phosphor. We conclude by discussing the prospects for efficient and stable blue OLEDs.

Influence of a magnetic field on the device performance of OLEDs

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Magnetic field effects in organic light emitting diodes (OLEDs) have attracted more and more attention in recent research activities. In an external magnetic field both the current flow through an OLED and the light emission from the device are increased. Even though the exact physical mechanism causing this magnetoresistance effect is not yet revealed we show strong evidence that the presence of triplet excitons within the device is linked to the appearance of the effect. We measured the magnetoresistance in different OLED structures as a function of magnetic field and driving voltage. Using different cathode and emitter materials we show a dependence of the magnetoresistance effect on the charge carrier balance within the device. In double-carrier devices a significant magnetoresistance effect is observed whereas in single-carrier devices the effect is lower by at least one order of magnitude. The effect occurs in fluorescent devices for voltages above turn-on where both electrons and holes are injected and form excitons. Introducing phosphorescent emitters in a fluorescent matrix results in a decrease of the magnetoresistance effect since triplet excitons are effectively removed from the system by radiative decay. In photoluminescence measurements no influence of an external field on the signal could be detected. Since optical excitation creates only singlet excitons this suggests that triplet excitons created after electrical charge carrier injection play a major role in the magnetoresistance mechanism.

FDTD and RCWA simulations of oled light extraction structures

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In a conventional bottom emitting organic light emitting diode about 50% of the generated photons are waveguided and dissipated in the oled stack, the other 50% being emitted into the substrate (about 25% of which are extracted into air). The main reason is the refractive index mismatch between the organic layers (n=1.7-1.9) and the glass substrate (n=1.5). One possibility to extract the organic modes into the glass substrate is the application of scattering structures close to the emission zone, e.g. photonic lattices between the anode and the substrate. The prediction of the their effectiveness requires the numerical solution of the Maxwell equations for a radiating dipole in a planar medium including structured layers. We show how this can be accomplished with the Finite Difference Time Method and/or the Rigorous Coupled Wave Analysis. Effective numerical implementations of these well-known methods are presented and their pros and cons discussed. The results of the simulations are compared to experimental values taken from the literature. The general conclusion is that extraction of the organic modes by scattering structures into the substrate seems to be limited by their strong attenuation due to absorption and the overlap of the modes with the scattering structures.

Towards an experimentally validated second-generation OLED device model

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Organic Light Emitting Diodes (OLEDs) are potentially highly-efficient large-area light sources that can be used for general-lighting applications. In the past years, the luminous efficacy of prototype white OLEDs has shown a very fast, fivefold, increase. In principle, there seems to be no fundamental obstacle towards 100 lm/W efficiency, beyond that of fluorescent lamps. However, trial-and-error approaches as used today will in future not anymore be optimal for reaching that goal, in view of the ever-increasing complexity of OLEDs (20 layers or more). For the further development of efficient OLEDs, the availability of an experimentally validated device model will be crucial.

In this talk, we present recent progress in the development of more advanced OLED device models, supported by experimental results. The focus is on the understanding of the role of energetic disorder on the mobility, current density and recombination. First, some limitations are shown of "first generation" device models, as applied to single carrier devices based on a blue-emitting polymer or a green-emitting small molecule. Such models solve the drift-diffusion equation using a continuum approach, and take only a field-dependence of the mobility into account. It is shown that a new model, which takes also a carrier-concentration dependence of the mobility into account, provides a more consistent description of a large set of temperature and layer-thickness dependent current-voltage curves. It is also shown that in materials with realistic disorder, the current density is of a filamentary nature. Second, a novel 1D-model is presented for calculating the current density and recombination in double-carrier OLEDs. Using that model, disorder is shown to strongly enhance the current density, and to strongly affect the shape of the recombination distribution in single-layer and multilayer devices. Also, the effect of disorder on transient phenomena, such as the current density response in a dark-injection experiment, is discussed. Finally, an outline is given of a future "second generation" 3D OLED device model, which should include the laterally non-uniform nature of the current density and recombination.

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Method for determining the depth profile of emitting dipoles in organic light-emitting devices from experiment

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For understanding and further improving the luminous efficacy of organic light-emitting diodes (OLEDs), it is of crucial importance to know the precise distribution of emitting dipoles across the device. In the literature, various methods have been proposed to determine this distribution from experiment [1]. However, in all cases this was done by considering only profiles with certain selected shapes. In this contribution, we show how the distribution can be deduced from experiment without making any assumption about its shape. For that purpose, we use (i) the measured wavelength, angle and polarization dependent emission spectra and (ii) the theoretical spectra for emission from distinct dipole positions in the device, as obtained from a thin-film microcavity outcoupling model [2]. The inverse outcoupling problem is then solved using a least squares fit of the experimental data, leading to the dipole intensity and orientation profiles. A key point, providing strongly enhanced accuracy, is the use of a special procedure whereby the angle and polarization dependences at all wavelengths are given essentially equal weights.

We present a successful application of the method to the case of blue-emitting polyfluorene-based OLEDs. The recombination is found to take place predominantly at the anode side, as already predicted from a preliminary transport modelling study [3]. A critical comparison is presented with the predictions from a new and more advanced device model.

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Influence of charge balance and exciton distribution on efficiency and lifetime of phosphorescent OLEDs

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A way to reach highly efficient and stable red bottom emission organic light emitting diodes (OLEDs) is the use of doped transport layers, charge and exciton blockers and phosphorescent emitter materials to combine low operating voltage and high quantum yield. We will show how efficiency and lifetime of such devices can be further increased.

In our contribution, we report on highly efficient red p-i-n type organic light emitting diodes using an iridium-based electrophosphorescent dye, Ir(MDQ)2(acac), doped in alpha-NPD as host material. By proper adjustment of the hole blocking layer, the device performance may be enhanced to 20 % external quantum efficiency at an operation voltage

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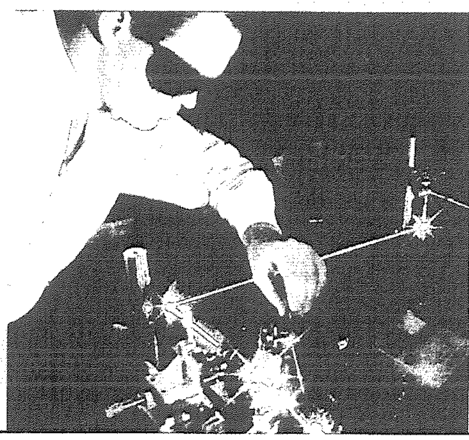

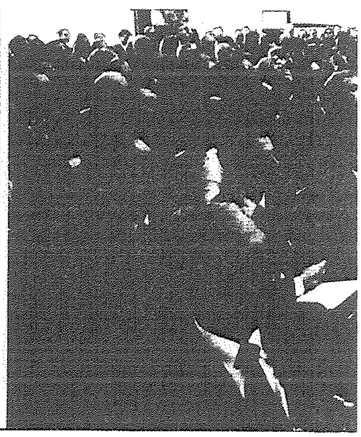

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