Brilliant Fluorescent Resists for E-beam and Photolithographic Applications

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Many applications require colorized materials, while especially microscopy of biological samples involves a requirement of fluorescent micro or nano pattern. Standard photolithography can be used for the fabrication of well-defined pattern on a micrometer scale and e-beam lithography to realize structures in a sub-micron range.

At first, we evaluated a solvent-developable negative resist Atlas 46 S, following the SU-8, which is based on the reproducible raw material of a cresol novolac epoxy resin for this purpose.(3) Different soluble fluorescent dyes were added causing intense emission in wavelength regions between 350 nm and 720 nm, respectively. First experiments demonstrated dyed Atlas S layers could easily spin coated, exposed and developed, without changing the processing parameters. The dyed resist architectures show a high temperature stability up to at least 250°C. Running the photolithographic process twice by using different dyed resists allowed the design of adjacent pattern showing a different fluorescence (fig. 1). For example, following to the generation of the yellow emission pattern a second resist layer containing the red emission dye is provided on top. The second, selective exposing and final developing step results in architectures of “mixed” emission. We were able incorporate upconverting nanoparticles (UPNCs) into standard PMMA and the new Atlas 46 resist system. The resulting resist resists showed a good luminescence upconversion intensity. All tested systems are stable and does not show agglomeration or decomposition of the nanoparticles. There was no need for alteration of the standard processing parameters.(1) The realization of nanometer-scale architectures requires e-beam processes. PMMA is one of the most used materials for e-beam lithography. Red and yellow fluorescent dyes were encapsulated in PMMA and positive patterned using an e-beam standard process. As a result, intense emission nanopattern could be obtained (fig. 3). In principle, running multi-layer e-beam processes as used for the generation of lift-off architectures or t-gate fabrication, allows the realization of adjacent or overlapping resist architectures with different emission properties. (2)

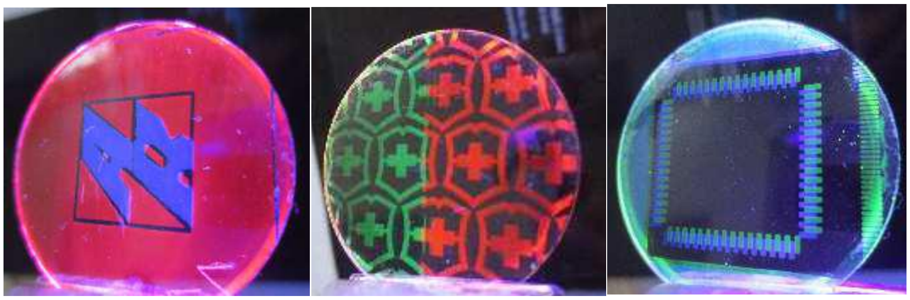

Figure 1: adjacent Atlas 46 layers (film thickness 3 µm) showing a different fluorescence (left side, middle); overlapping fluorescent structures of Atlas 46 (right side)

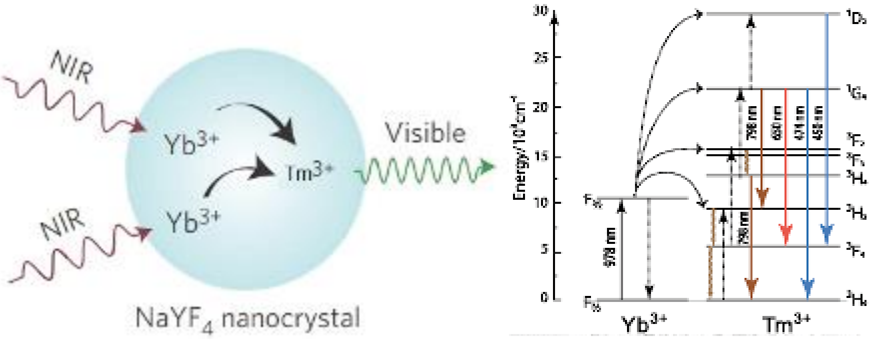

Figure 2: Scheme of frequency upconversion using Thulium(Tm) as Activator and Ytterbium (Yb) as Sensitizer. Yb-ions absorb NIR light and transfer energy (of two or more) photons in sequential steps to one Tm-ion, which subsequently can emit light in the visible spectral range.

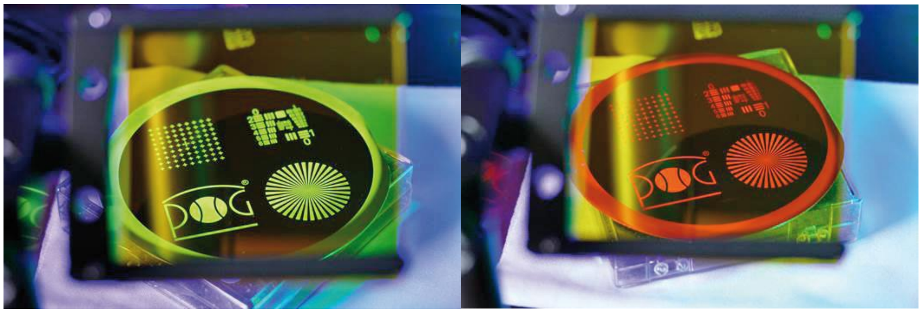

Figure 3: Well-defined 50 nm structures (left: yellow emission with SX AR-P 672.08/1; right: red emission with SX AR-P 672.08/2) © Präzisionsoptik Gera

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