Ecole Doctorale des Sciences Fondamentales

Title of the thesis: Synthesis and characterization of nanophosphors suitables for micro-LEDs-based devices

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Summary :
Besides the more and more common use of Light Emitting Diodes (LEDs) in our everyday life, a new type of miniature LEDs (micro-LEDs) has emerged last years. This pioneering technology, developed by a team of CEA LETI, represents an important step forward for many applications such as smart lighting devices, augmented reality using smart glasses or even 3D flexible, large and transparent screens.
The phosphors currently used in solid-state lighting are not suitable for micro-LEDs based devices, especially because of their size. When using micro-LEDs displays, the elementary unit is a pixel made of an InGaN blue LED structured on a micrometric scale (pixel size comprised between 3 and 10 µm). As for White LEDs (WLEDs), blue light emitted by InGaN has to be converted in white, red or green light using color-converting phosphors. A breakthrough technology employing tailorable submicronic, even nanometric, phosphors is thus required.
Size reduction of phosphors can be carried out using two strategies: a top-down approach based on a grinding process which generally generates a lot of defects causing a significant decrease in emission properties of the ground phosphors; a bottom-up approach leading to nanophosphors whose optical features are far from competing with those of micrometric phosphors. Only the quantum dots (QDs) based on cadmium currently provide both interesting performances and sizes compatible with the foreseen applications, but their toxicity hampers them to be widely used over the long term. Furthermore, like organic phosphors, QDs are not stable under thermal or photonic stresses which represents a crippling point for their use in micro-LEDs displays. *The development of highly performant and stable nanophosphors thus remains a big challenge. It is in this context that this thesis should be considered* since its main objective will be the elaboration of inorganic efficient and eco-friendly nanophosphors whose features will be stable under both photonic and heat stresses.
Phosphors will be elaborated through soft-chemistry processes (microwave assisted or not solvothermal way for example) for which different parameters will be optimized (solvent, pH, temperature, duration…). Studies in surface chemistry will also be led to improve the optical properties of the elaborated nanophosphors. The developed matrices will belong to aluminates or vanadates families.

Structural, morphological and optical properties of synthesized phosphors will be analyzed by means of XRD, IR and Raman spectroscopies, SEM, TEM, DLS, quantum yields, excitation and emission spectra as well as decay times measurements. Less classical techniques such as SAXS will also be employed. The evolution of colorimetric parameters of the nanophosphors will be studied under thermal and photonic constraints. The most interesting formulation for integration in microdisplays and the associated synthesis process will be identified. Corresponding nanophosphors will be dispersed in resins to elaborate composites which could be coupled with microLEDs that we will have access within our collaboration with CEA LETI. Optical performances of these devices will be then studied.