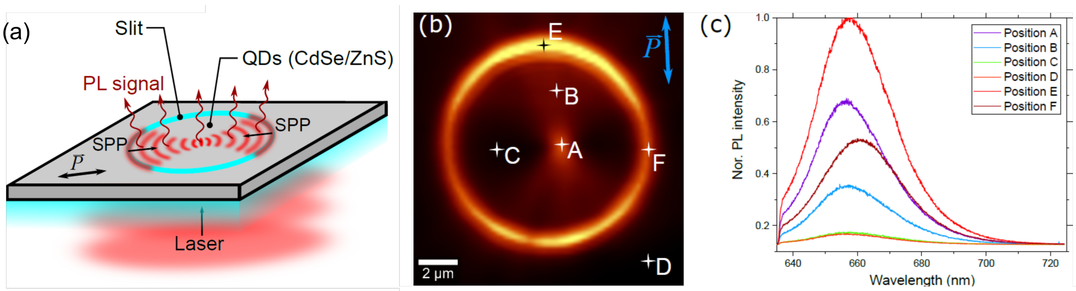

Figure 1: (a) Scheme and operation principle of SPID. (b) Spatial map of the luminescence from quantum dots excited with SPP. (c) Spectra of the luminescence recorded at selected areas of SPID indicated in panel (b).

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[2] P. Dvořák, Z. Édes, M. Kvapil, T. Šamořil, F. Ligmajer, M. Hrtoň, R. Kalousek, V. Křápek, P. Dub, J. Spousta, P. Varga, and T. Šikola, *Opt. Express* **25**, 16560 (2017).

[3] P. Dvořák, M. Kvapil, P. Bouchal, Z. Édes, T. Šamořil, M. Hrtoň, F. Ligmajer, V. Křápek, and T. Šikola, *Nanoscale* **45**, 21363 (2018).