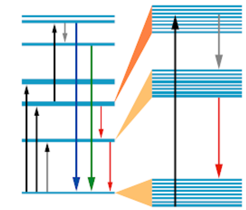
Controlled synthesis and photoluminescence properties of hexagonal Eu^{3+} activated $Na(Y,Gd)F_4$ microphosphors

PRE'19



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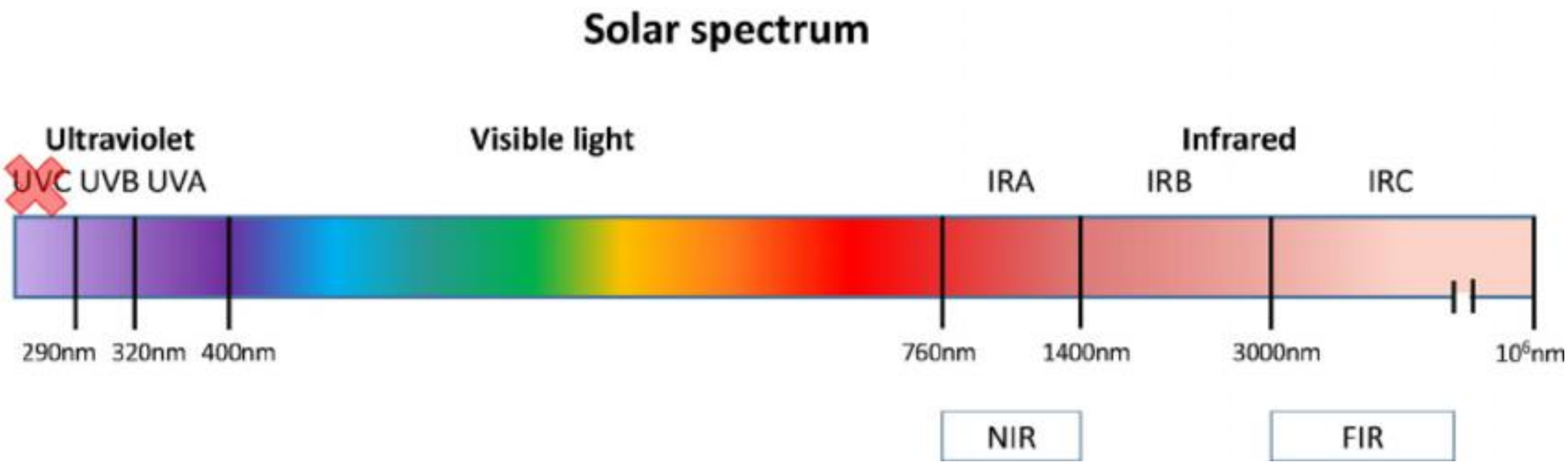
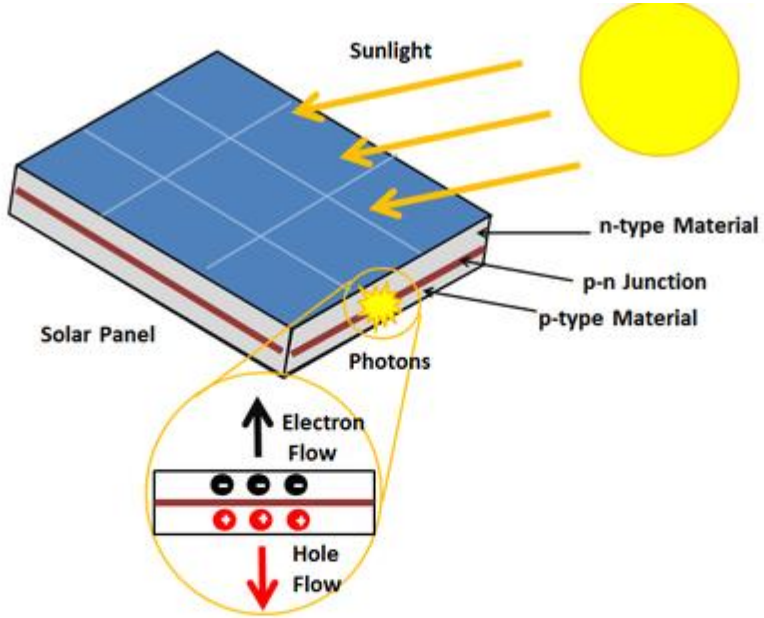
Outline

1. Solar spectrum and photovoltaic cell
2. Several issues of efficiency
3. Spectral convertor for solar cell
4. Fluorides
5. Synthesis of materials
6. Characterizations
7. Results and Discussions
8. Conclusions

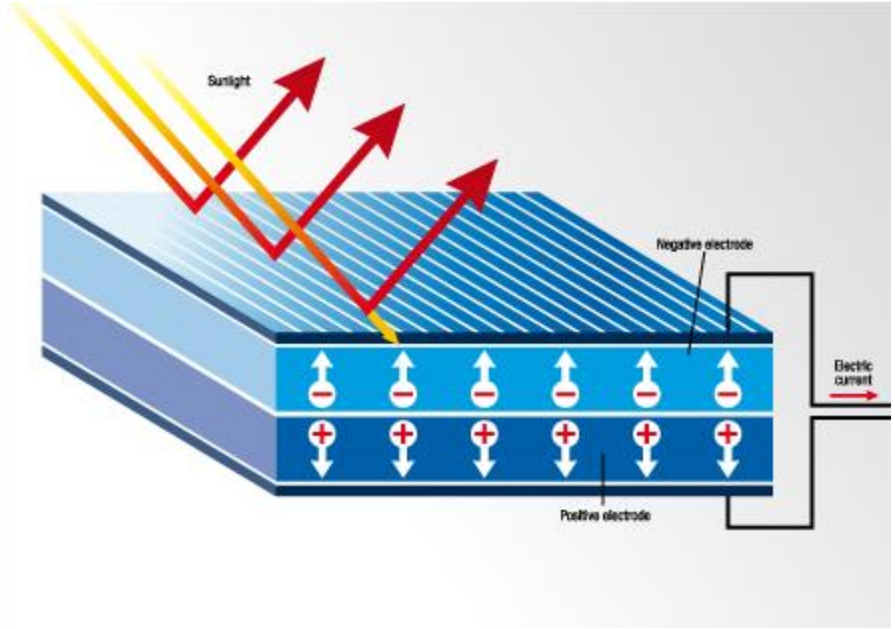


Photovoltaic cell



Photovoltaics is the conversion of light into electricity using semiconducting materials

Solar cell in detail



❖ Current annual solar energy usage is well below 1% of total energy consumption, while fossil fuels account for over 90% of the energy consumption.

❖ Before the large-scale use of solar energy, more efficient PV systems at reduced costs must be developed.

❖ A major problem limiting the conversion efficiency of PV cells is their insensitivity to a full solar spectrum.

❖The spectral is attribution of sunlight at Air Mass 1.5 global (AM 1.5G) consists of photons with wide wavelengths ranging from ultra-violet to infrared (280–2500 nm, 0.5–4.4 eV), but current PV cells only utilize a relatively small fraction of the solar photons.

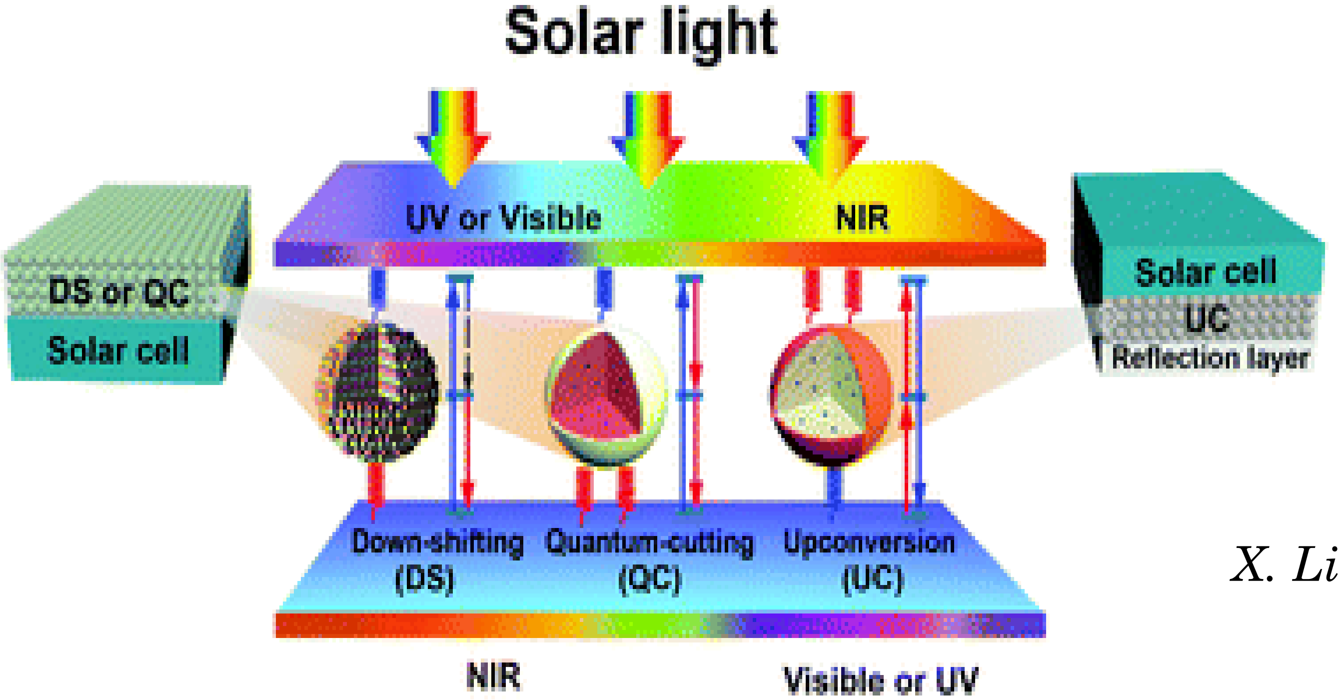
❖ The fact is that each PV material responds to a narrow range of solar photons with energy matching the characteristic band gap of the material.

❖ In principle, only photons with energy higher than the band gap are absorbed, but the excess energy is not effectively used and released as heat

Theoretical max. level of efficiency for crystalline silicon (c-Si) with a band gap of 1.1 eV is approximately 31% or 41%, depending on the concentration ratio, as defined by the Shockley–Queisser limit

Brief review of Spectral Convertors for solar cell

Difficulty in improving the Efficiency of PV energy conversion lies in the spectral mismatch between the energy distribution of solar photons and the band gap of a semiconductor material



X. Liu et al.

Third generation solar photon conversion for better photon management

Luminescent material which are capable of converting a broad spectrum of light into photons of a particular wavelength, used to minimize the loses in the solar cell based energy conversion process

The first successful demonstration of efficient visible quantum-cutting in a $LiGdF_4:Eu^{3+}$ phosphor was reported by Wegh et al. in 1999 with a theoretical quantum efficiency of 190%

NIR quantum-cutting for Tb – Yb co-doped systems was first reported by Vergeer et al. in 2005 $Yb_xY_{1-x}PO_4:Tb^{3+}$ powder phosphors

When compared to the most common Ln^{3+}–Yb^{3+} (Ln=Tb, Tm, and Pr) couples, the Ce^{3+}–Yb^{3+} couple could harvest a broad solar spectral range to give rise to intense NIR emissions

Why fluorides?

The most promising phosphors for UC and QC luminescence are found in fluorides

Fluorides like $NaREF_4$ (RE = rare earth), especially $NaYF_4$ is the ideal host material for luminescent RE^{3+} ions because of their high transparency arising from the low phonons energies and high ionicity.

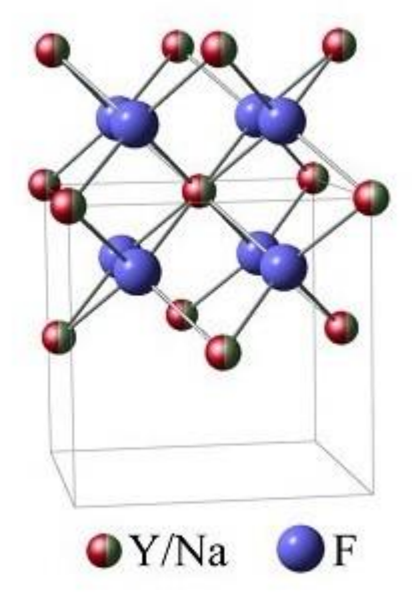
That leads to less absolute fundamental absorption compared to oxide or sulphides .

Two polymorphic forms α (cubic)and β(hexagonal)

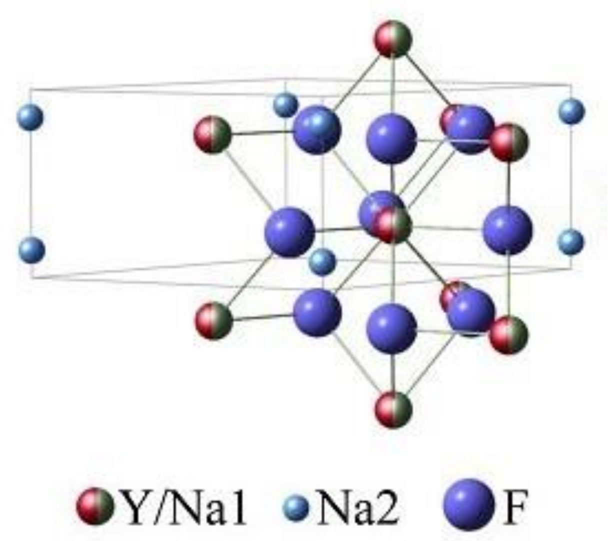
ß-NaYF4 has attracted more attention as an excellent host for Up-conversion processes under near-infrared (NIR) excitation for their low-energy phonons

Crystal Structure of NaYF4

Cubic NaYF4



Hexagonal NaYF4

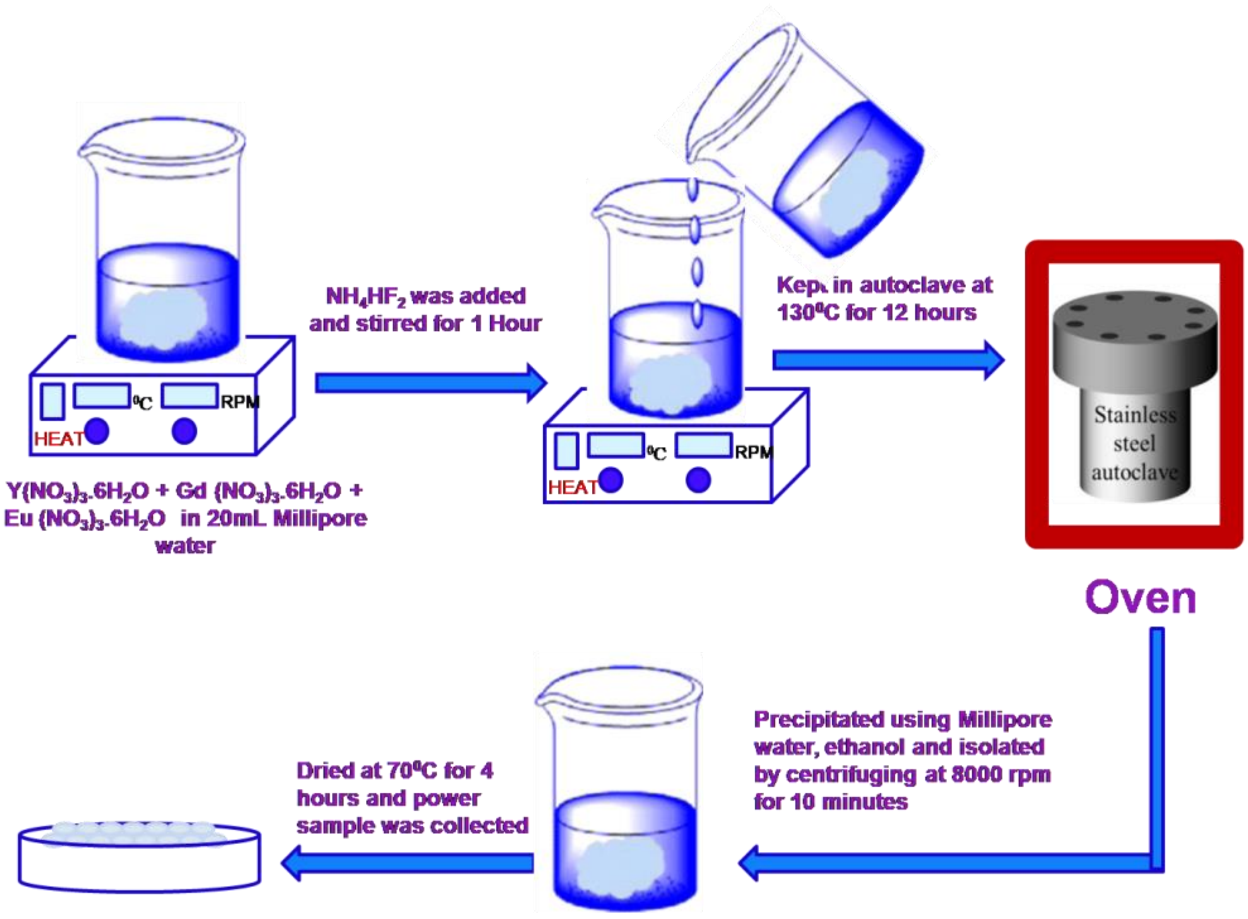


Material of interest

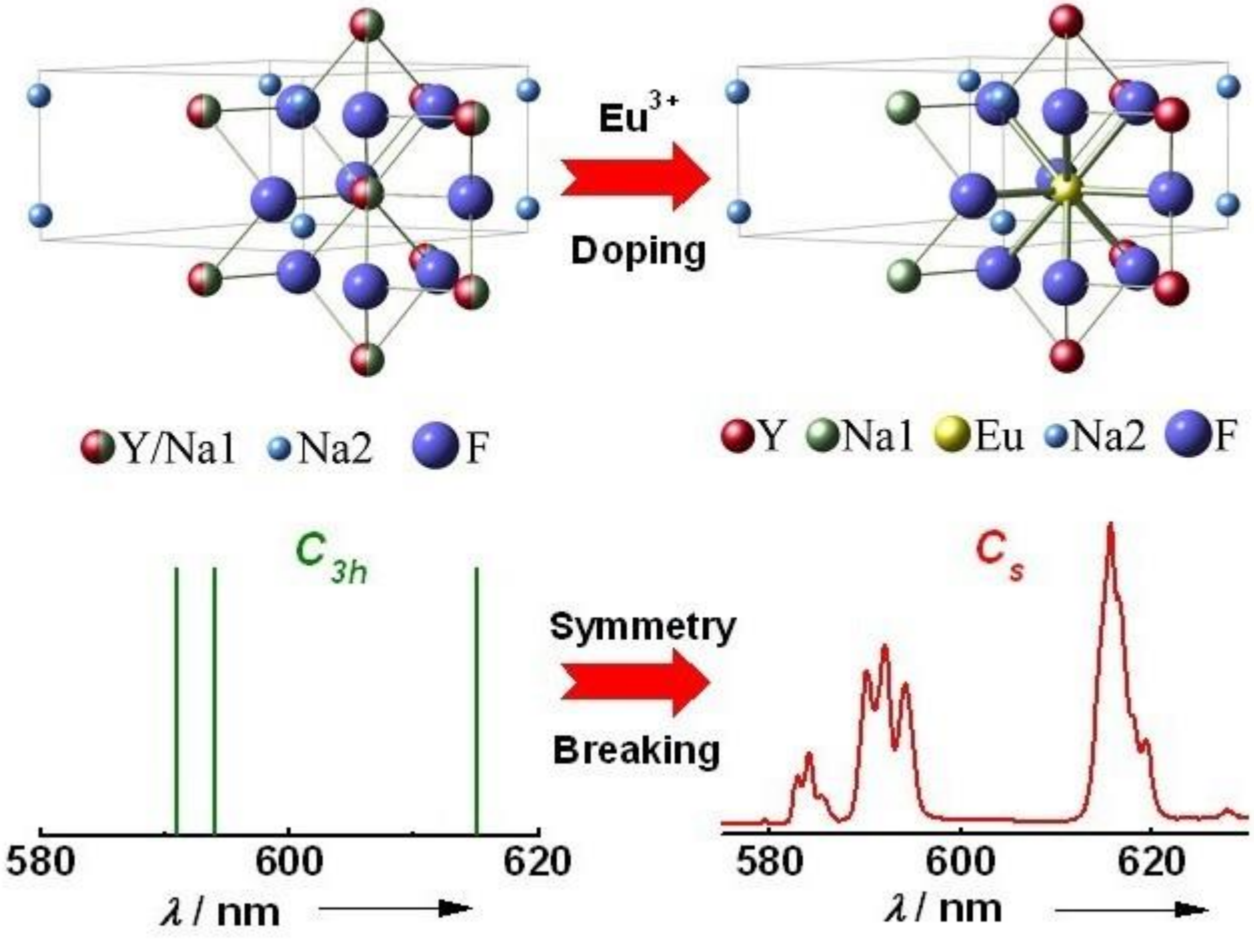
$\boxed{\mathbf{Na(Y,Gd)F_4 : xEu^{3+}}}$

SYNTHESIS

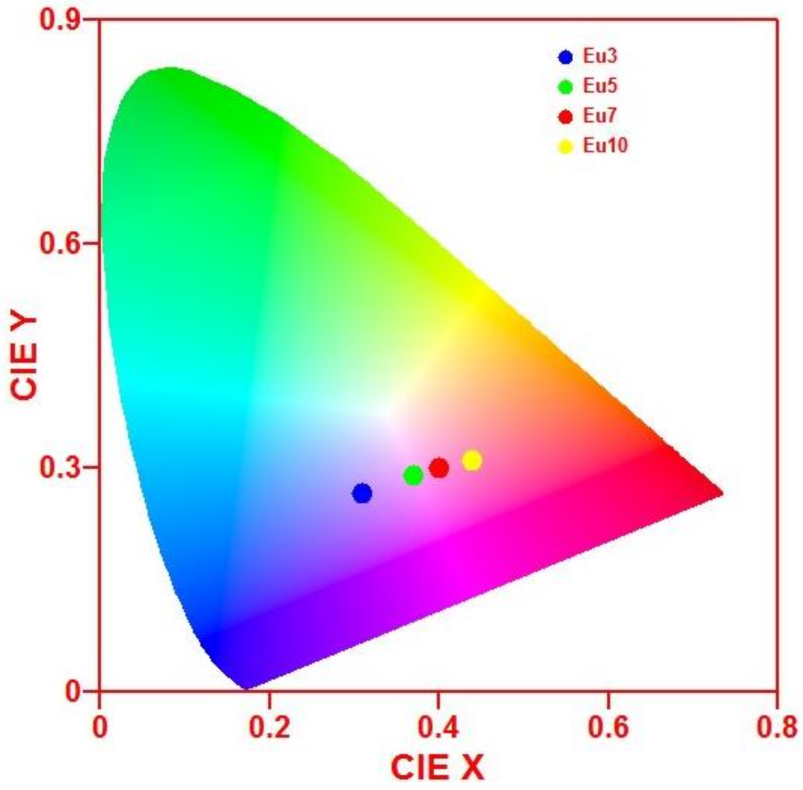
Hydrothermal method



Hexagonal $NaYF_4$



CIE diagram



The emission color tuned from blue to pink and finally the emission is red

Conclusions

- Synthesized hexagonal microcrystal of **$Na(Y,Gd)F_4 : xEu^{3+}$** by hydrothermal route
- XRD analysis confirms the single phase and crystalinity of the samples
- TEM and EDAX confirms the morphology and surface chemical compositions of the doped samples
- FTIR spectra reveals the functional groups attached to the samples helps in stabilizing the samples

Thank You so much