Luminescent Orthophosphates New Features in Spotlight

Eugeniusz Zych

Faculty of Chemistry, University of Wroclaw

14 F. Joliot-Curie Street, 50-383 Wroclaw, Poland

The problem of orthophosphates:

~~No pulling crystals by Czochralski method~~

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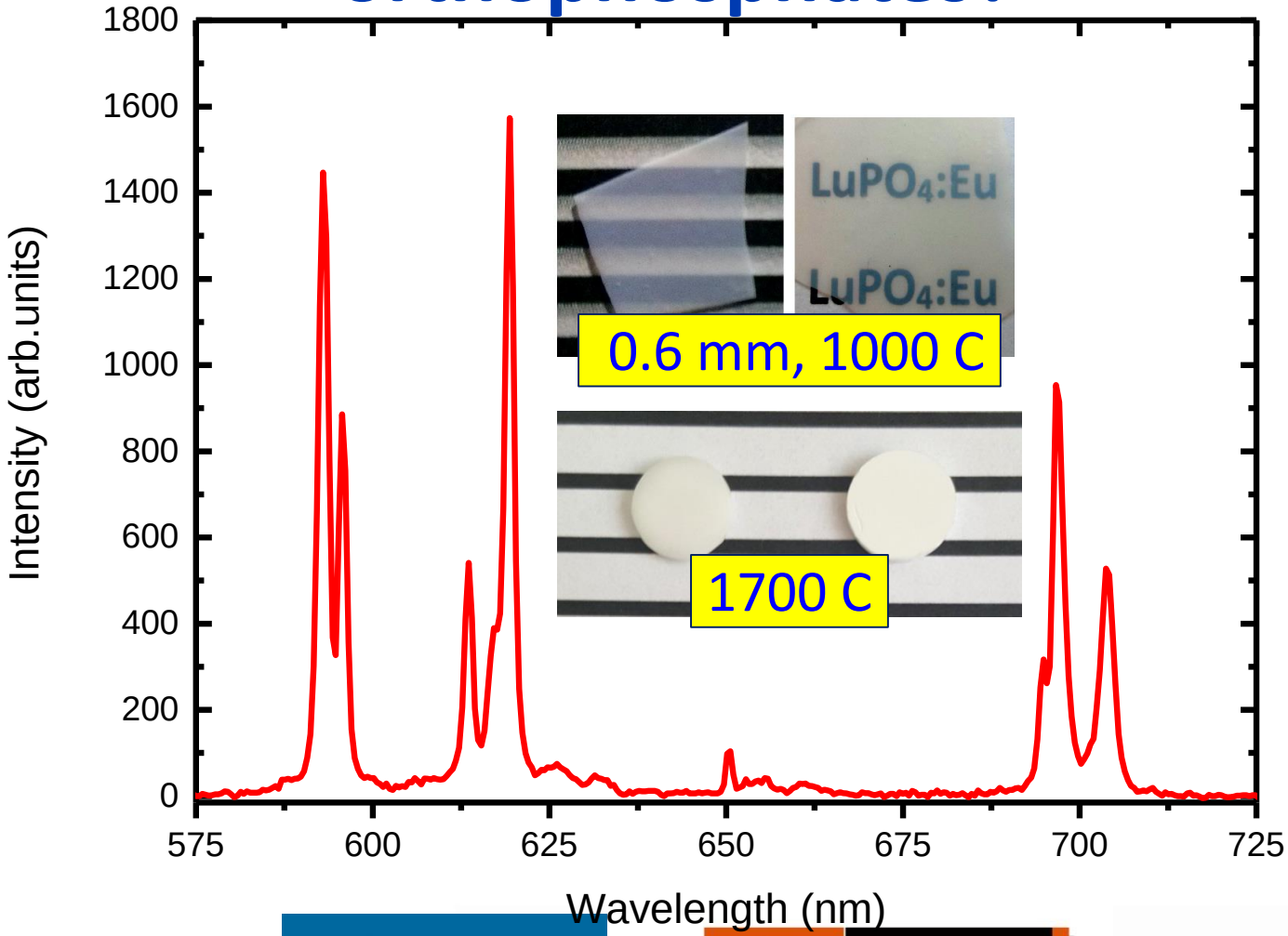
Can sintering be a solution for orthophosphates?



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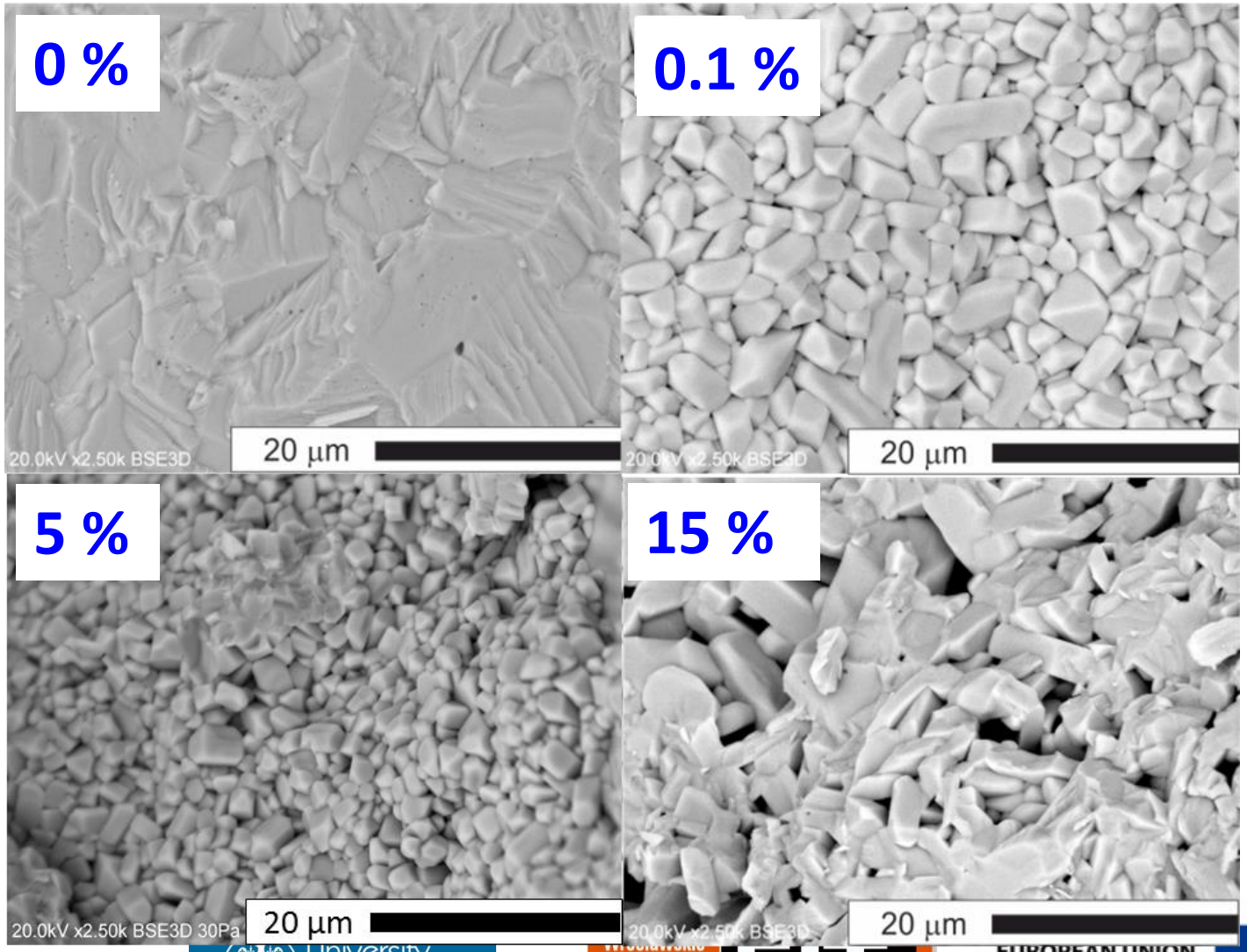
$LuPO_4$:Eu ceramics - morphology



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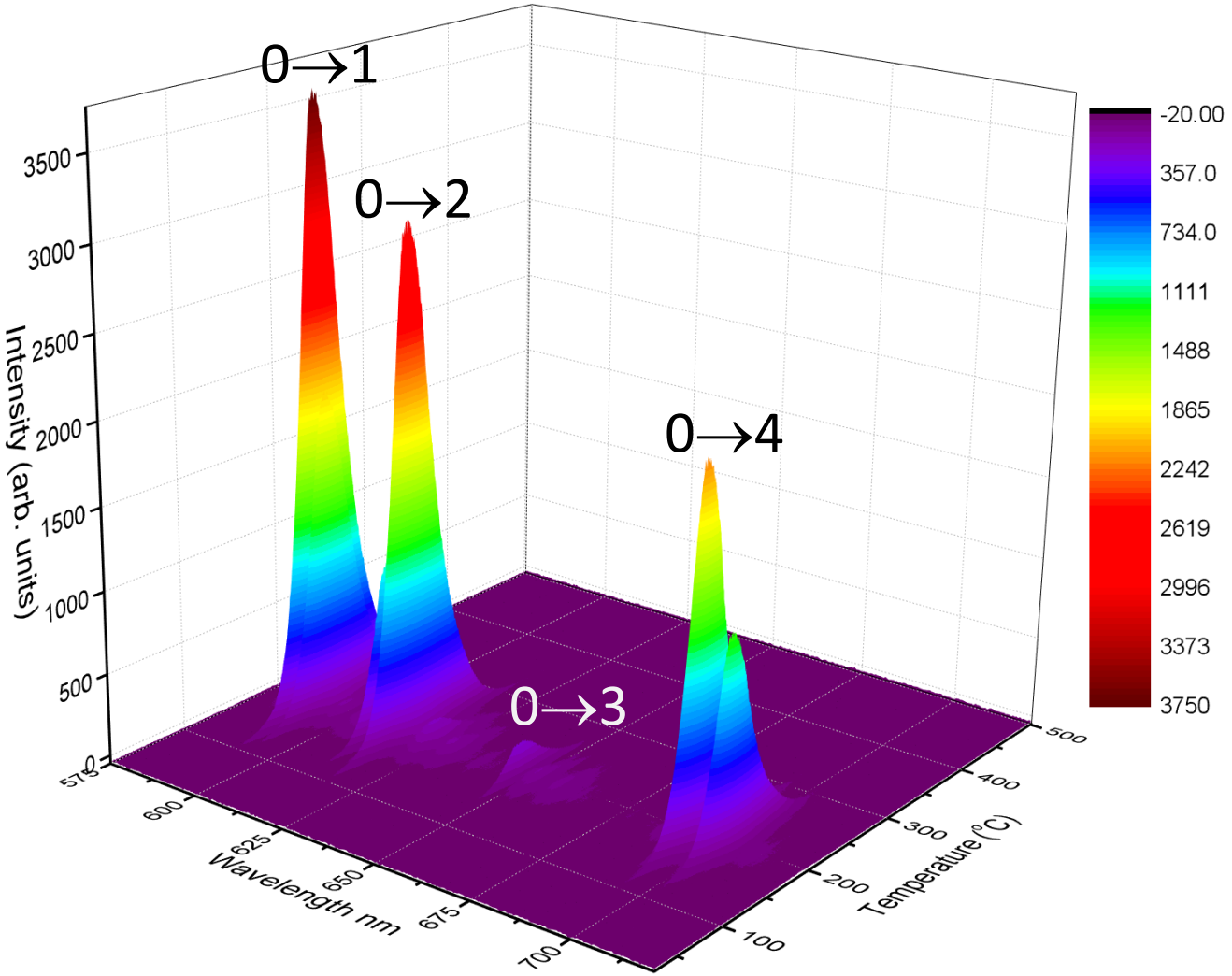
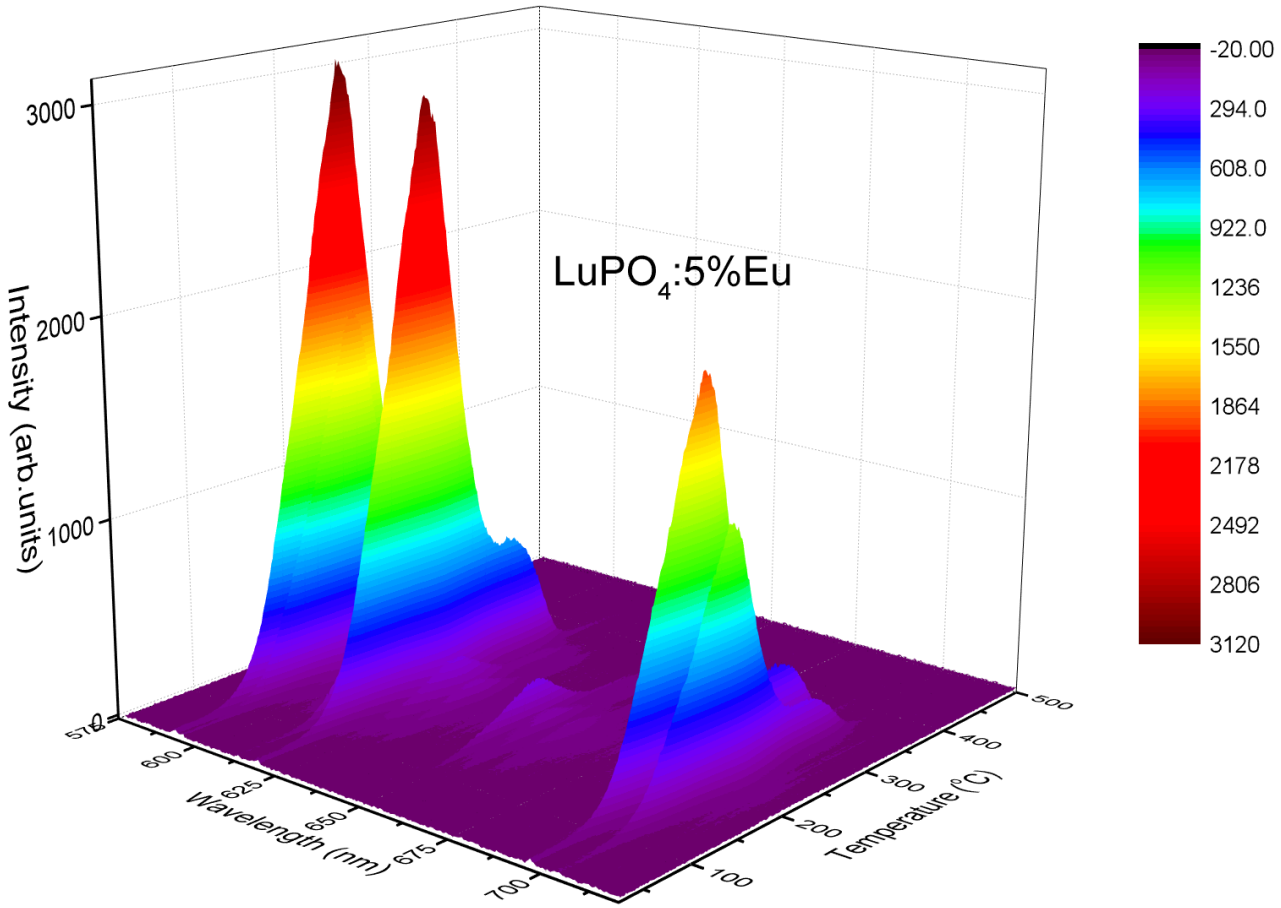
Sintered $LuPO_4$:Eu shows thermoluminescence

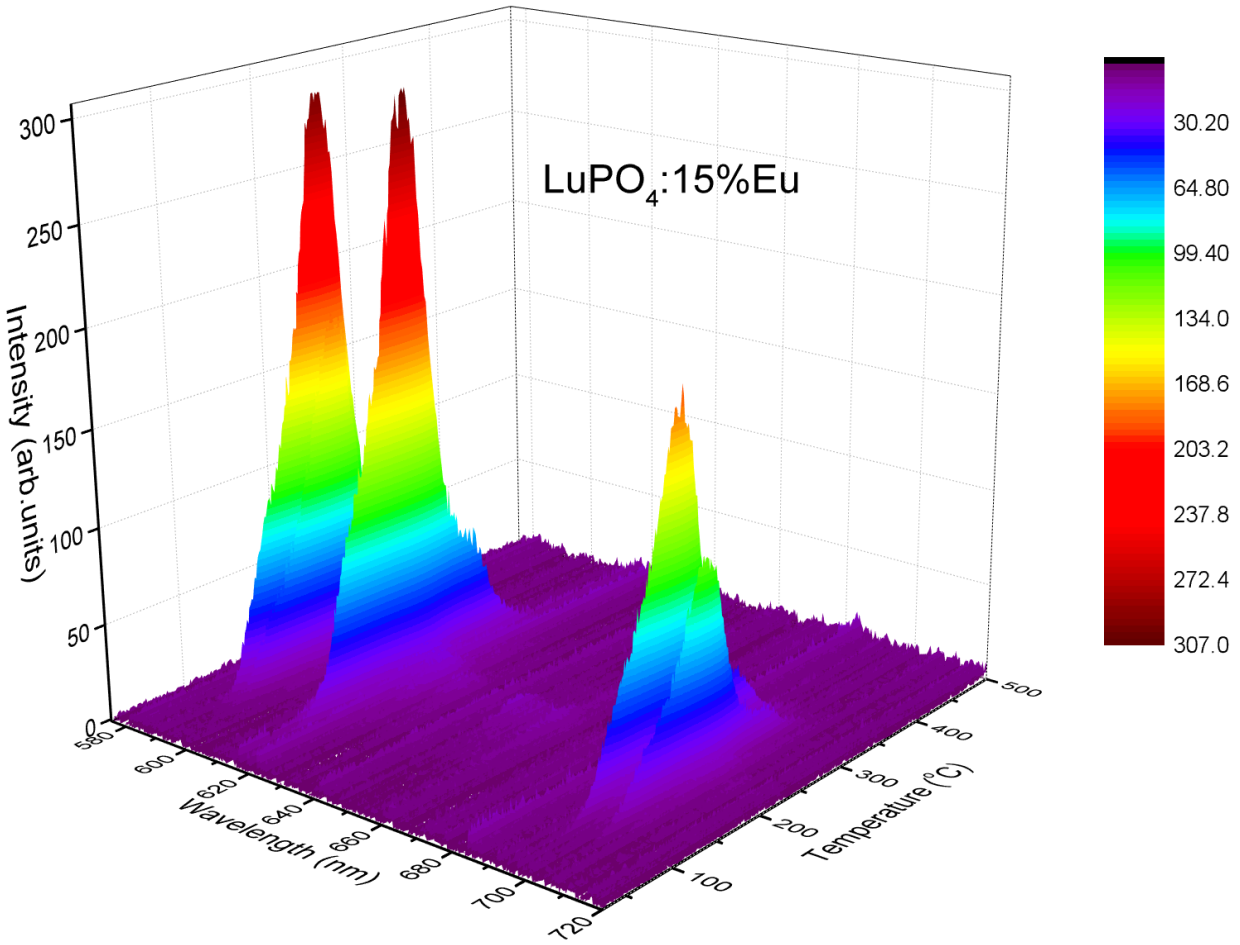
$LuPO_4$:0.1%Eu


0→1
0→2
0→3
0→4
Intensity (arb. units)
3500
3000
2500
2000
1500
1000
500
0
575
600
625
650
675
700
Wavelength nm
100
200
300
400
500
Temperature (°C)
-20.00
357.0
734.0
1111
1488
1865
2242
2619
2996
3373
3750

$LuPO_4$:5%Eu


LuPO4:5%Eu
Intensity (arb.units)
3000
2000
1000
0
575
600
625
650
675
700
Wavelength (nm)
100
200
300
400
500
Temperature (°C)
-20.00
294.0
608.0
922.0
1236
1550
1864
2178
2492
2806
3120

$LuPO_4$:15%Eu


LuPO4:15%Eu
Intensity (arb.units)
300
250
200
150
100
50
0
580
600
620
640
660
680
700
720
Wavelength (nm)
100
200
300
400
500
Temperature (°C)
30.20
64.80
99.40
134.0
168.6
203.2
237.8
272.4
307.0

How/where the energy (e′ and h•)

is trapped?

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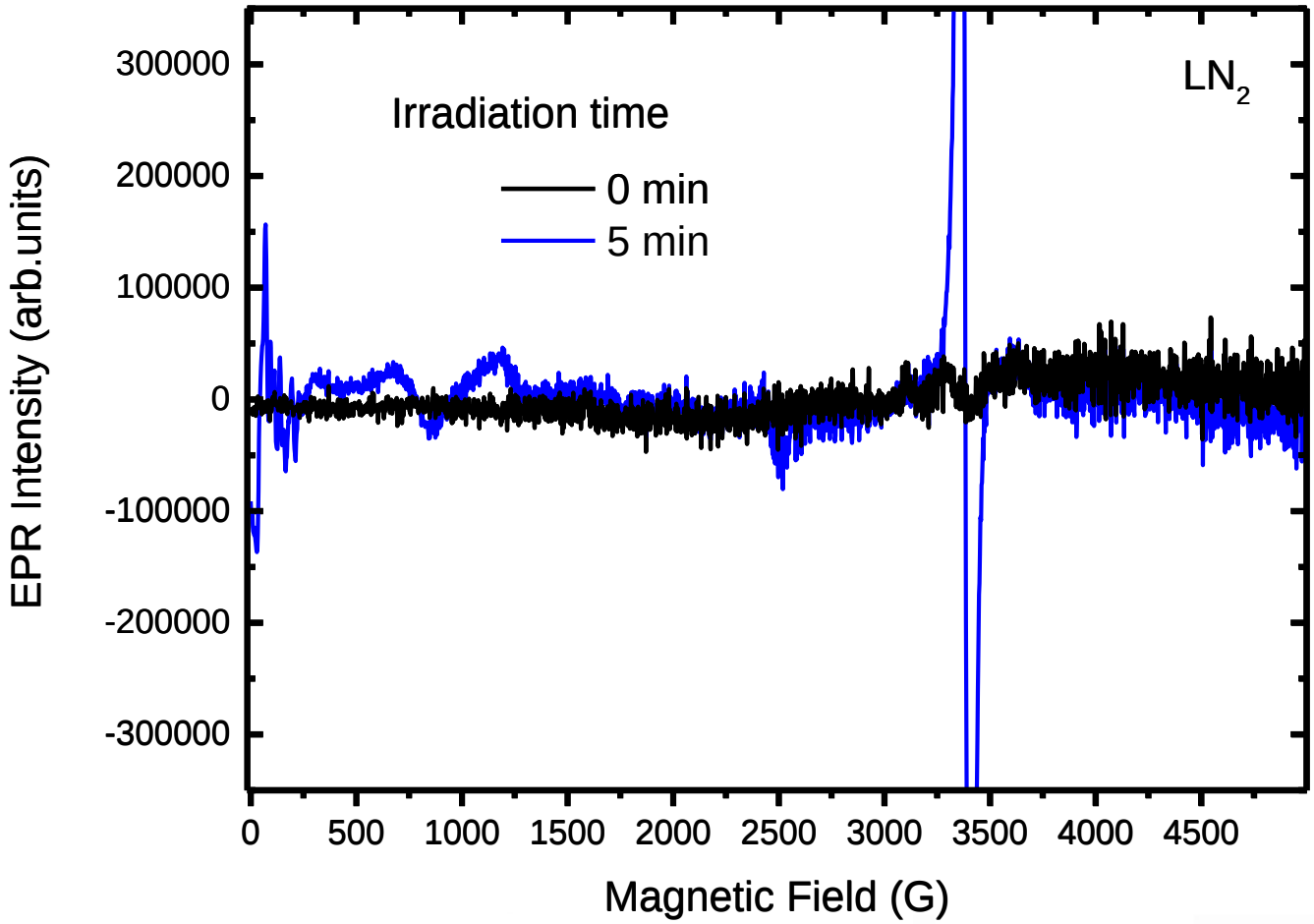
Seeking the trapped carriers - EPR



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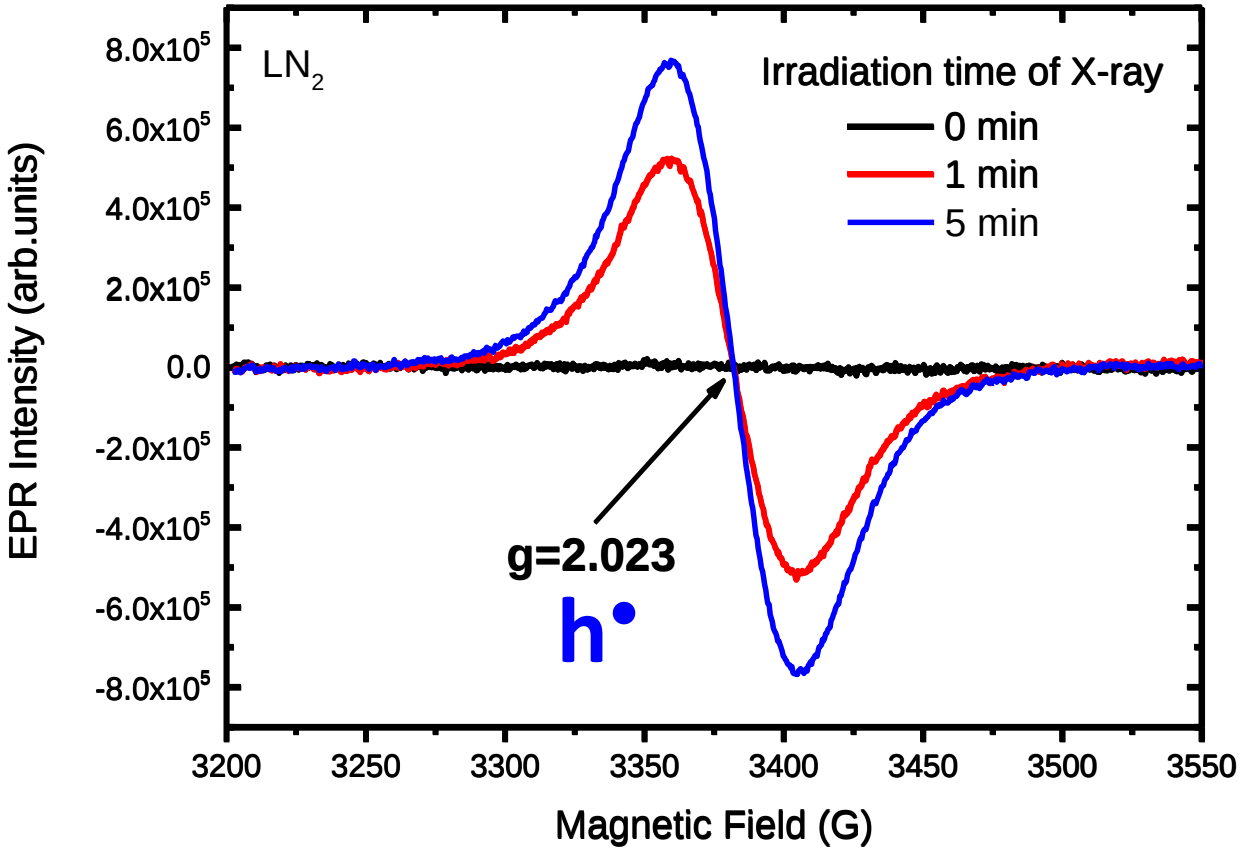
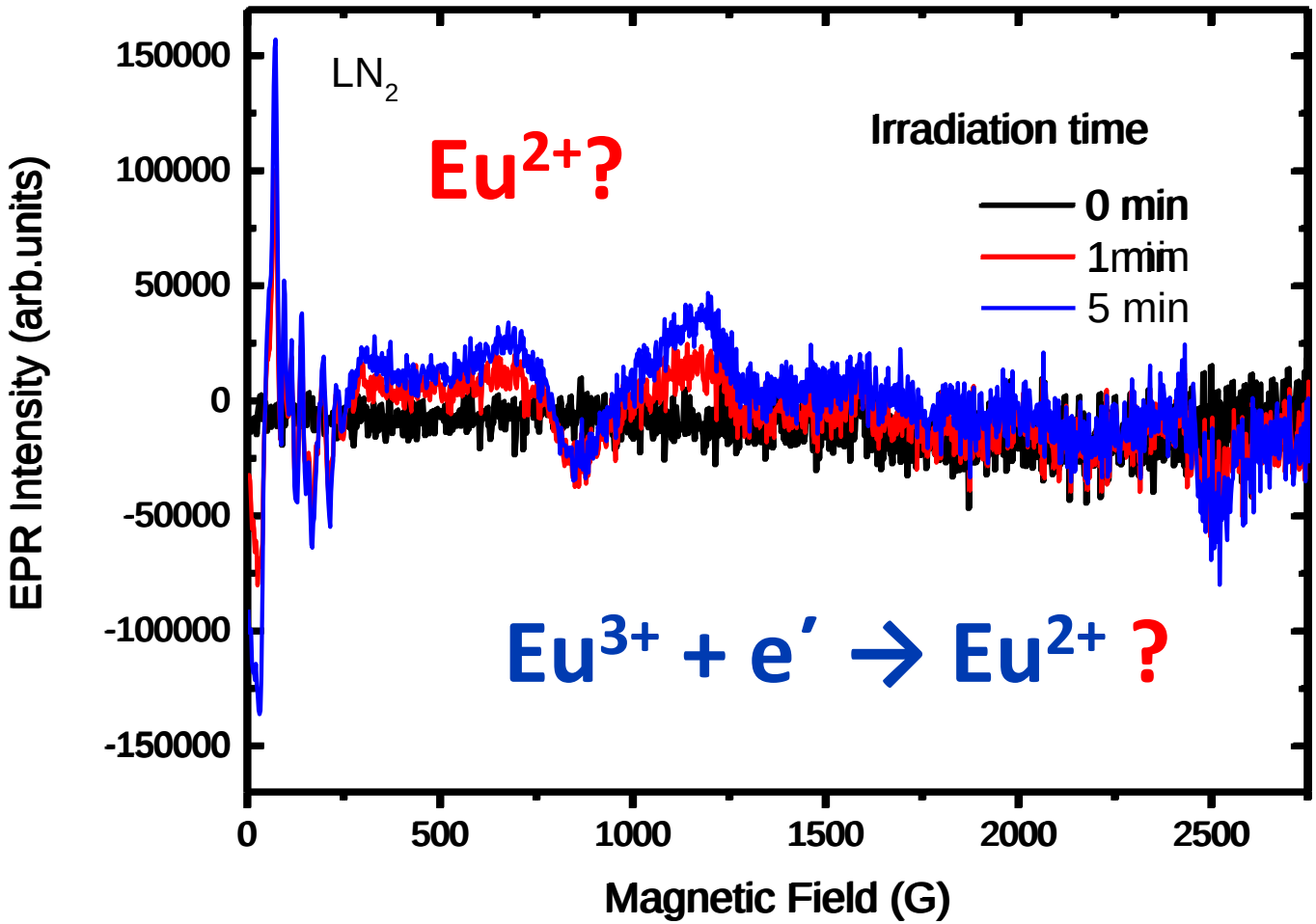
Seeking the trapped carriers - EPR



Seeking the trapped carriers - EPR



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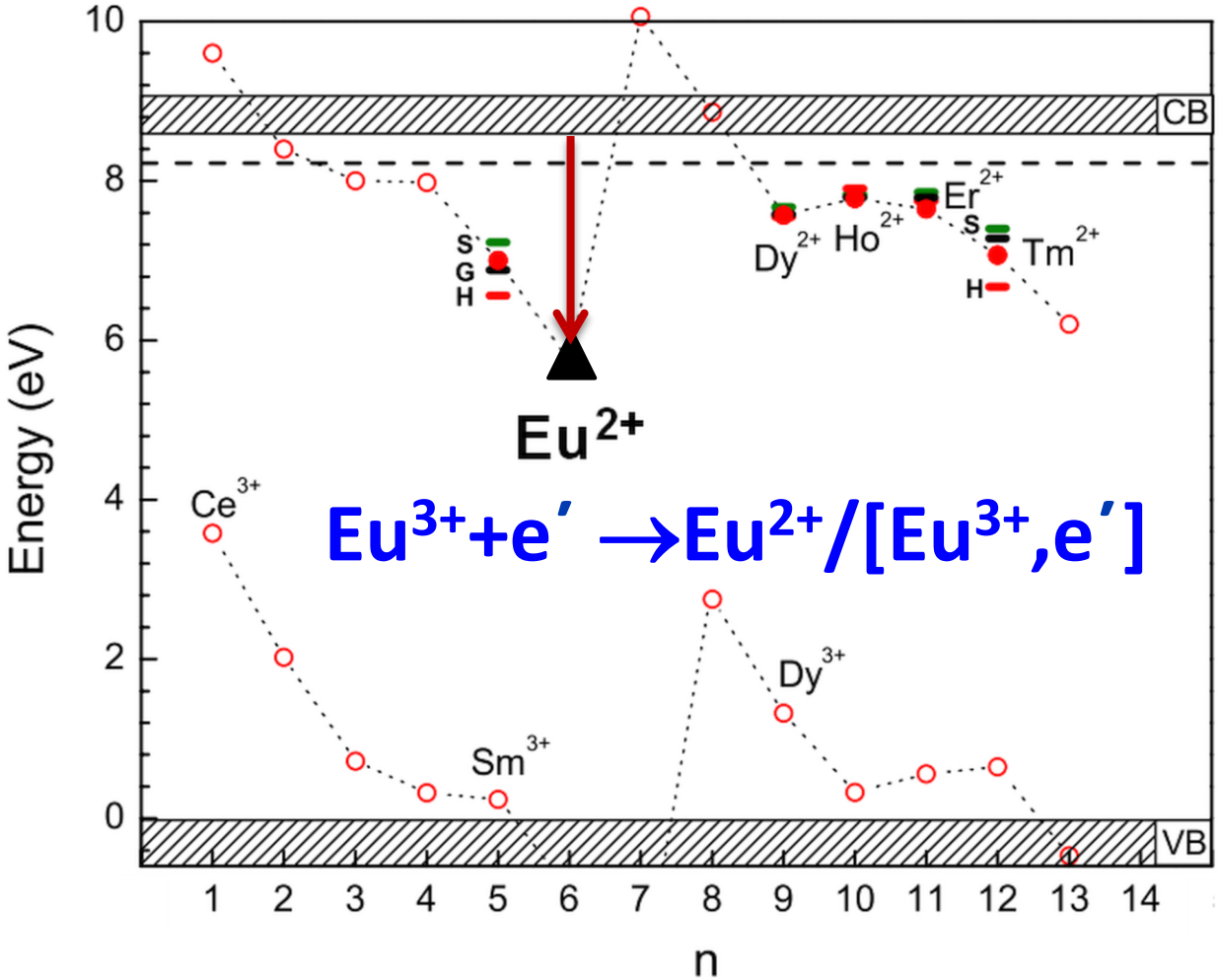
Probable mechnism of e-trapping



A. H. Krumpel, A. J. J. Bos, A. Bessière, E. van der Kolk, P. Dorenbos, *Phys. Rev. B* **80**, 085103, (2009)

Can we better prove the presence of Eu^{2+}?

PL

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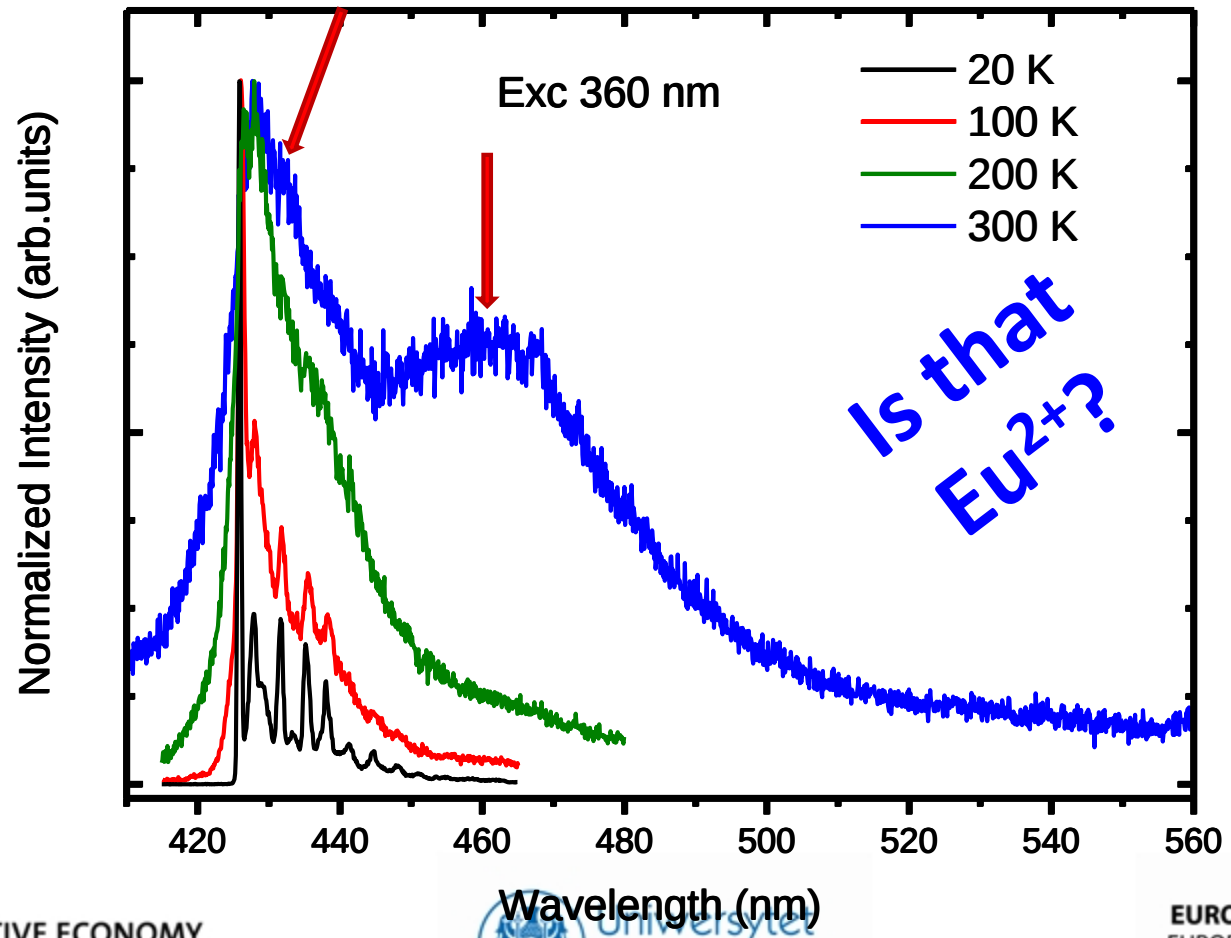
X-rayed sample
PL - temperature dependence



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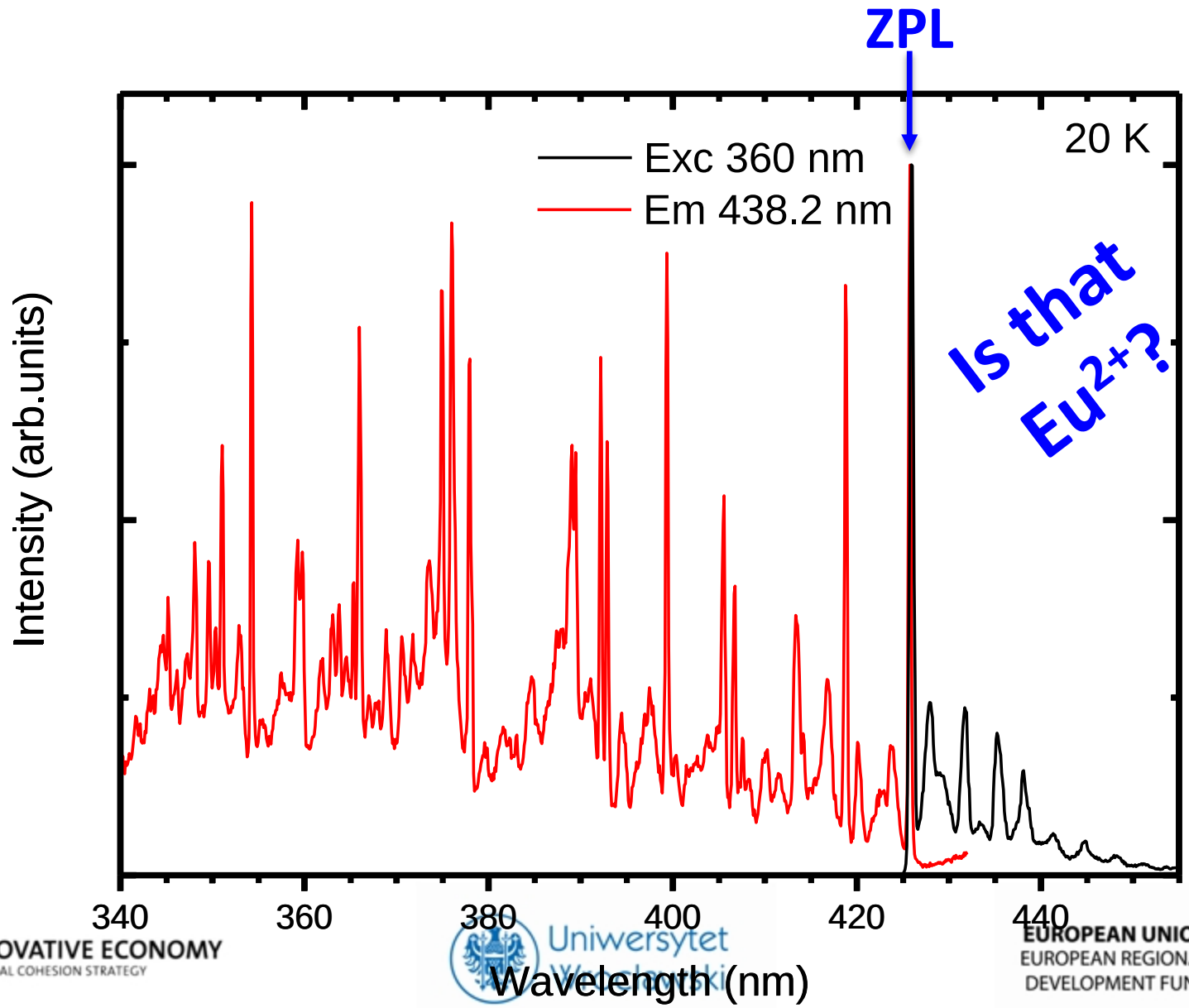
PL - Only after X-rays



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Can we get $LuPO_4:Eu^{2+}$ without X-rays?

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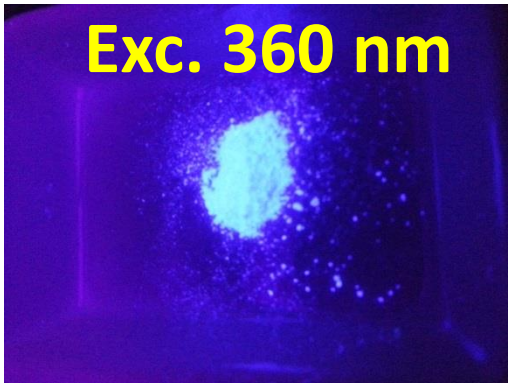
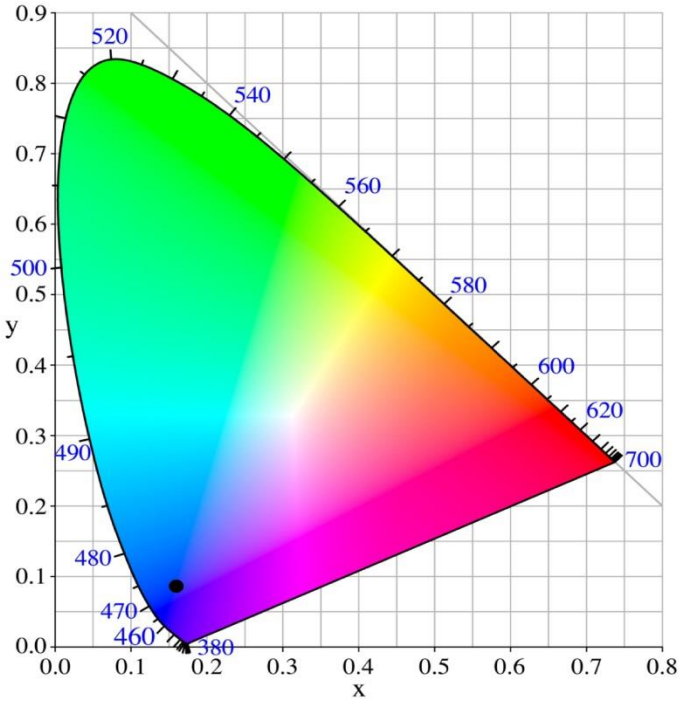
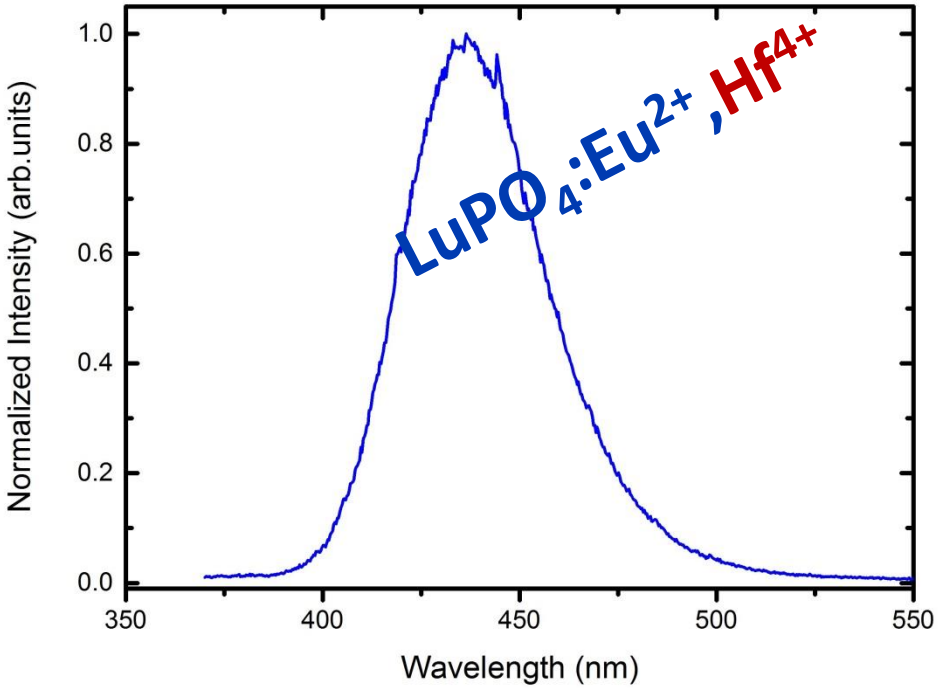
$LuPO_4$:Eu,Hf







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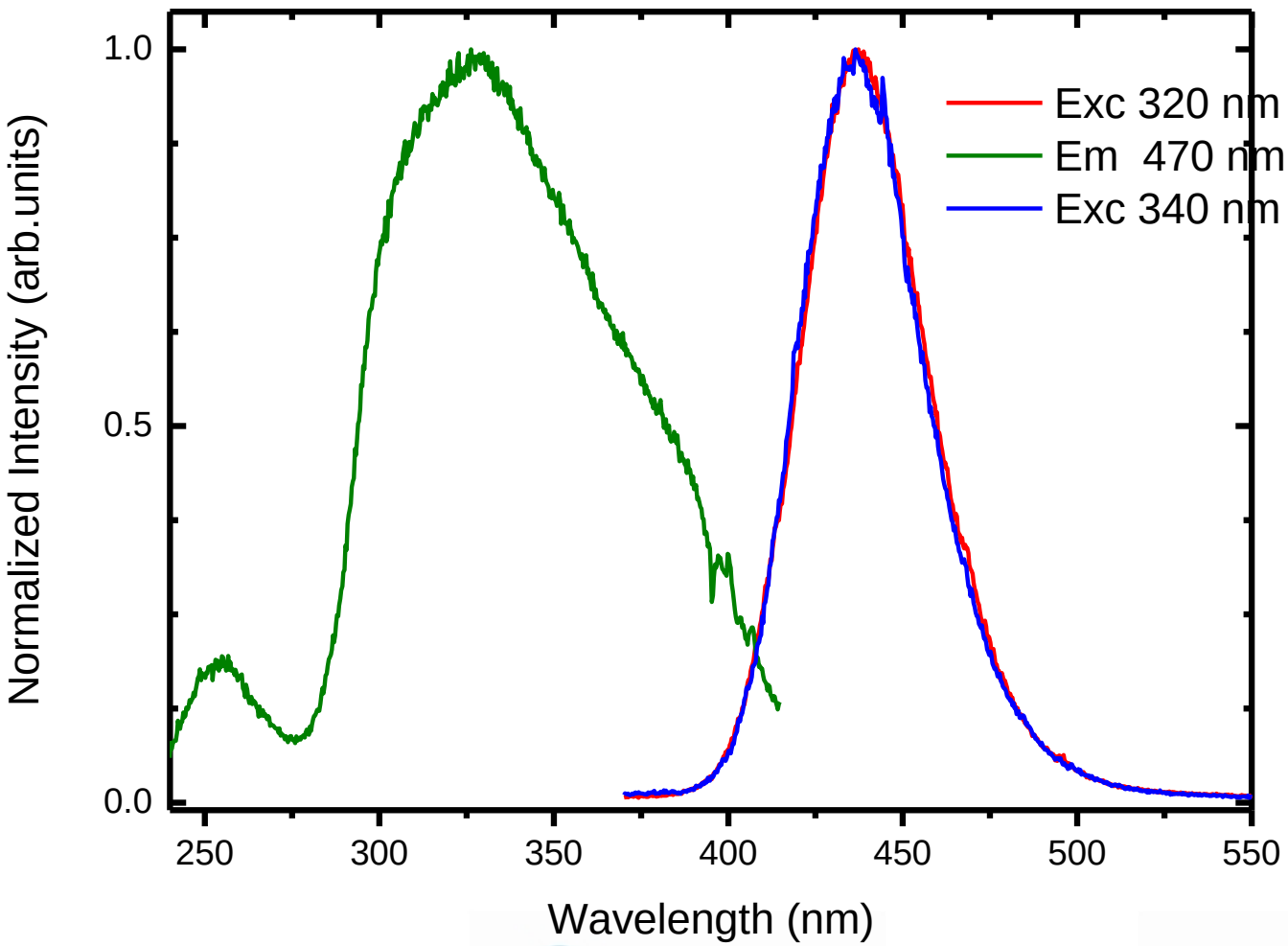
PL of $LuPO_4:Eu^{2+}$,Hf - RT



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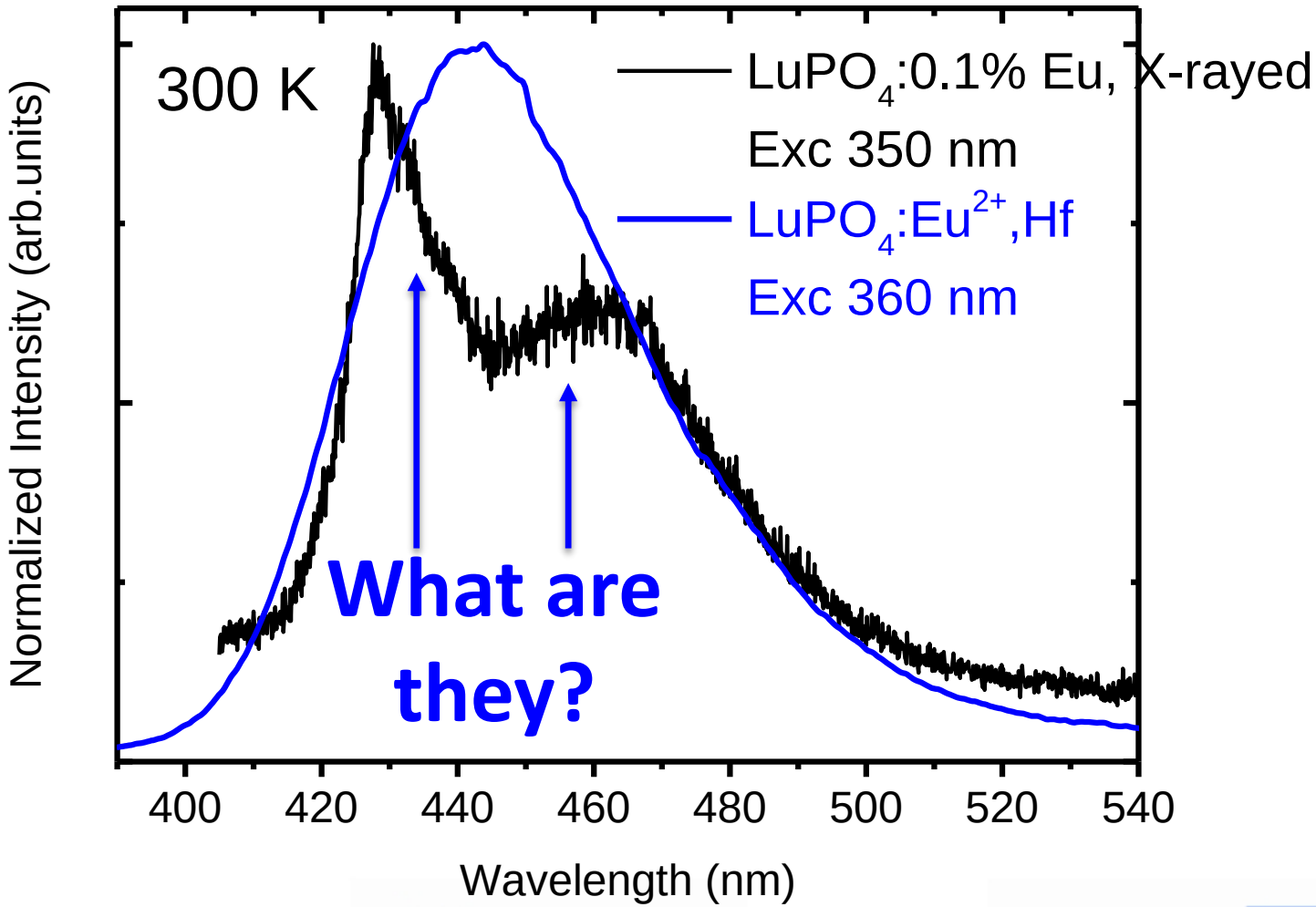
X-rayed $LuPO_4$:Eu vs. $LuPO_4$:Eu^{2+},Hf



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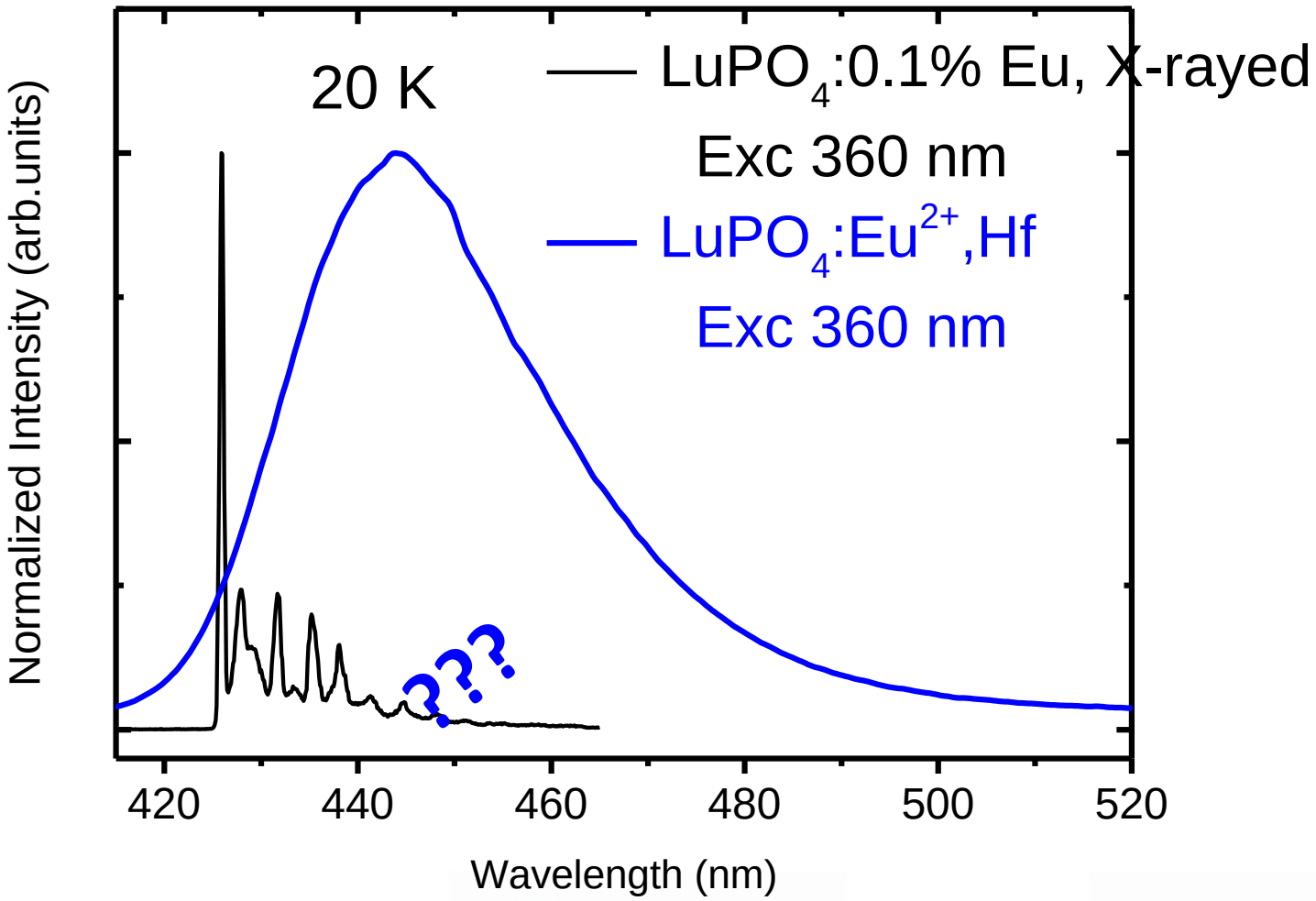
X-rayed $LuPO_4$:Eu vs. LuPO4:Eu^{2+},Hf



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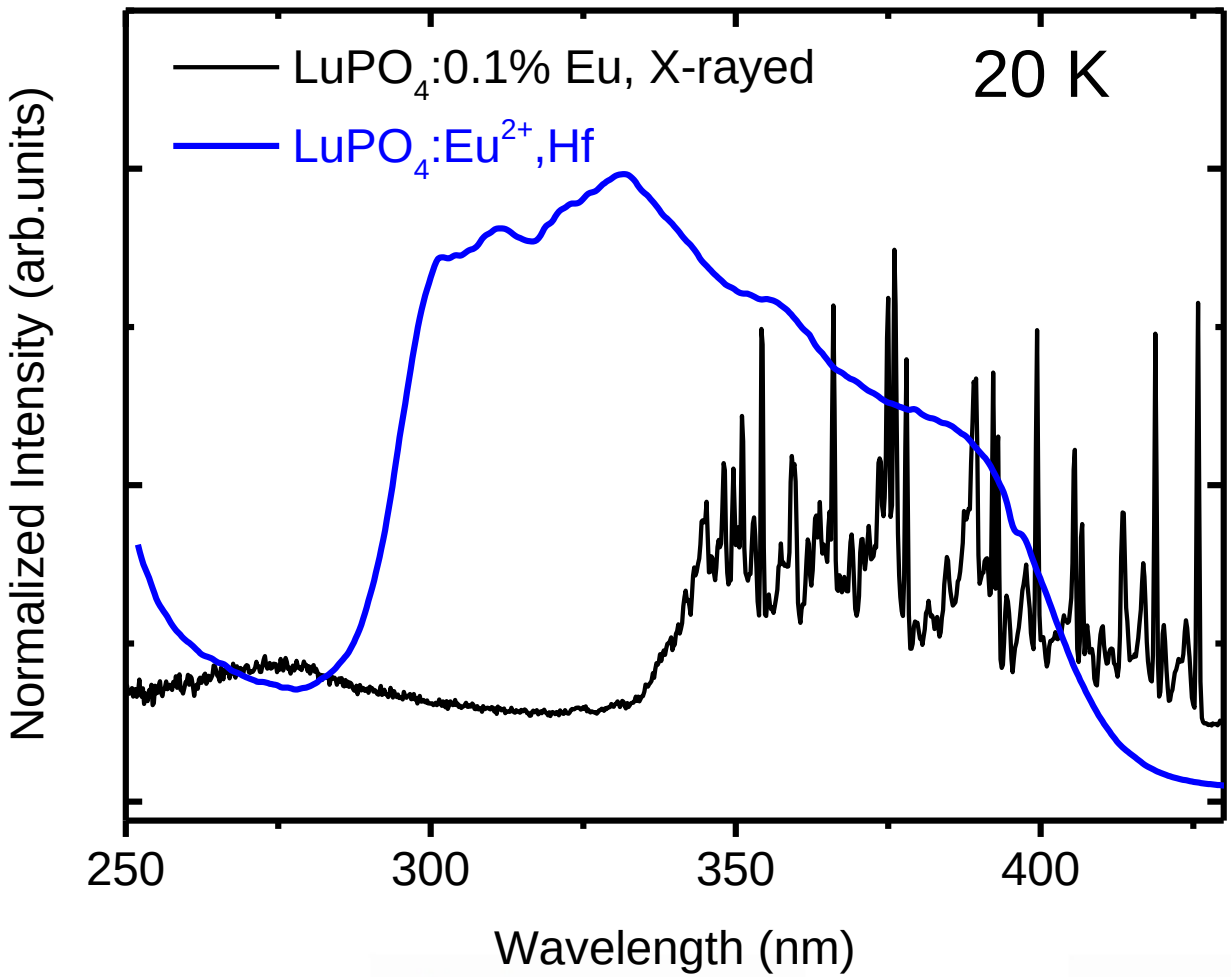
X-rayed $LuPO_4$:Eu vs. $LuPO_4$:Eu^{2+},Hf - 20 K



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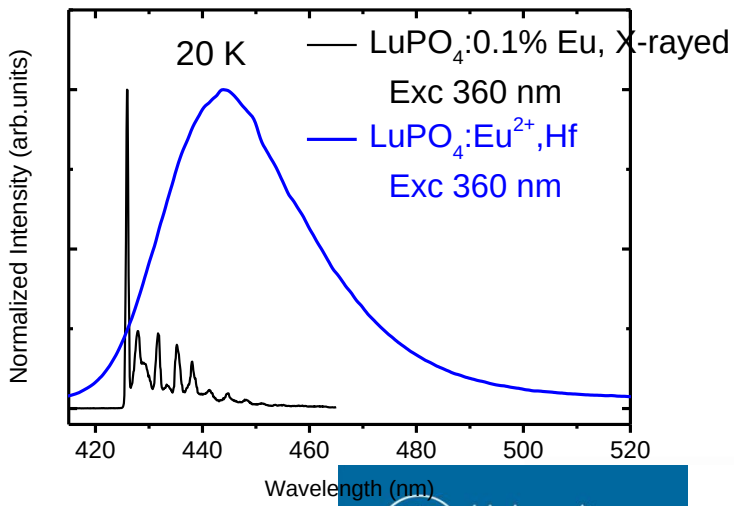
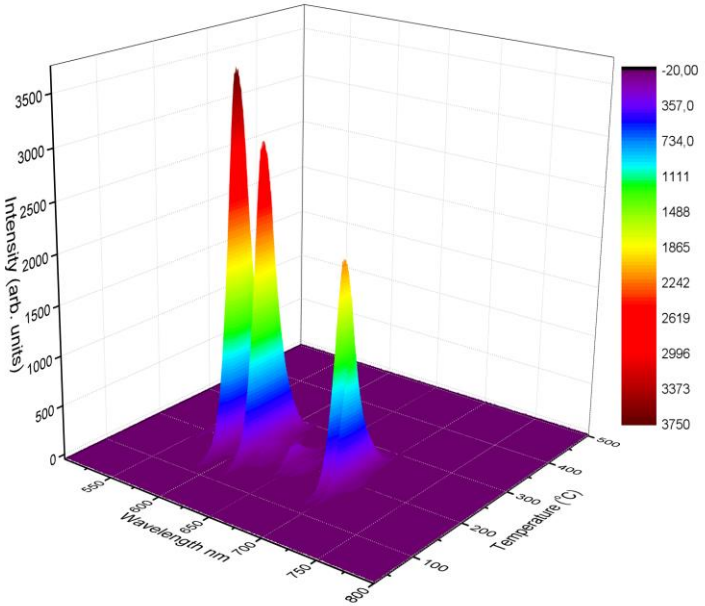
Summary

- High-temperature sintering transfers LuPO4:Eu into a storage phosphor
- Eu^{2+} can be stabilized in LuPO4 by Hf co-doping
- Unclear origin of blue PL in X-rayed LuPO4:Eu





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The research was supported by
Wroclaw Research Centre EIT+
within the project "The Application of Nanotechnology in Advanced Materials" - NanoMat (POIG.01.01.02-02-002/08) financed by the European Regional Development Fund (Innovative Economy Operational Program 1.1.2

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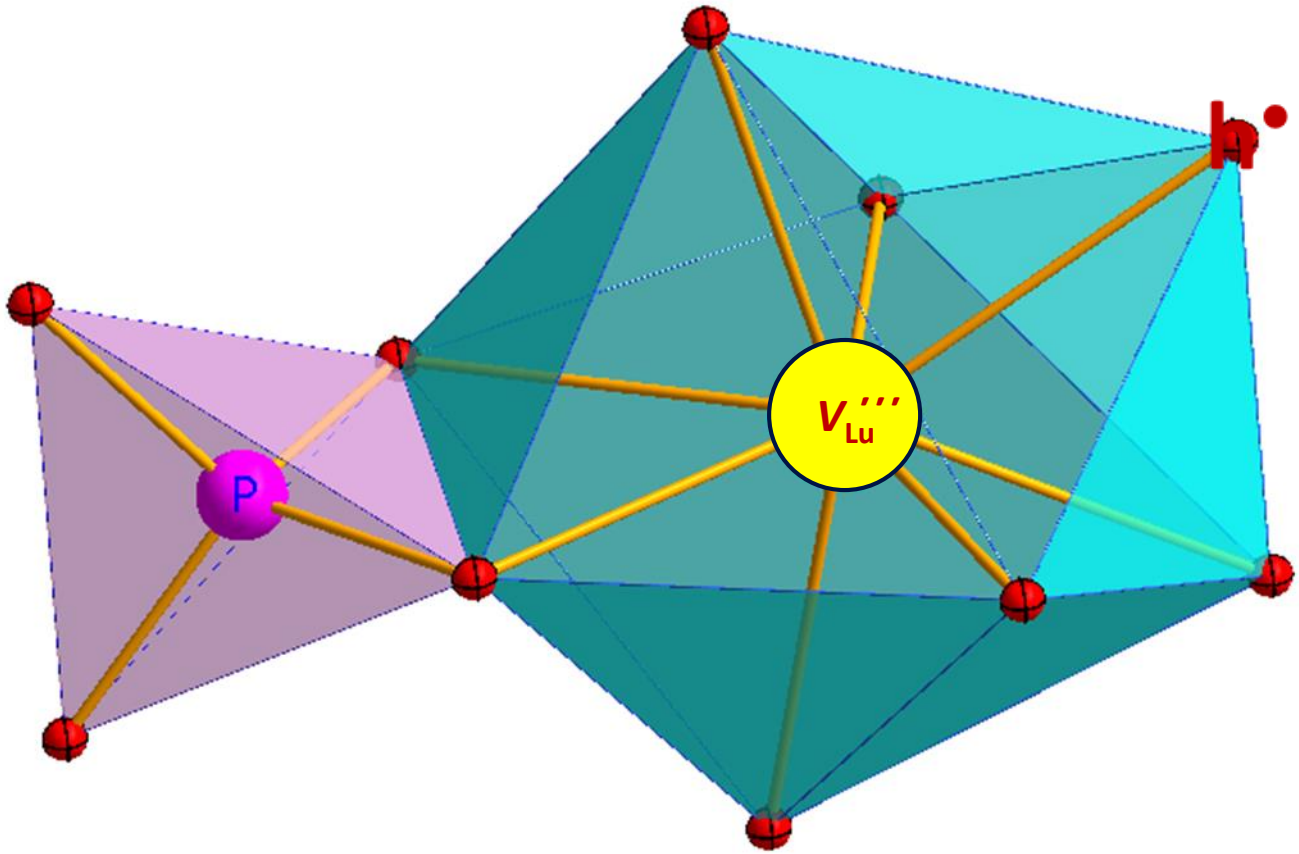
Proposed mechnism of energy trapping

$Eu^{3+} + e' \rightarrow Eu^{2+}$

$V_{Lu}''' + h^{\bullet} \rightarrow V_{Lu}''$ $[V_{Lu}''' - h^{\bullet}]$ g=2.023



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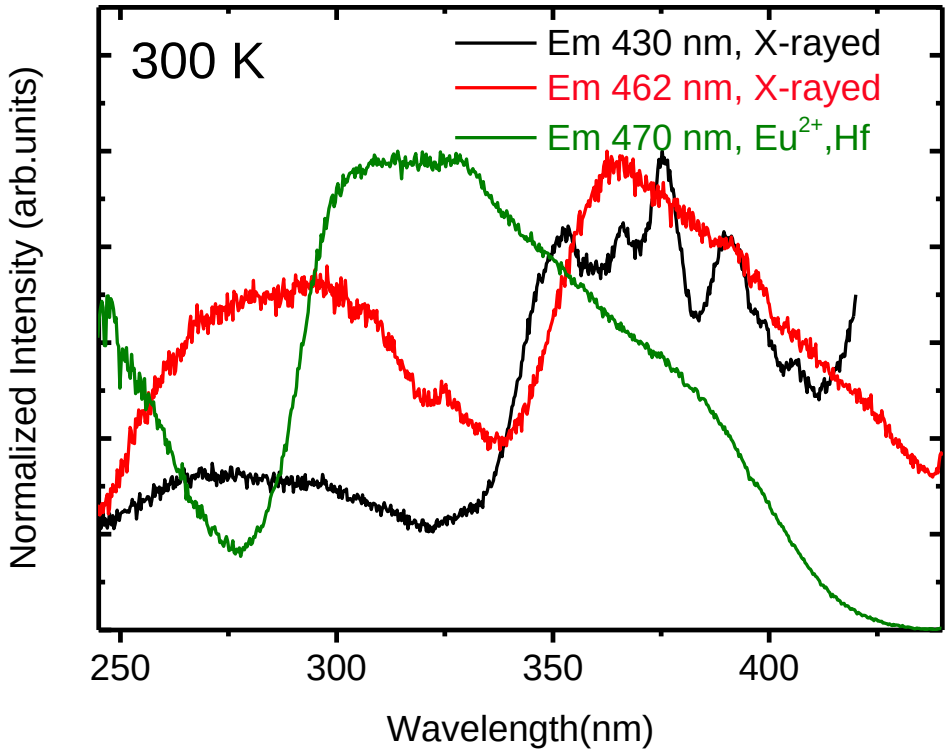
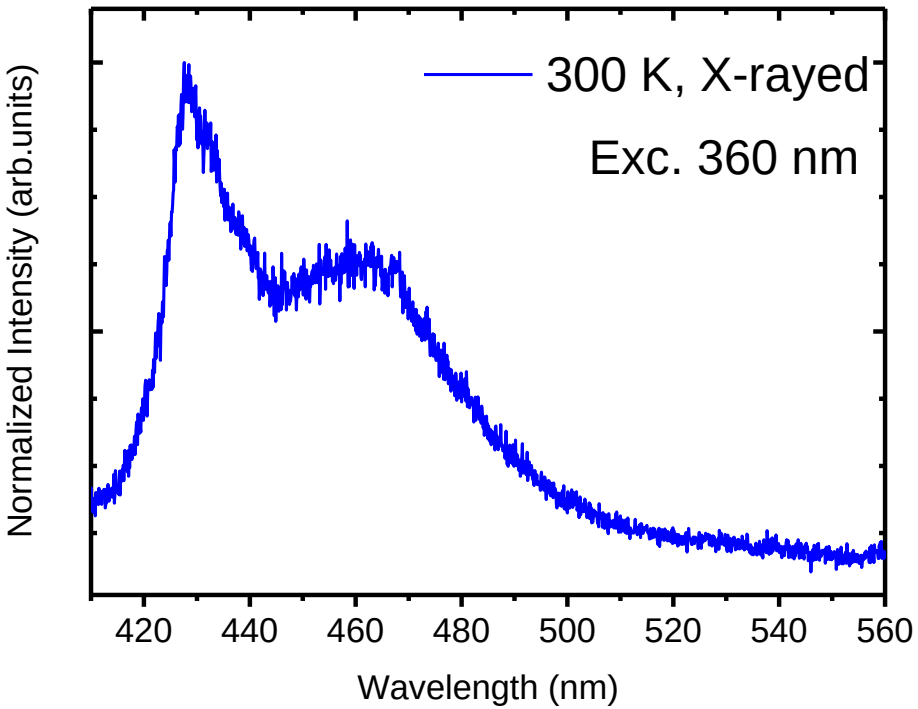
X-rayed $LuPO_4$:Eu vs. $LuPO_4$:Eu^{2+},Hf - 300 K





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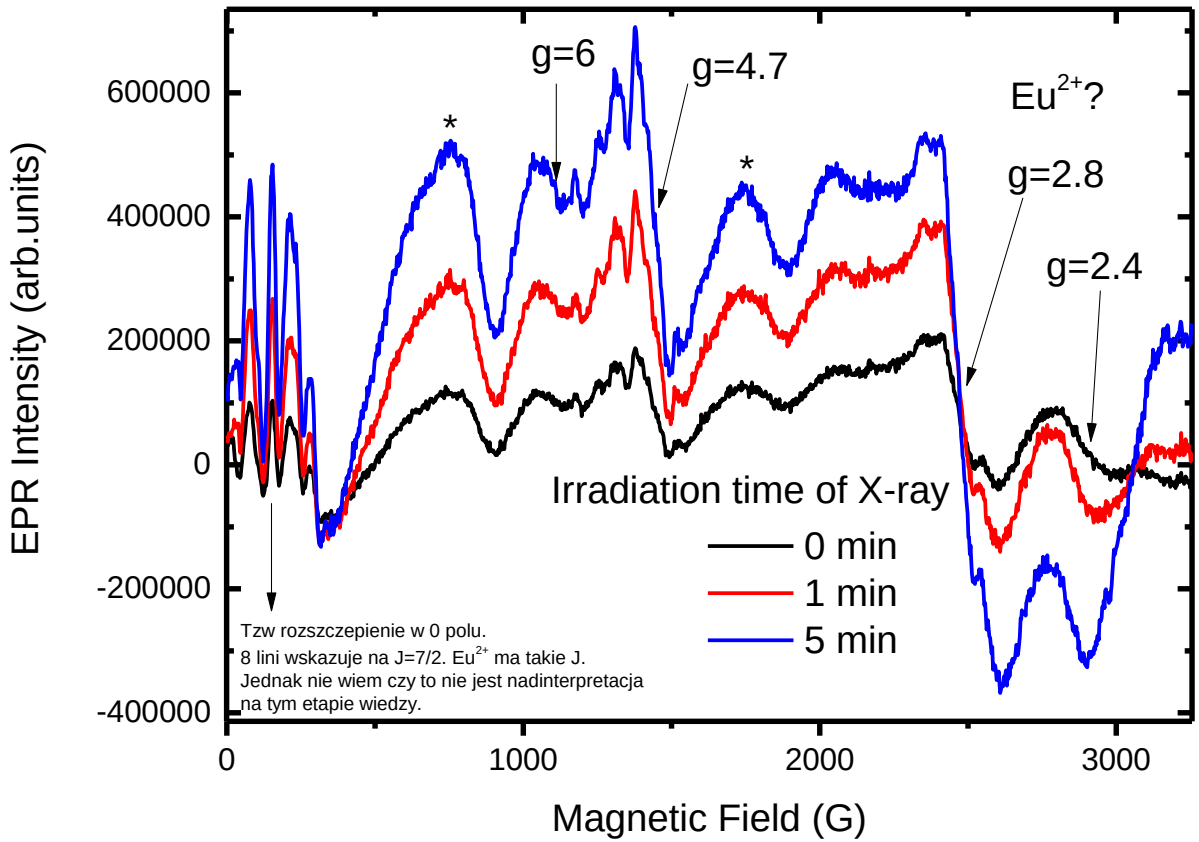
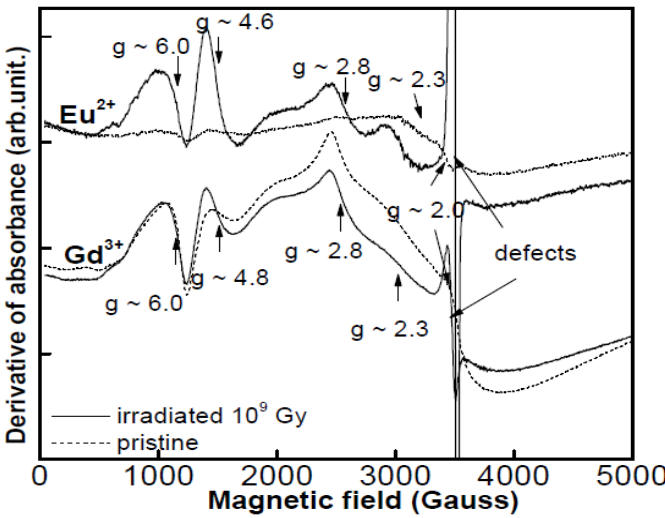
EPR effect of X-rays Eu,Hf





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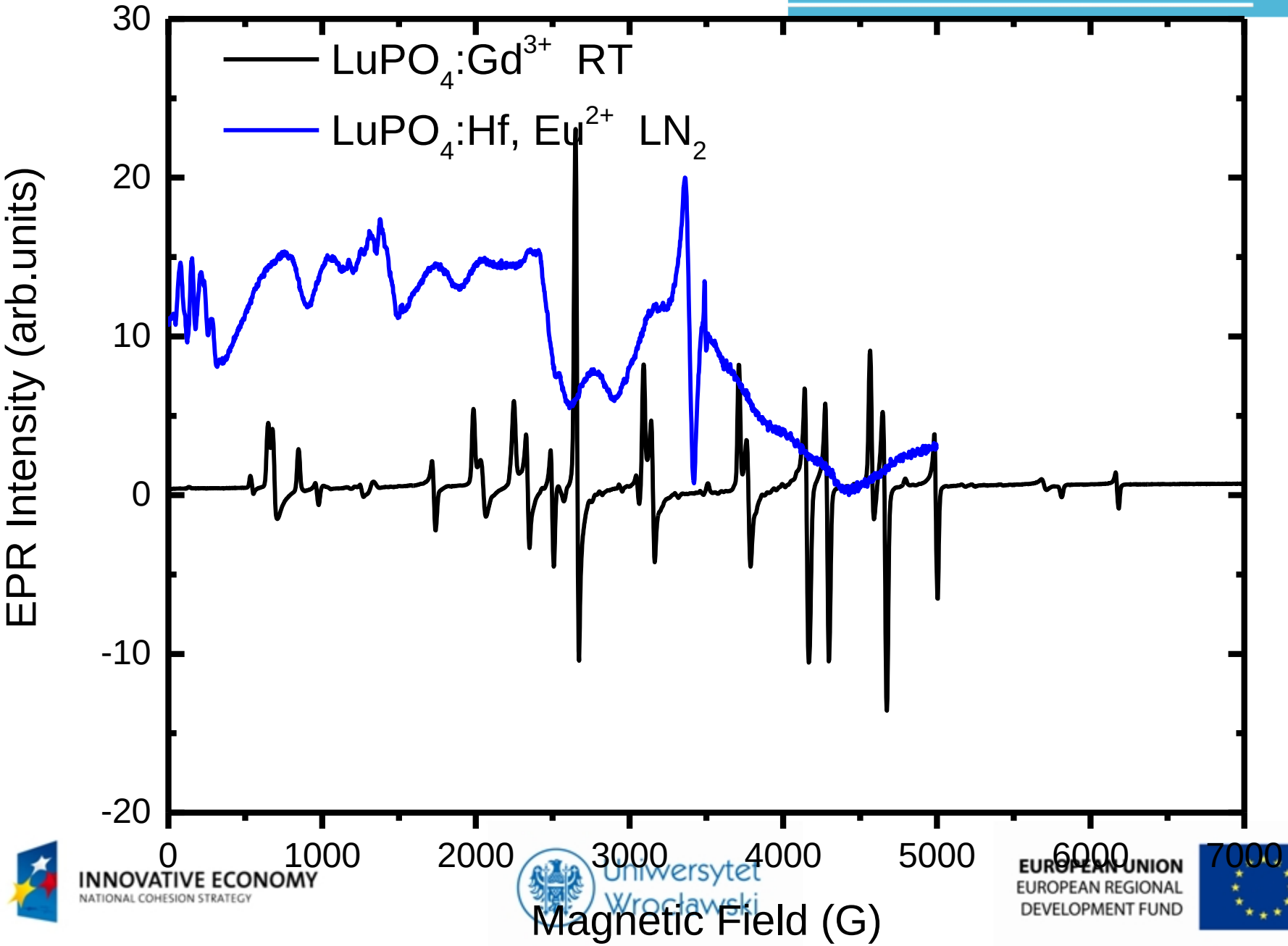

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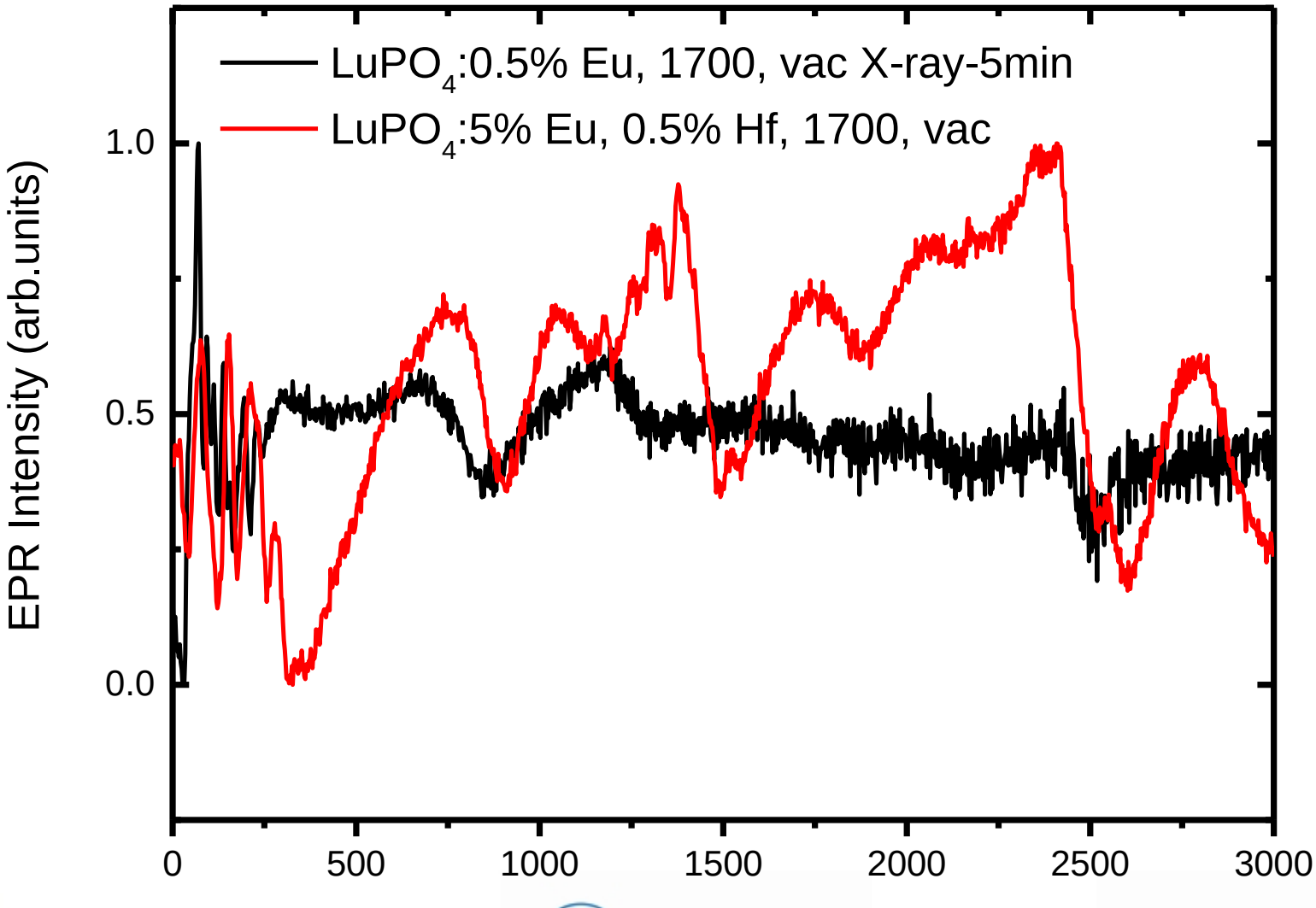

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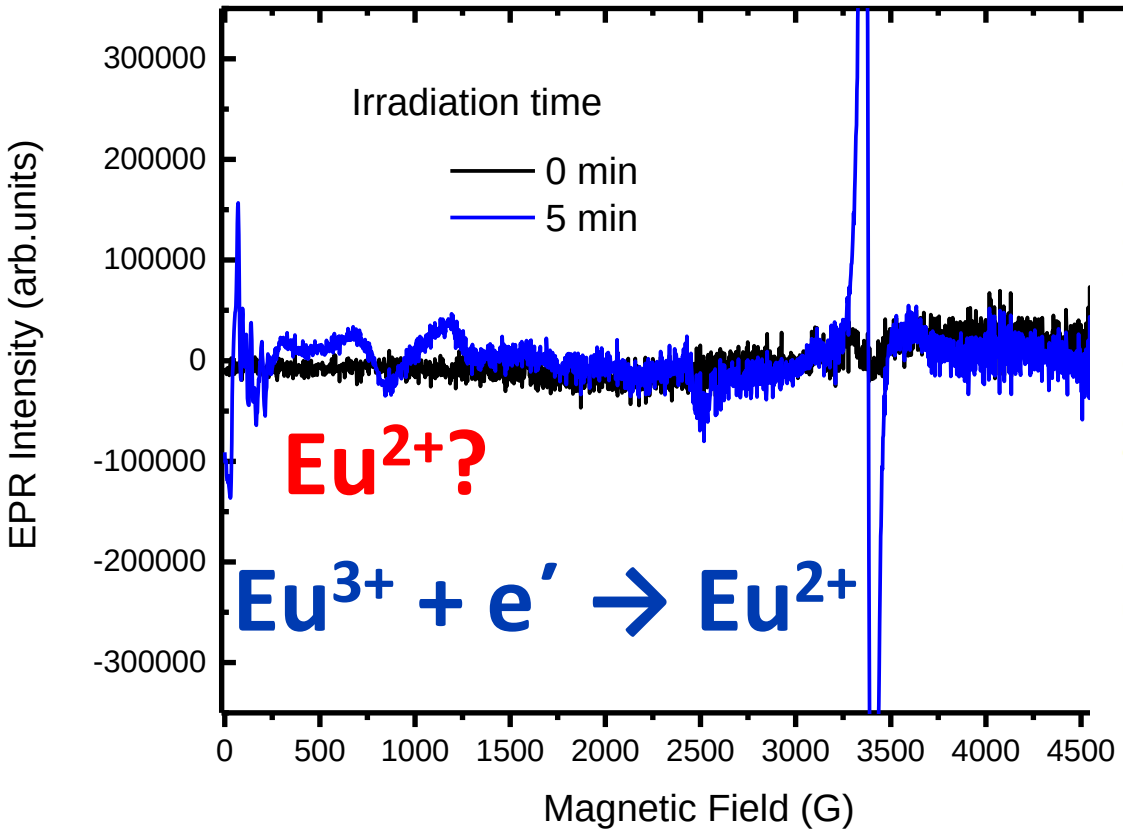
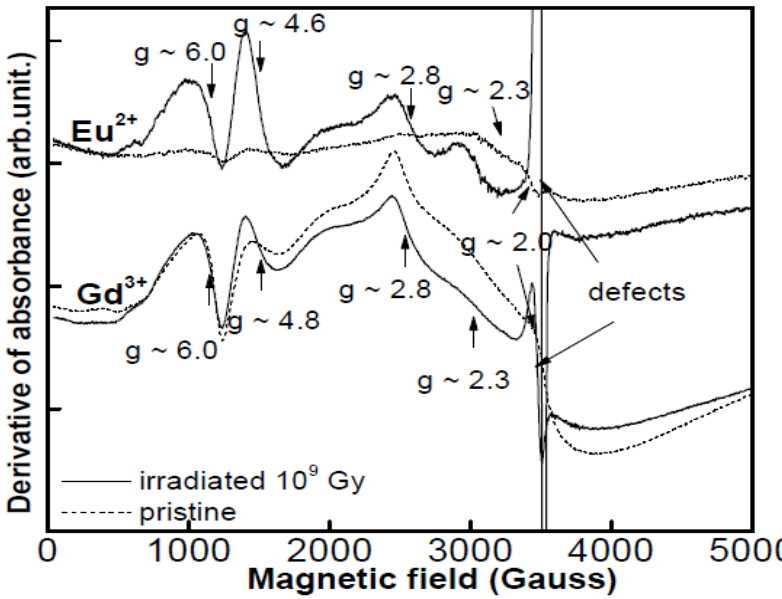
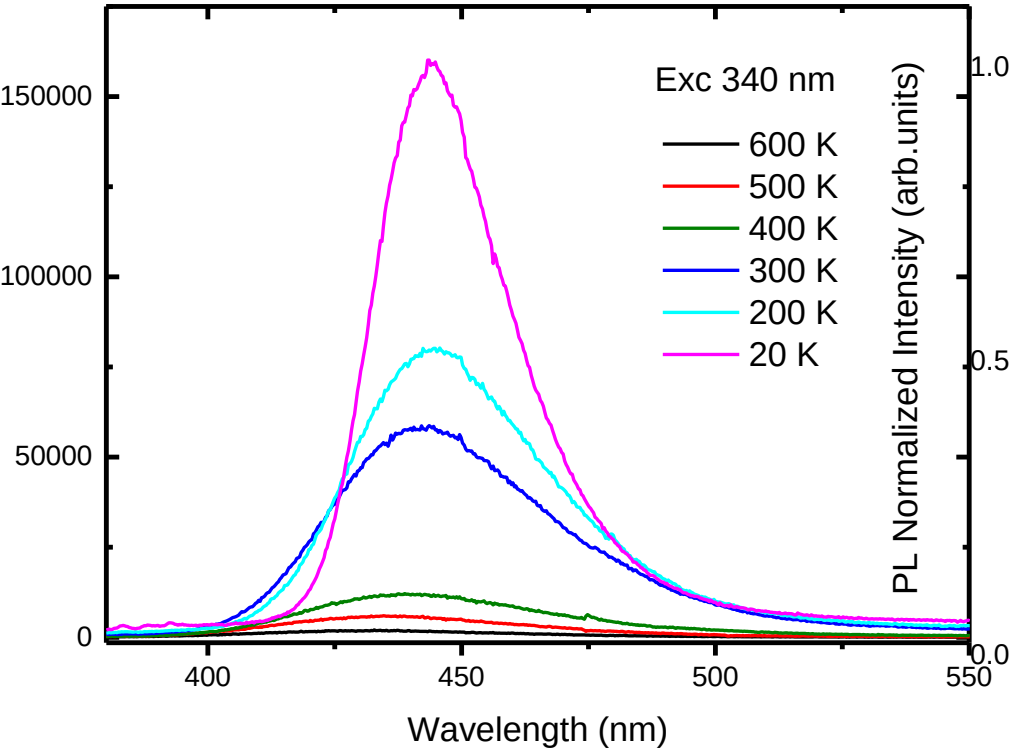
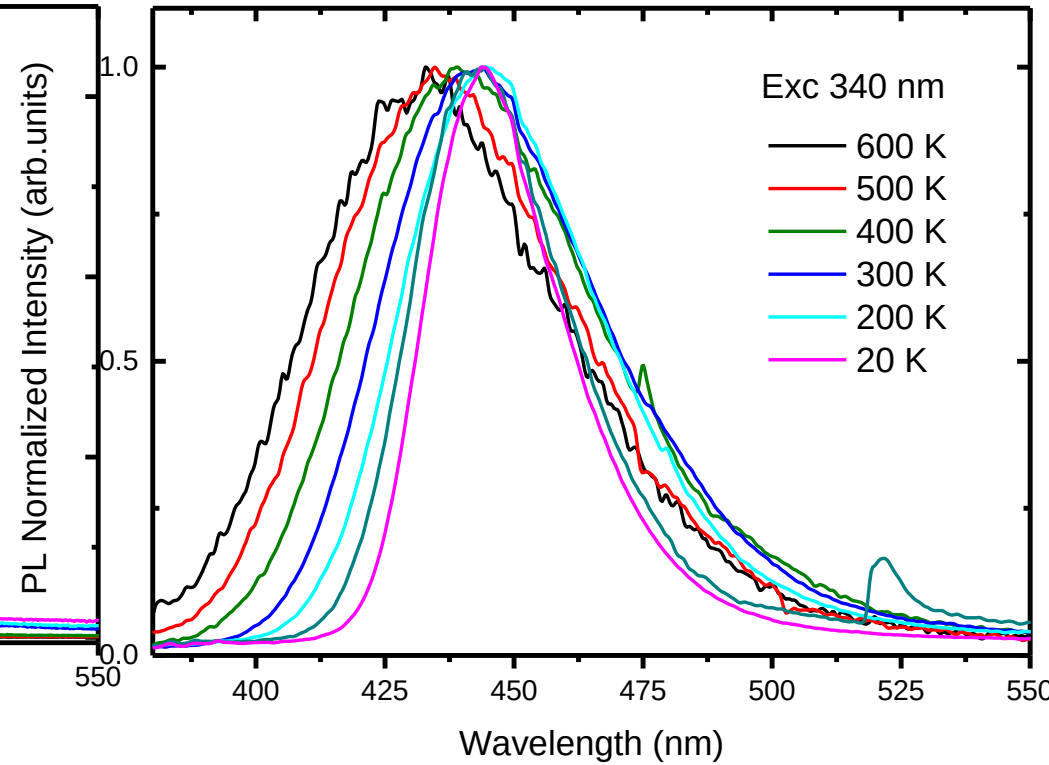
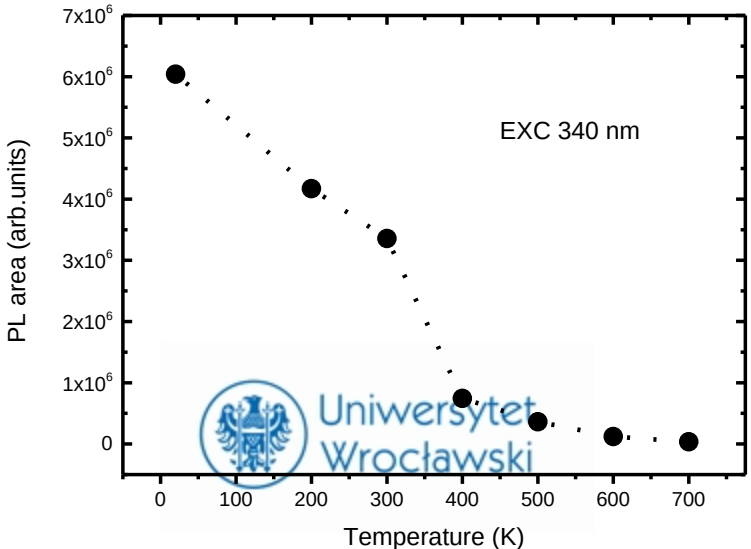
EPR


Irradiation time
0 min
5 min
EPR Intensity (arb.units)
Magnetic Field (G)
300000
200000
100000
0
-100000
-200000
-300000
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Eu2+?
Eu3+ + e′ → Eu2+


Derivative of absorbance (arb.unit.)
Magnetic field (Gauss)
Eu2+
Gd3+
g ~ 6.0
g ~ 4.6
g ~ 2.8
g ~ 2.3
g ~ 2.0
g ~ 4.8
defects
irradiated 10^9 Gy
pristine
0
1000
2000
3000
4000
5000







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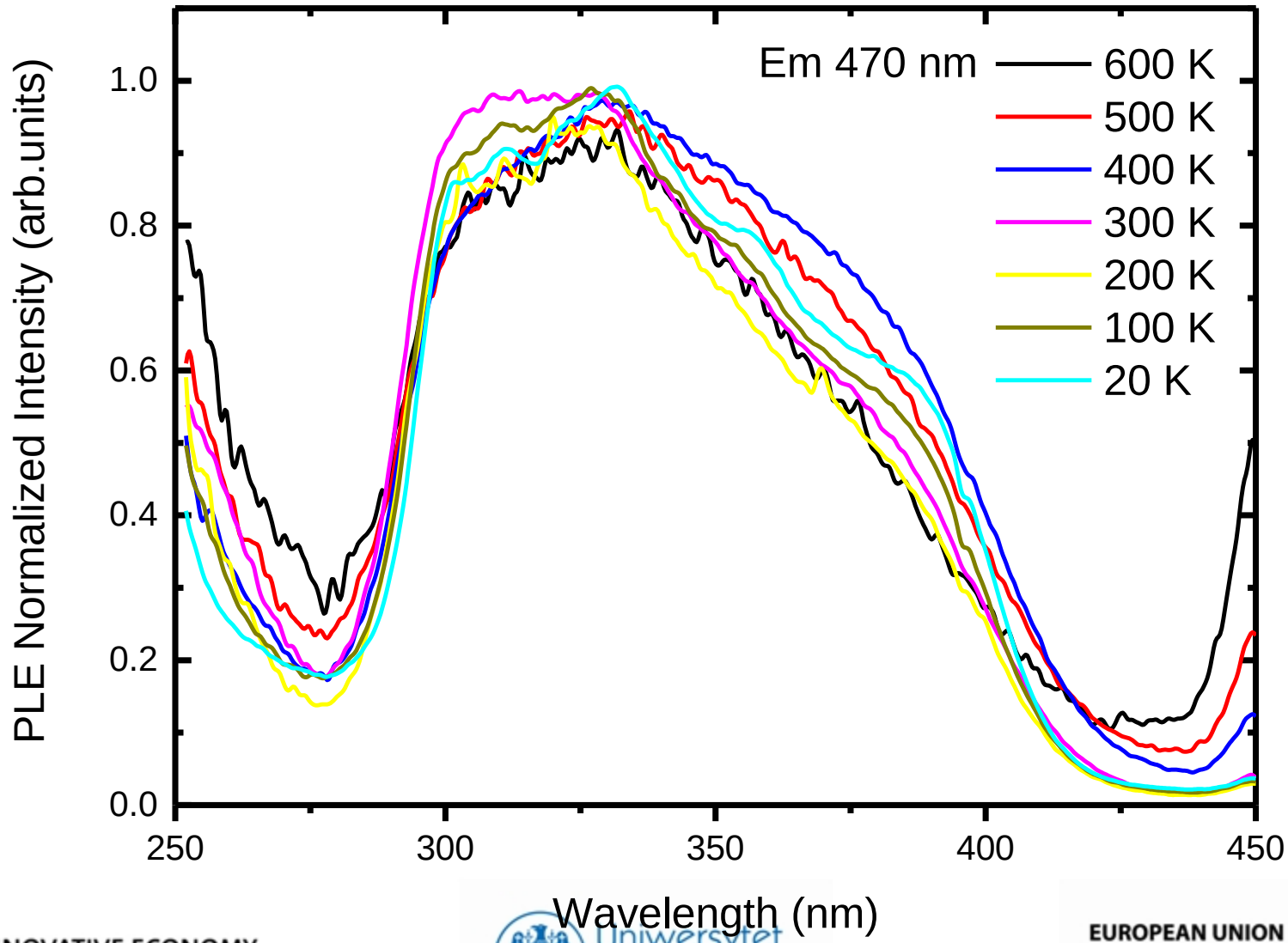

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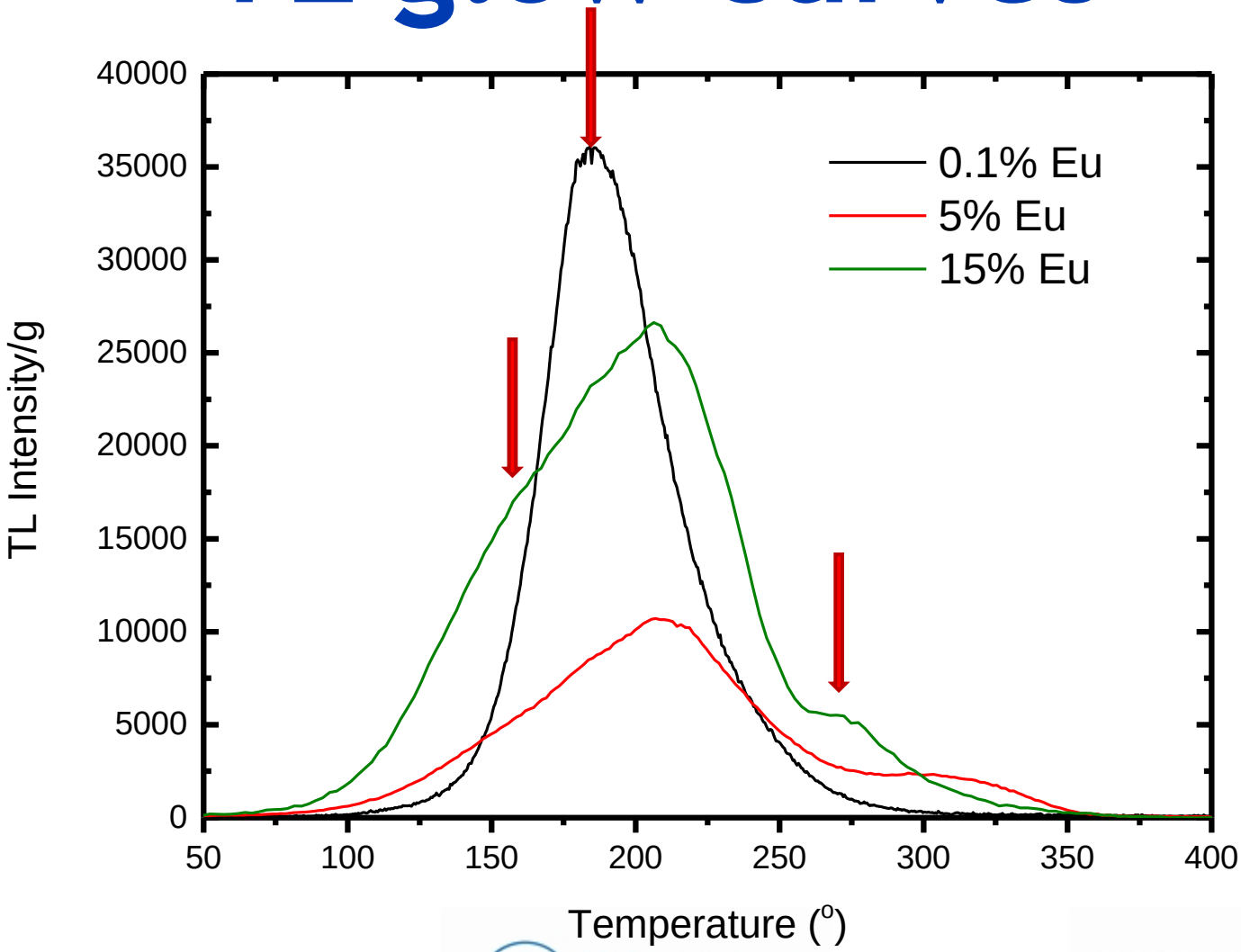
TL glow curves



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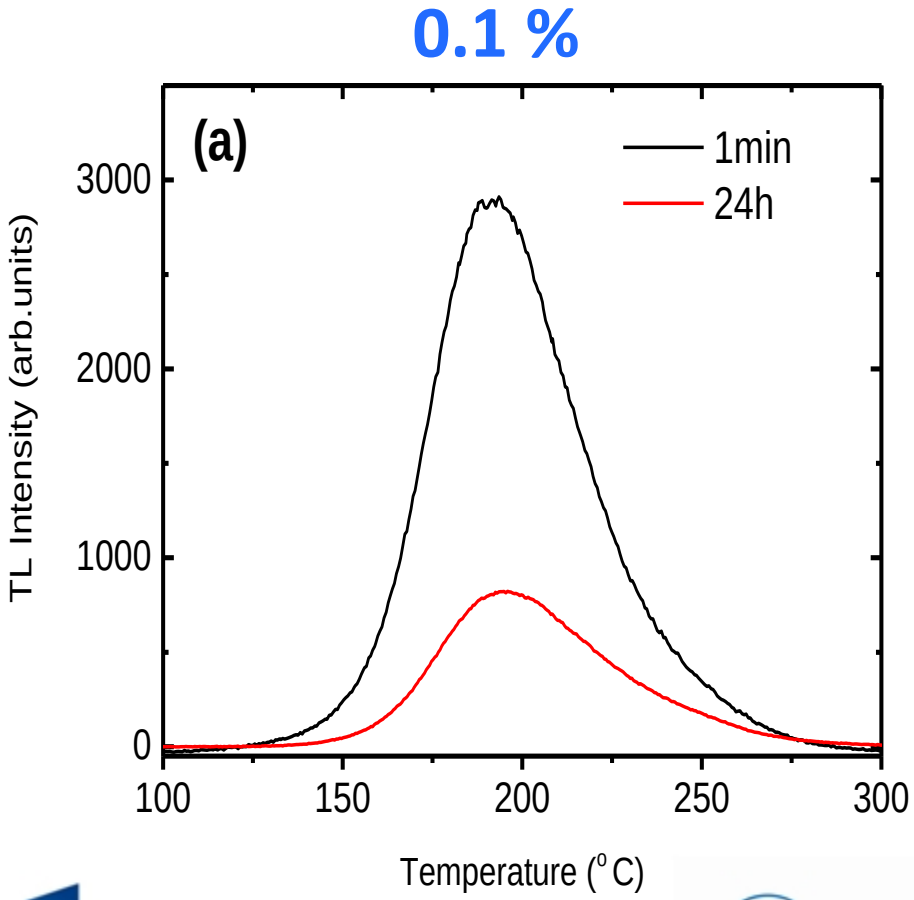
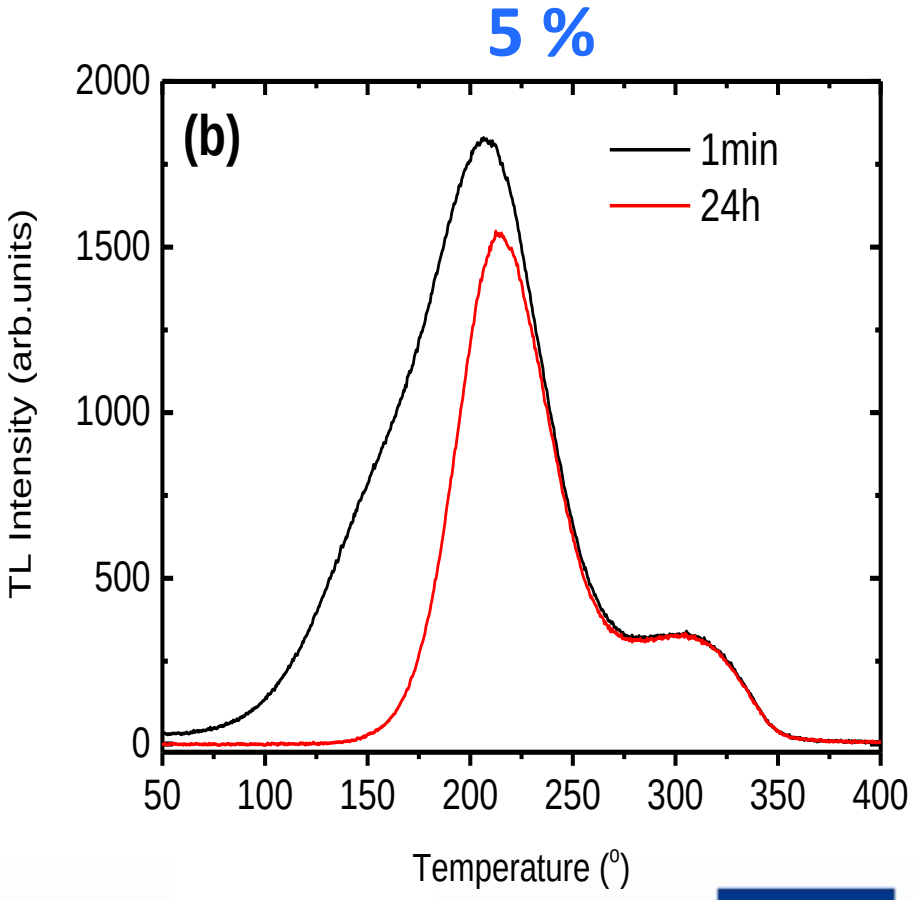
Fading - concentration dependence





$LuPO_4$:0.1%Eu - irradiation with X-rays

RL | Afterglow | TL (~170 °C)

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$LuPO_4$:0.1%Eu

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