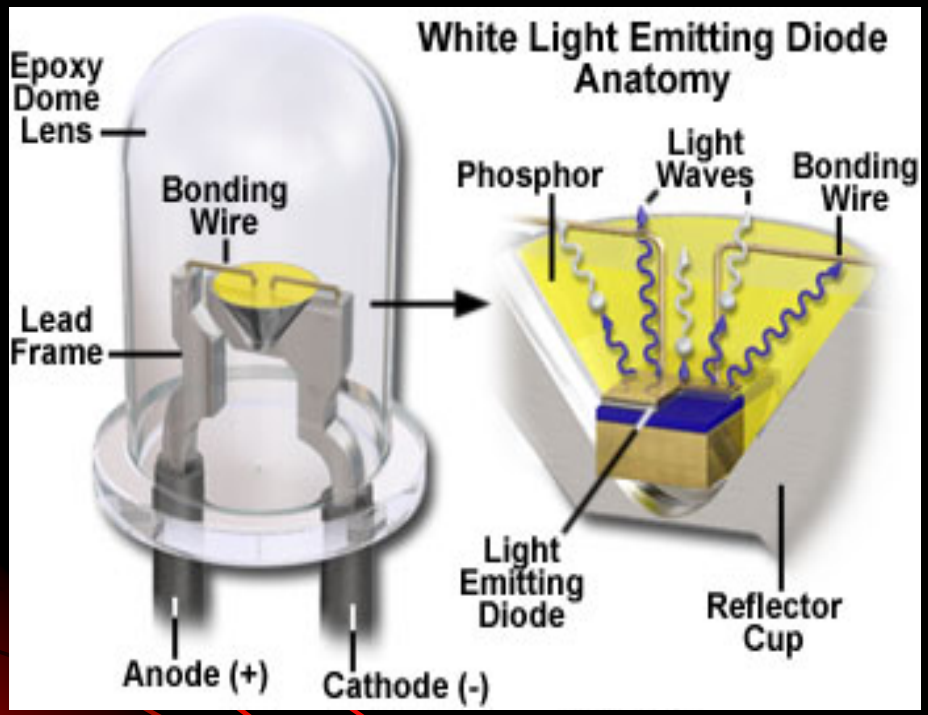
Red phosphors for solid-state (LED) lighting applications

- Intern: Dano Pagenkopf, Santa Barbara City College, Electrical Engineering/Materials Science
- Mentor: Dr. Gautam Gundiah
- Faculty Advisor: Prof. A. K. Cheetham
- Funding source: Mitsubishi Chemical Center for Advanced Materials

Introduction

- Solid state lighting (LEDs) use about an eighth of the energy that incandescent bulbs use, have a lifespan of over 50,000 hours and do not contain the mercury found in fluorescent bulbs.
- This translates to a 5+ year lifespan and energy savings of over 85% for lighting.
- Applications of LEDs:

Research objectives

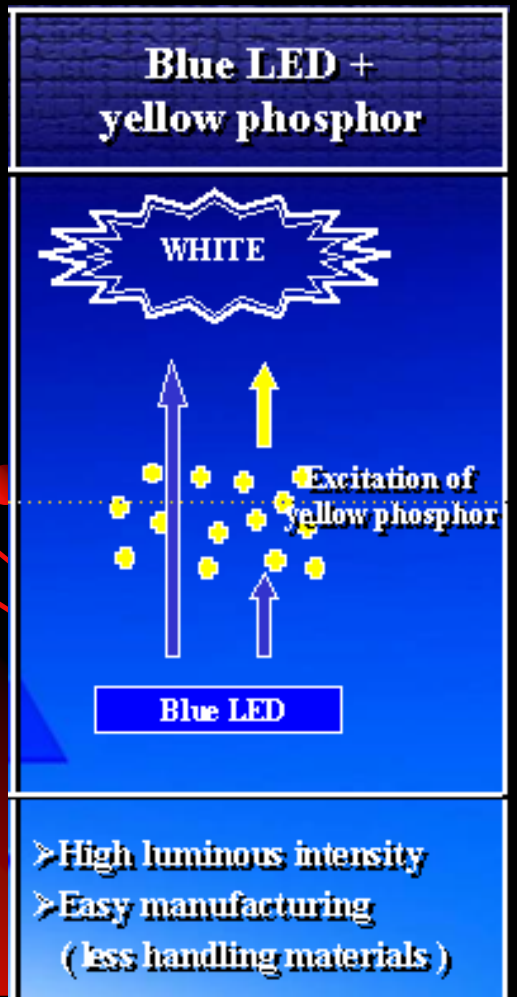


www.physics.utoledo.edu

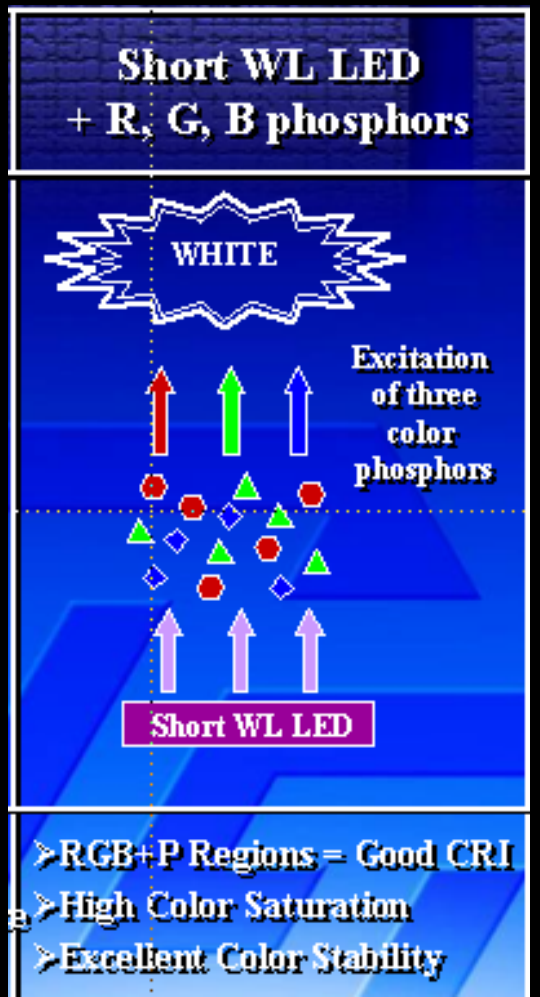
- A phosphor is a solid/powder that can absorb radiation of one wavelength and convert it to light of another color.

www.phosphortech.com

- Our current LEDs have a blue chip (460 nm) that excites a yellow phosphor, emitting a white light.
- The next generation of LEDs will use an ultraviolet chip (400 nm) that will excite red, green and blue phosphors.



www.toyoda-gosei.com



Research objectives…continued

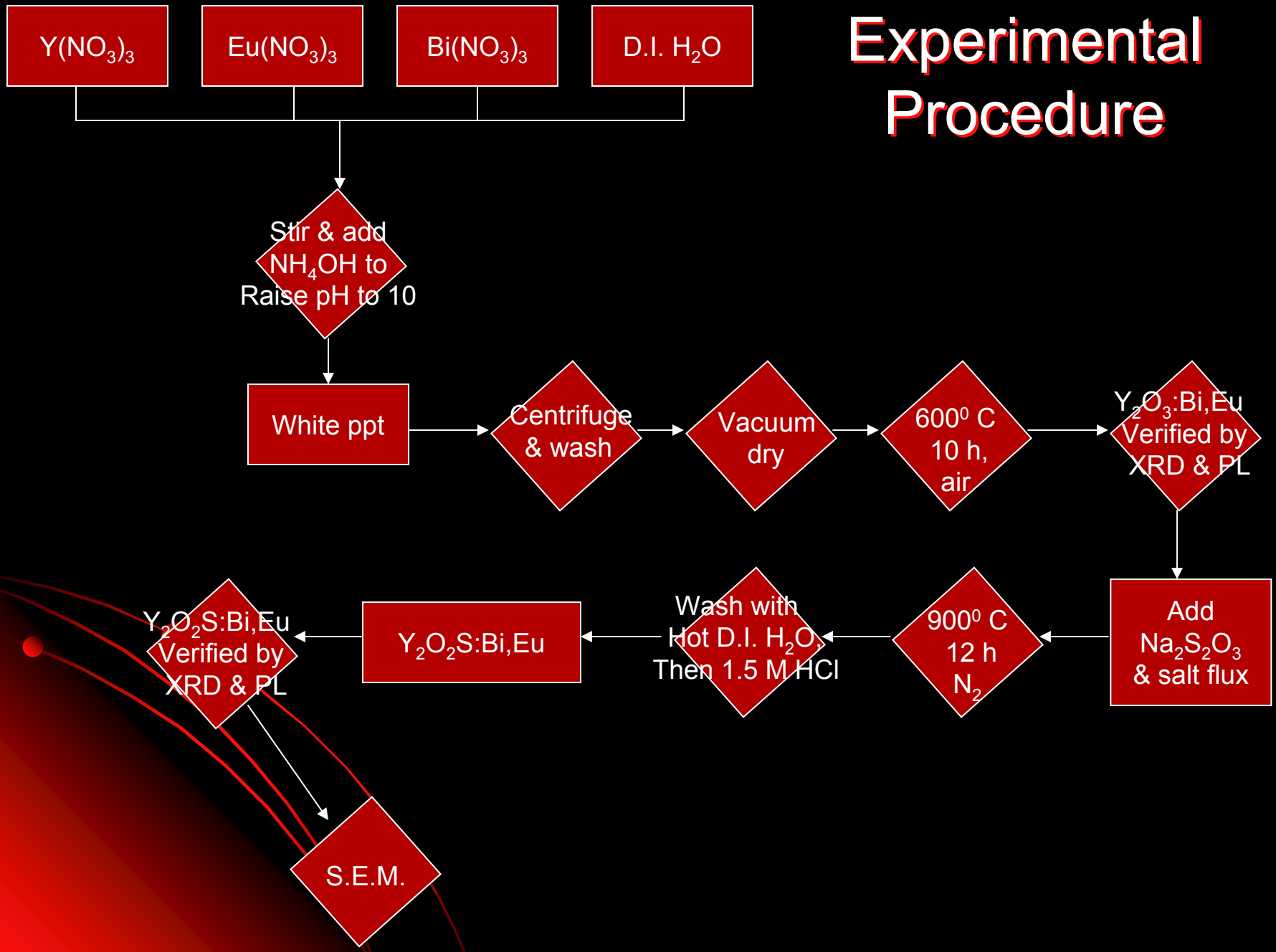
Commercial red phosphor- Yttrium oxysulfide Y_2O_2S:Eu

Excitation wavelength 340 nm, emission wavelength 627 nm

Can we tune the particle size by use of salt flux?

Can addition of Bi^{3+} shift excitation to a longer wavelength?

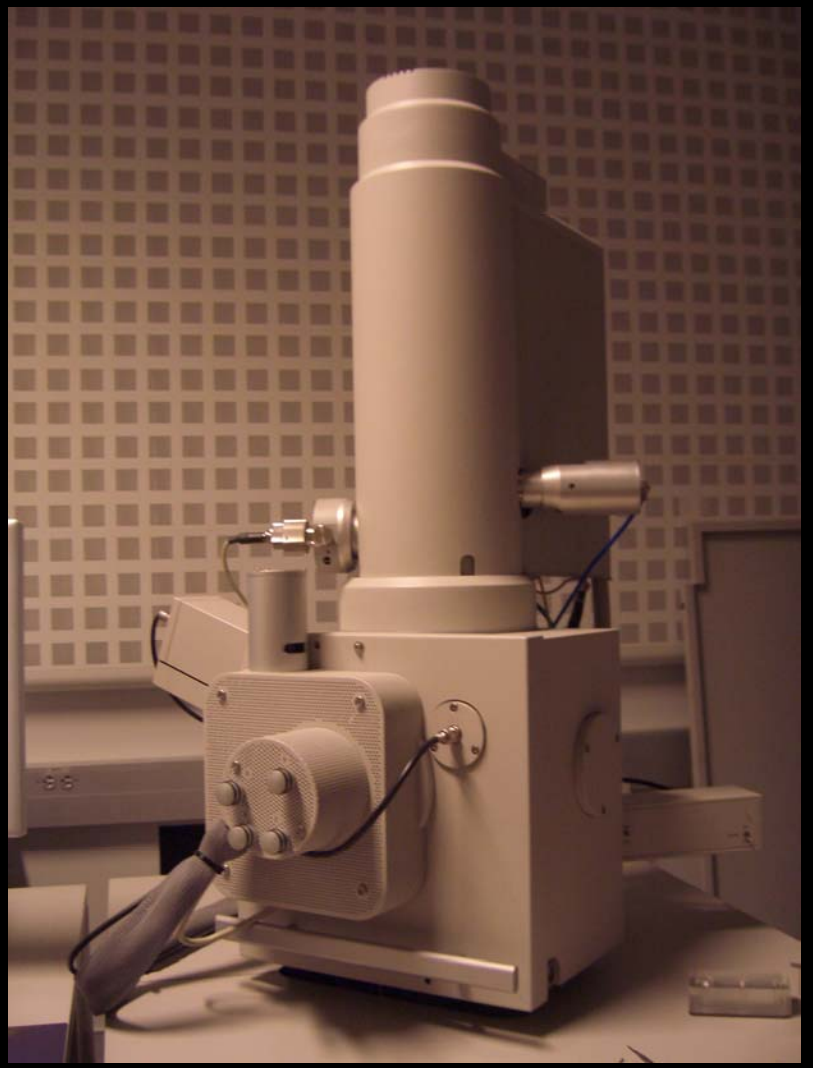
Experimental Procedure



Equipment used

Tube furnace (up to 1200°C)

Gold sputtering (for SEM)

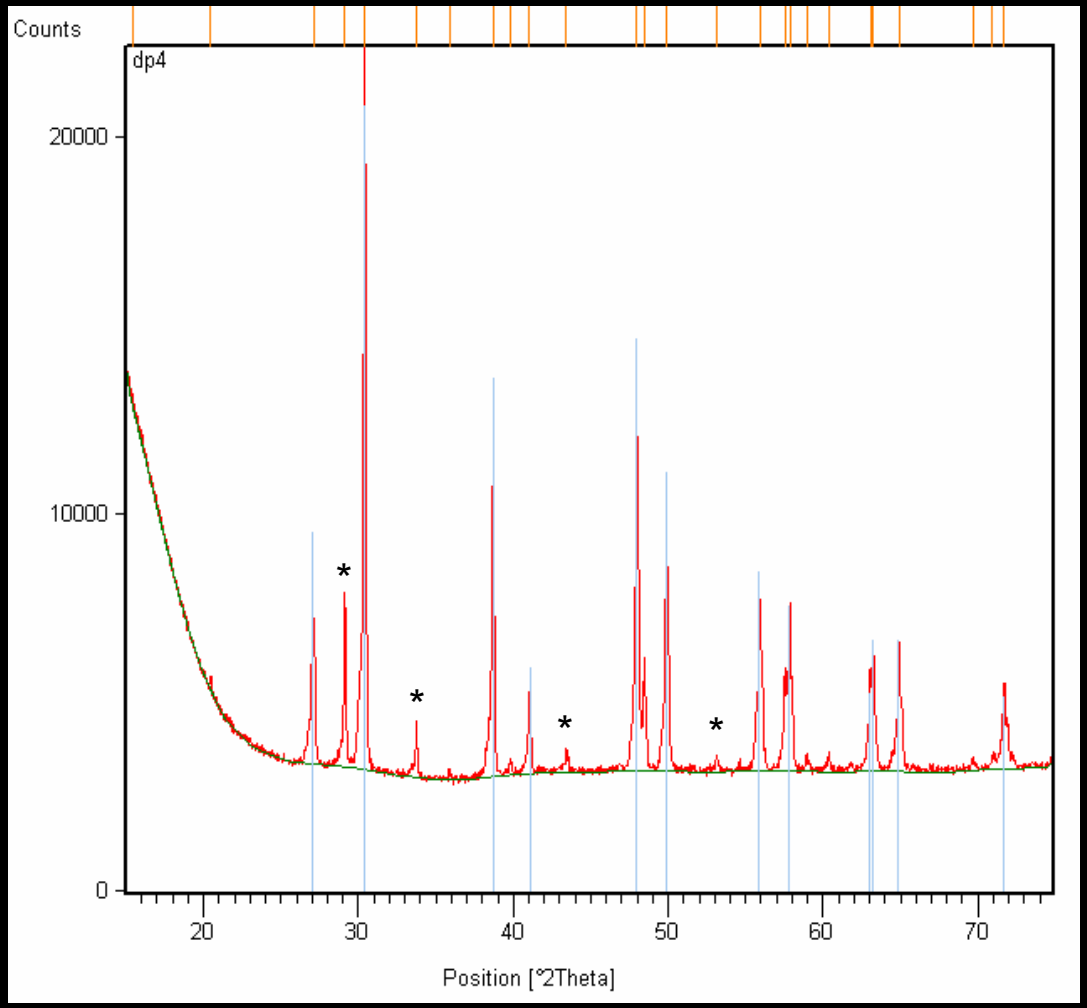


Scanning electron microscope (SEM)

Characterization – X-ray diffraction

To find out if the sample synthesized was pure

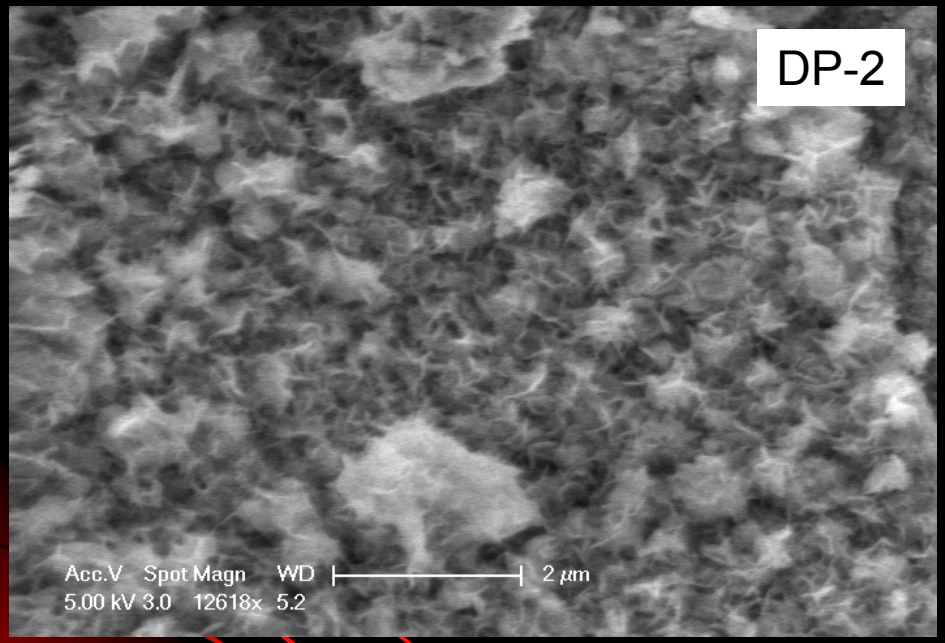
- Mainly pure Y_2O_2S (compared to standard)
- Impurity of Y_2O_3 (~30%)

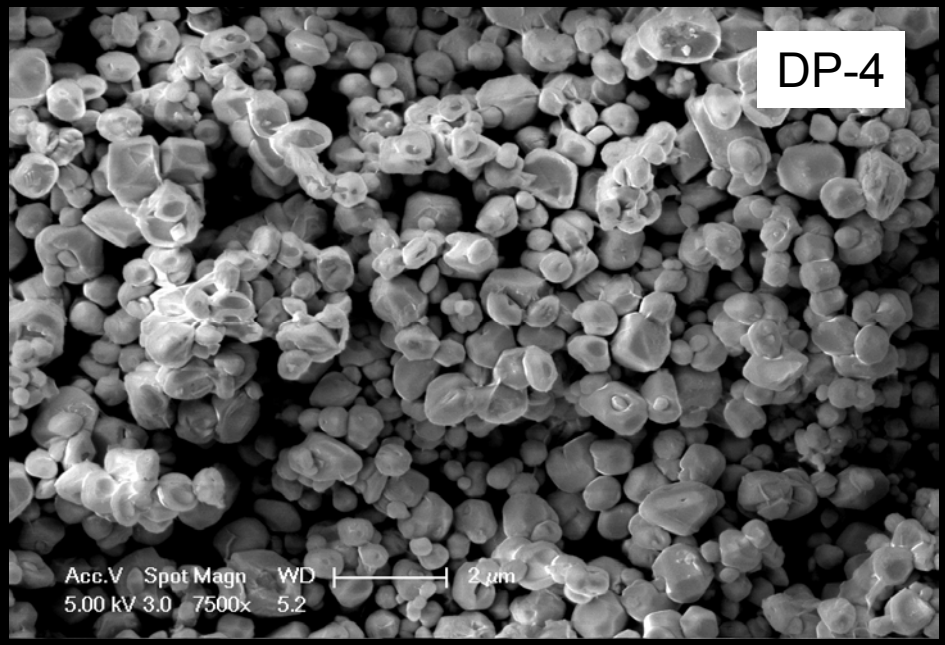


XRD pattern of Y_2O_2S:Eu(5%) without salt flux.

Characterization – Scanning Electron Microscopy (SEM)

To find out the morphology





Reactant Y_2O_3

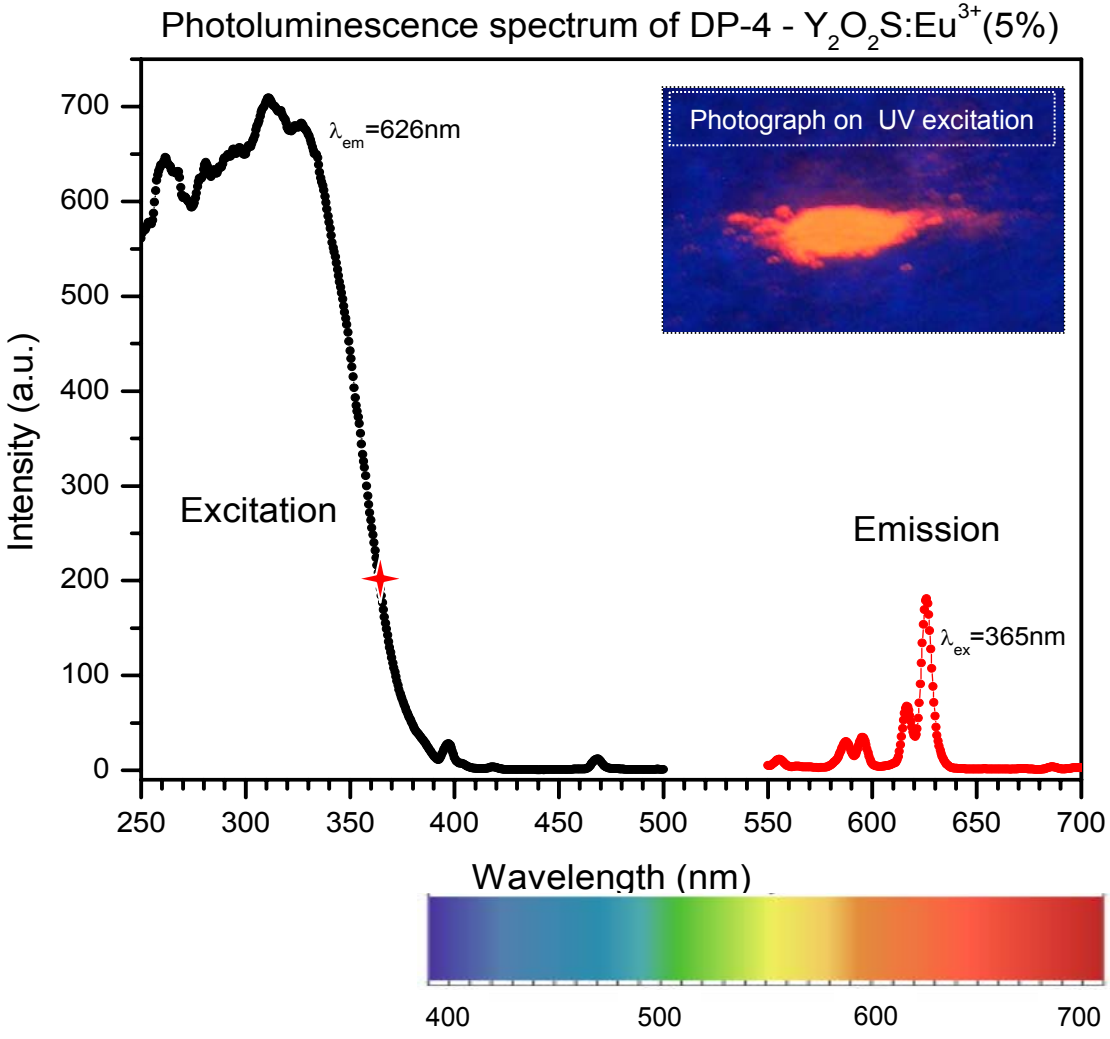
Product Y_2O_2S (no salt flux)

- Products look totally different from reactants.
- Product contains particles having a size between 200-1000 nm.

Characterization – Photoluminescence Spectroscopy

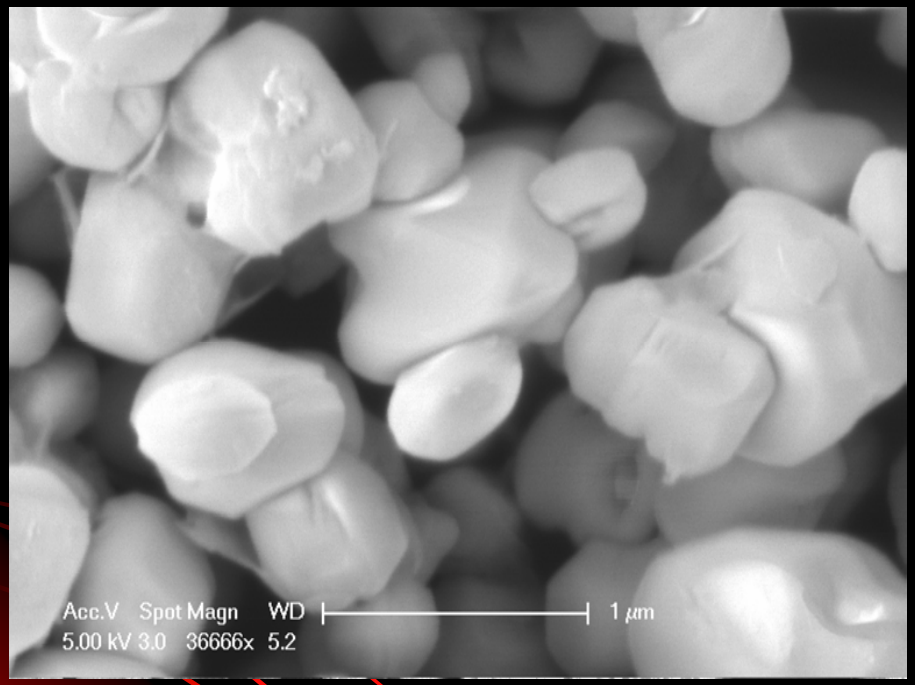
To measure luminescence (determine excitation and emission)

- Broad excitation with maximum at 330 nm.
- Line emission with maximum at 626 nm.



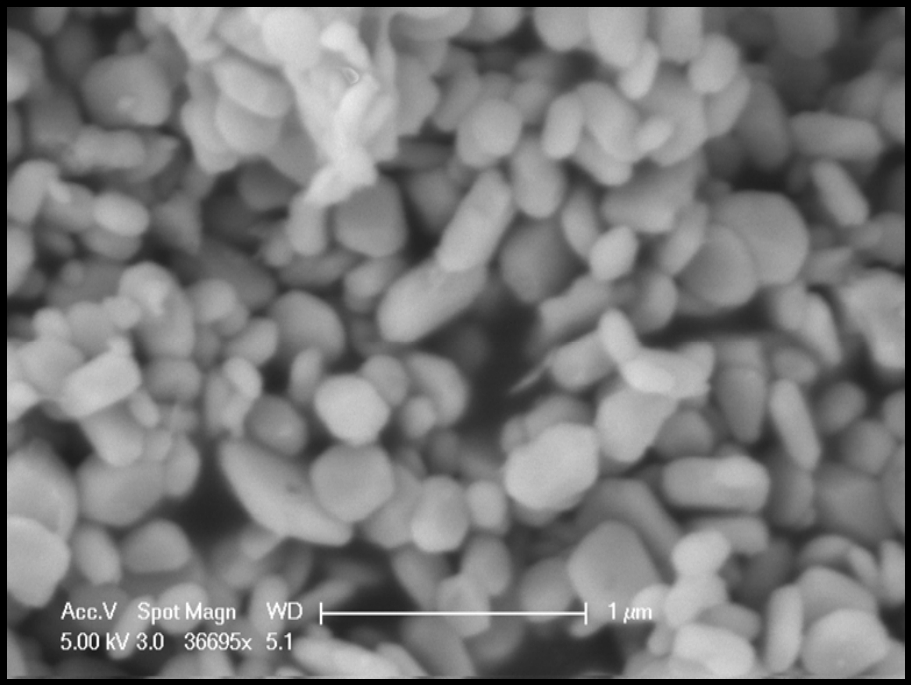
Effect of salt-flux addition

No salt flux



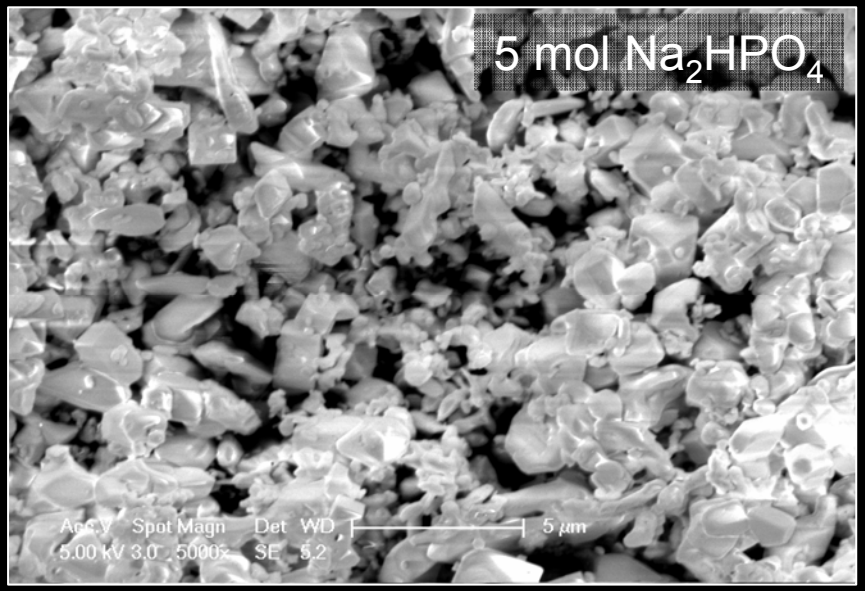
- Particle size 200-1000 nm

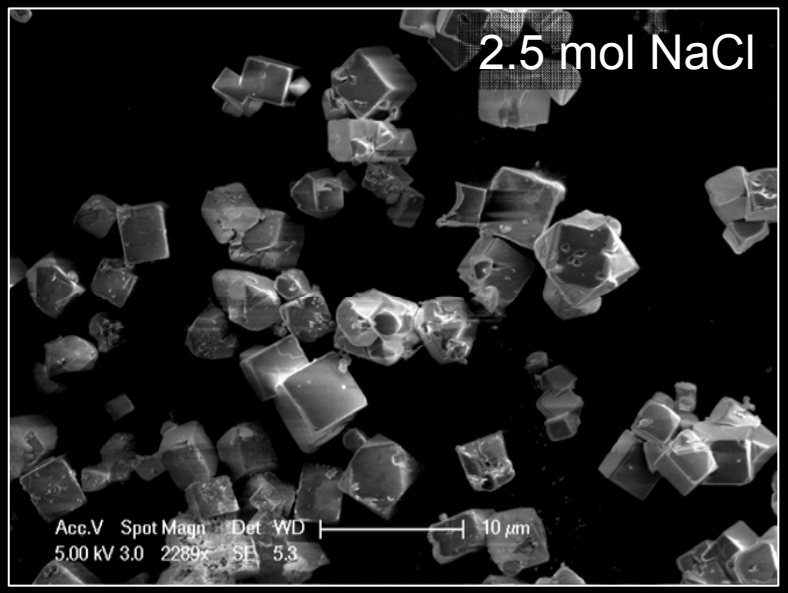
2.8 moles of Na_2HPO_4

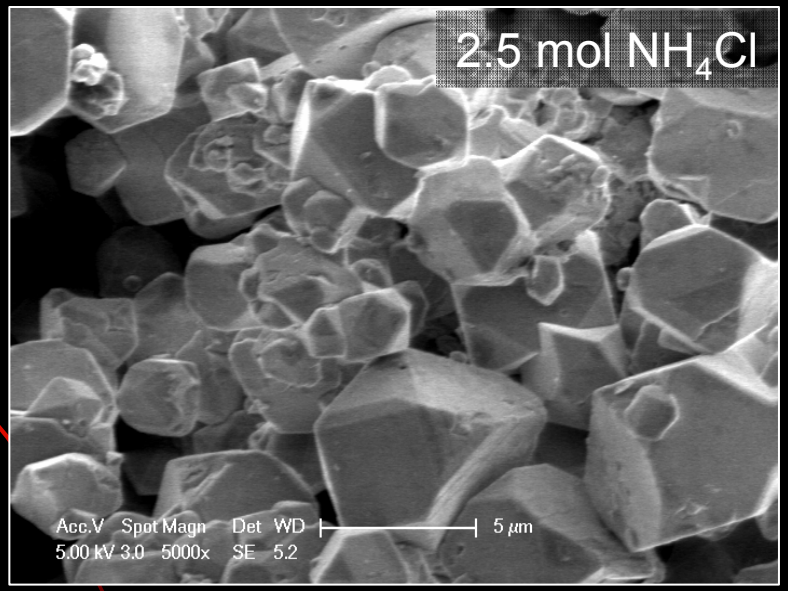


- Particle size 100-400 nm
- Slightly elongated rods present
- Further characterization under progress

Effects of adding different salt-fluxes







Further characterization under progress

Summary

- Optimized the synthesis of Y_2O_2S phosphor.
- Addition of salt-fluxes such as Na_2HPO_4, KCl, NaCl, NH_4Cl was studied.
- Bi^{3+} doping did not shift the excitation of Y_2O_2S:Eu.
- Learned the use of different instruments such as centrifuges, furnaces, ovens etc. to synthesize the samples and XRD, PL, SEM to characterize them.

Future Plans

- Optimize the flux and reaction conditions to obtain uniform morphology.
- Perform optical studies on the samples.

Acknowledgements

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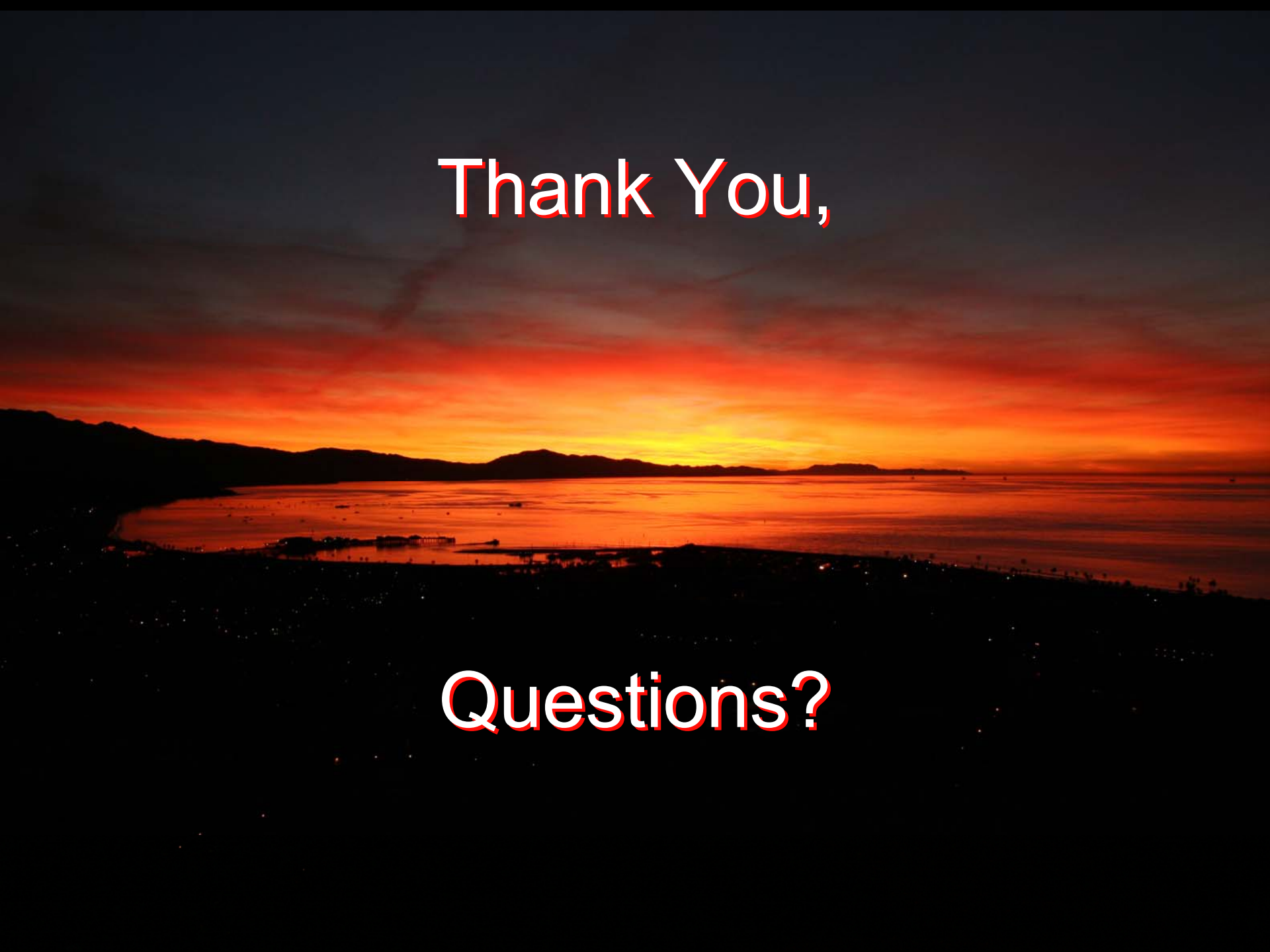
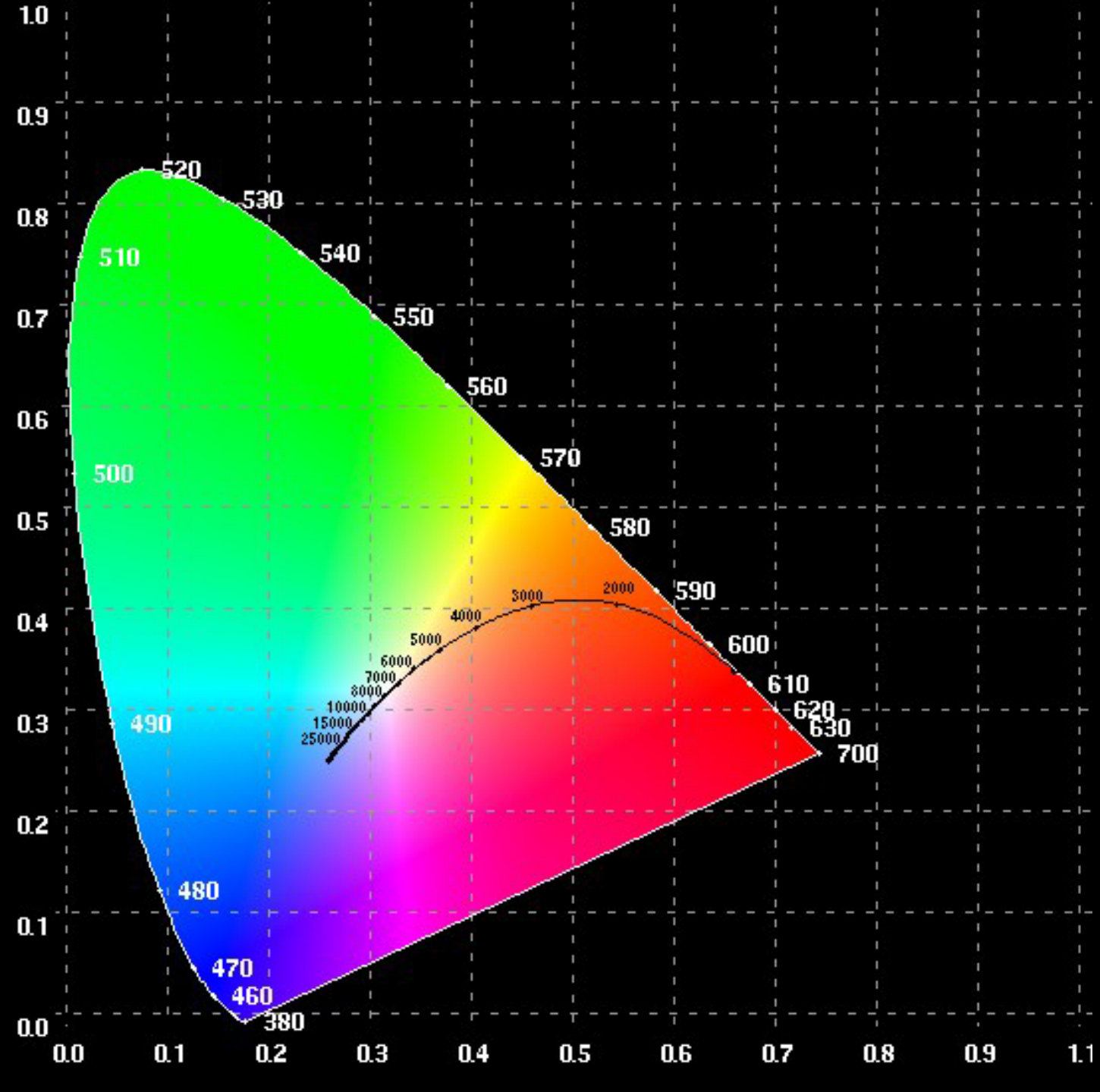
- INSET colleagues


Thank You,
Questions?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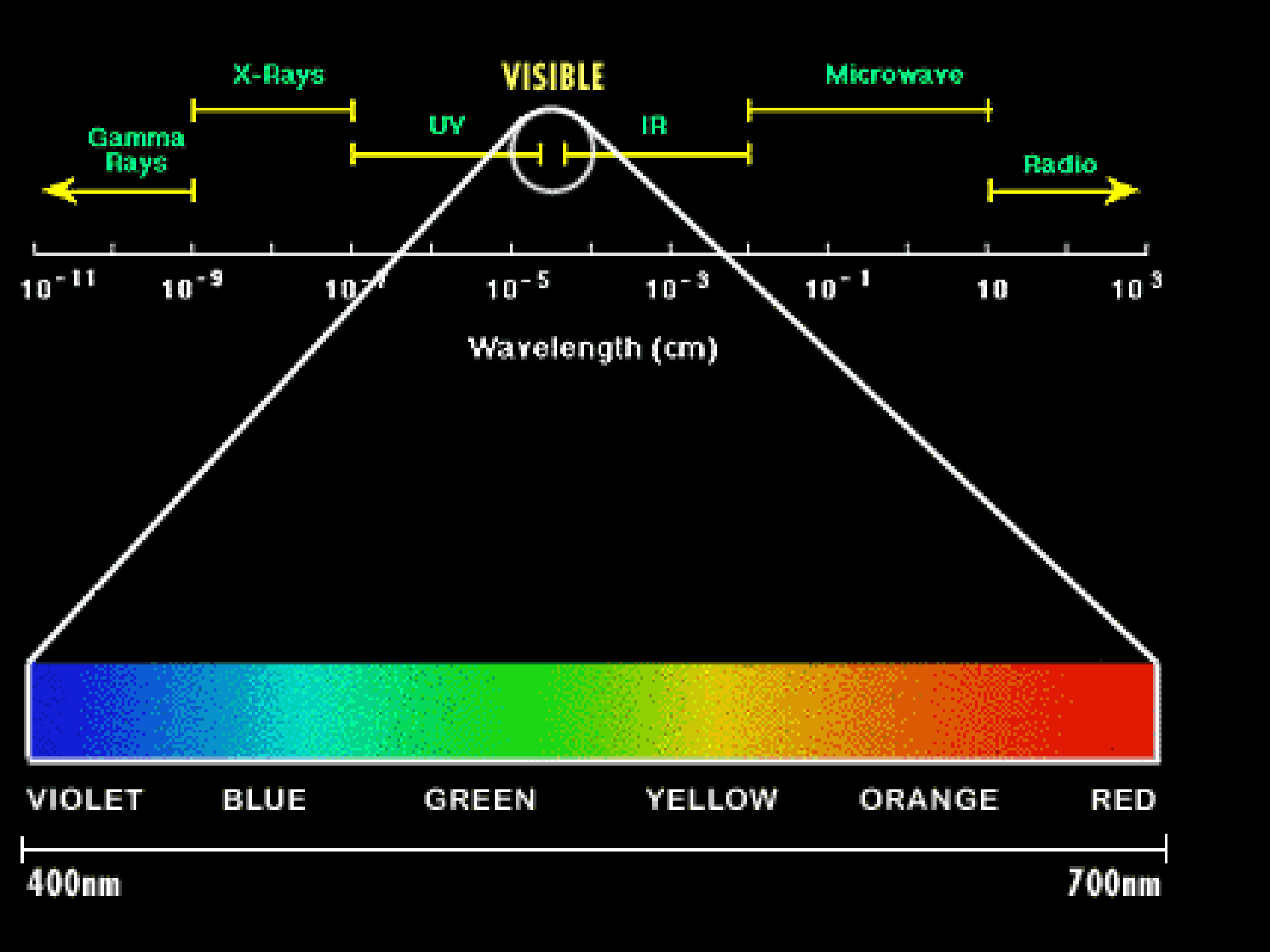
X-Rays
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UV
IR
Radio
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10^{-9}
10^{-7}
10^{-5}
10^{-3}
10^{-1}
10
10^{3}
Wavelength (cm)
VIOLET
BLUE
GREEN
YELLOW
ORANGE
RED
400nm
700nm

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