Synthesis and Characterization of Mn^{2+} Doped Zn_2SiO_4 Phosphor Films by Combustion CVD Method

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Outline

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  - Combustion CVD process
- Objectives
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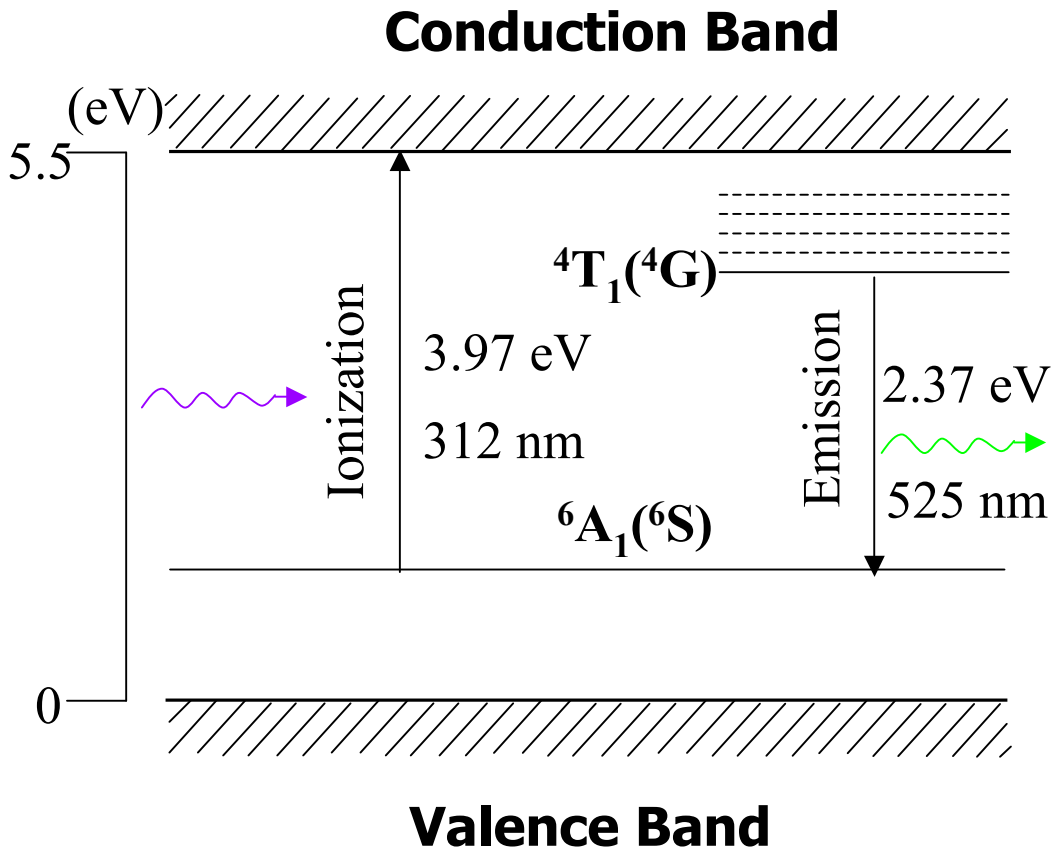
- Results and Discussions
- Conclusions
- Future Work

$Zn_2SiO_4:Mn^{2+}$ Phosphor Properties



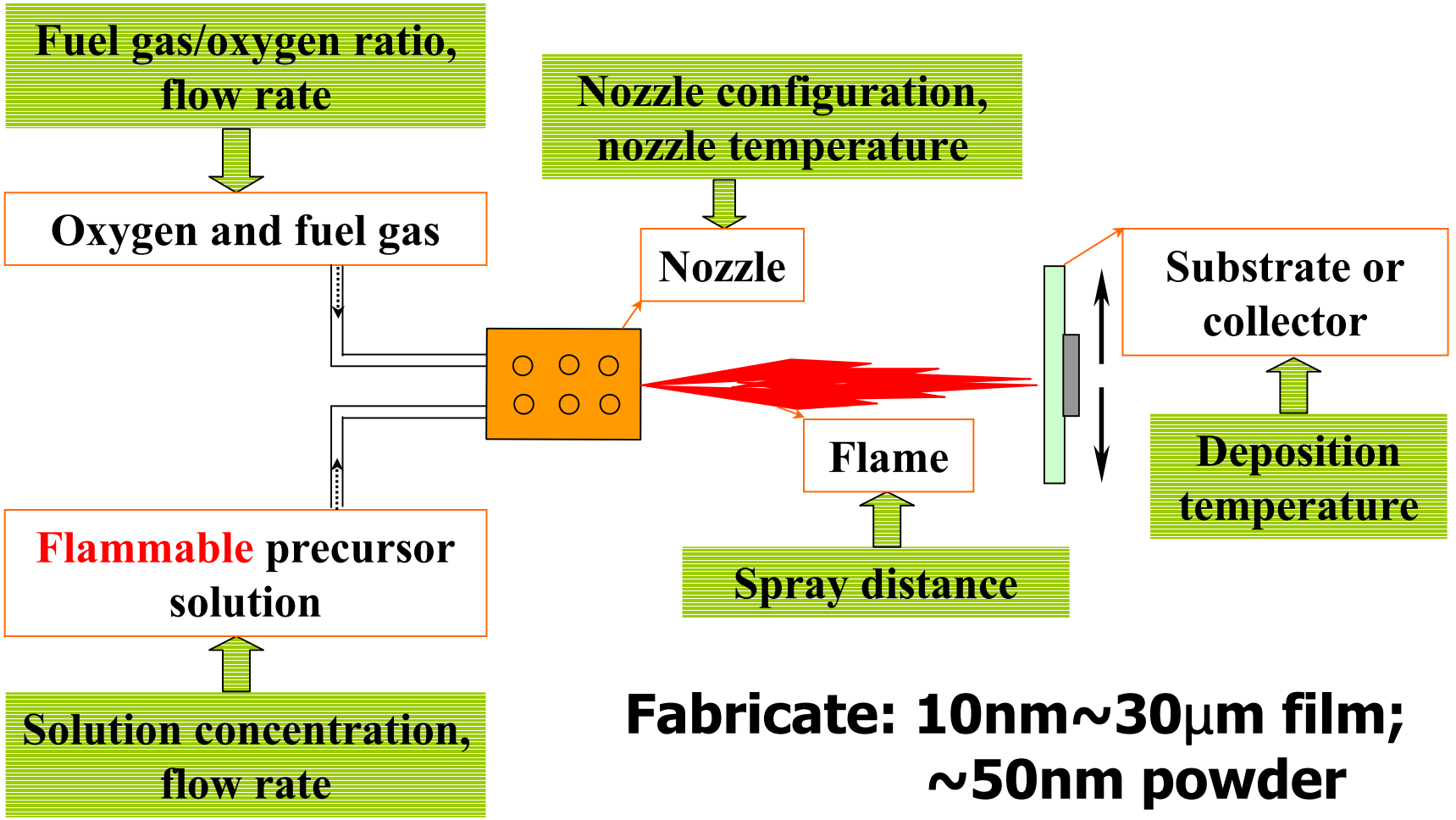
Application as Green phosphor

- Lamp
- CRT
- PDP
- EL

Synthesis of $Zn_2SiO_4:Mn^{2+}$ films

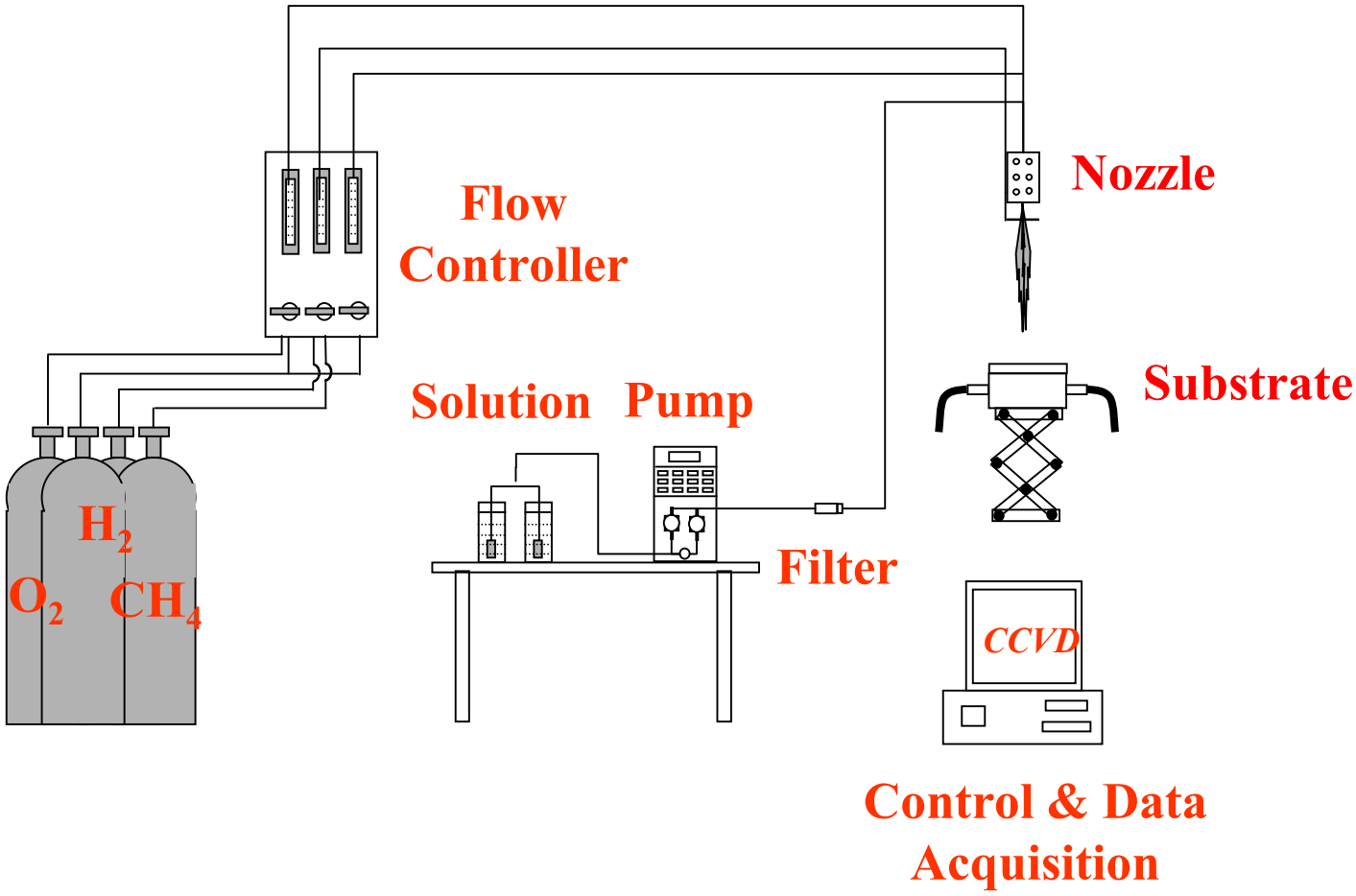
- Sol-gel process (R. Selomulya et al)
- Magnetron sputtering (A. H. Kitai et al)
- Charged liquid cluster beam technique (M. Cich et al)

Combustion CVD Process (A.T. Hunt et al)



Fabricate: 10nm~30μm film; ~50nm powder

Schematic of CCVD Process



Combustion CVD Setup

CCVD Advantages

- Cost-effective
- Rapid process
- Easy to operate
- Great flexibility
- Compositional homogeneity

Objectives

- To prepare efficient luminescent phosphor films using a Combustion CVD process.
- To characterize the microstructure features of the prepared films.
- To evaluate the optical properties of the prepared films.

Preparation Process

$Zn(NO_3)_2$, TEOS , $Mn(NO_3)_2$ and Ethanol

Aqueous solution

O_2, CH_4

Gas

Atomization

Ignition

Deposition for ~10 min

All chemicals Soluble in ethanol

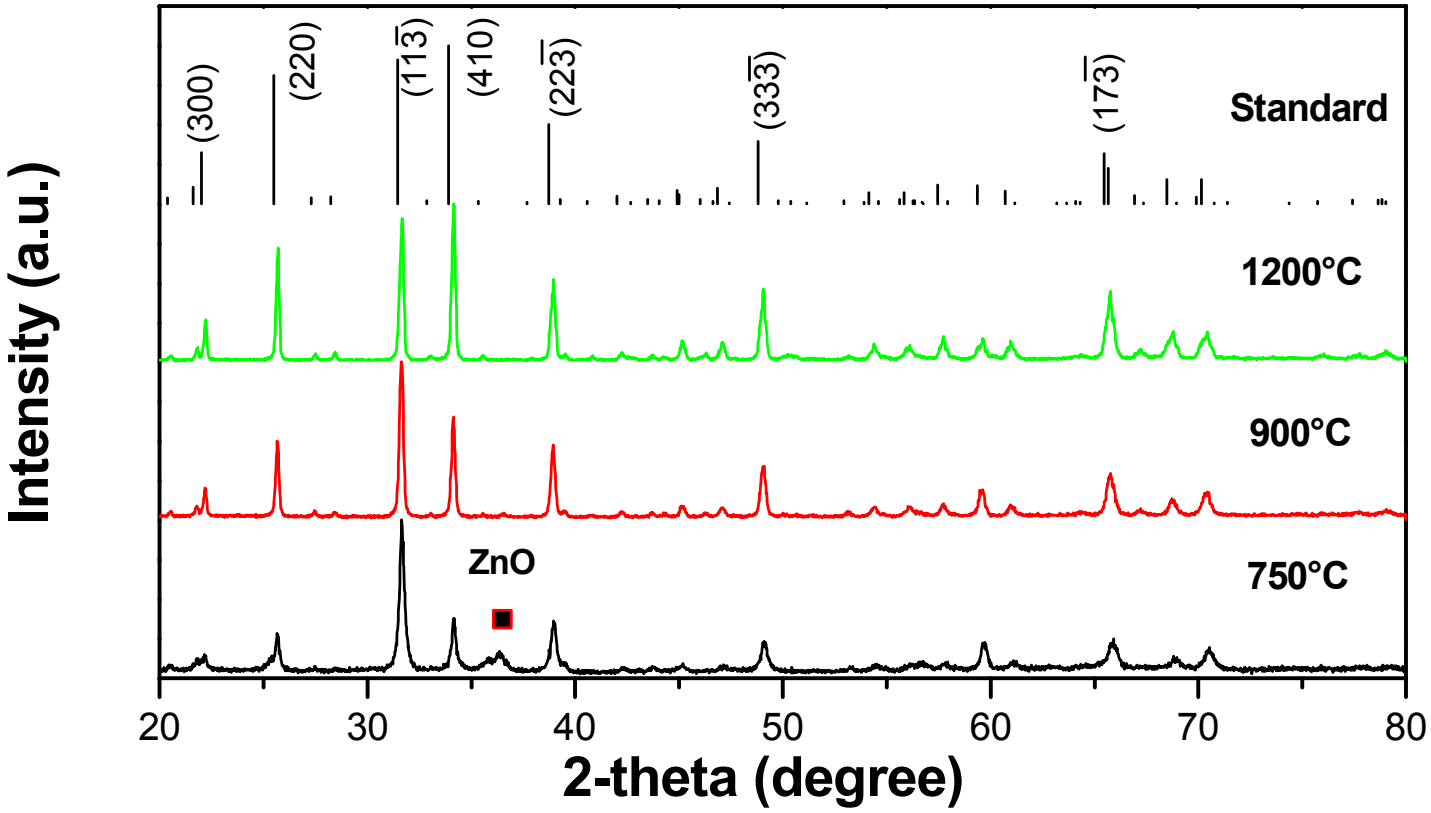
Products are limited to oxides

$Zn_2SiO_4:Mn^{2+}$ **Film**
(~20 μm in thickness, ~15mm in diameter)

Characterization Methods

- XRD
- SEM
- PL and PLE
- CL and CL Efficiency
- CL Decay

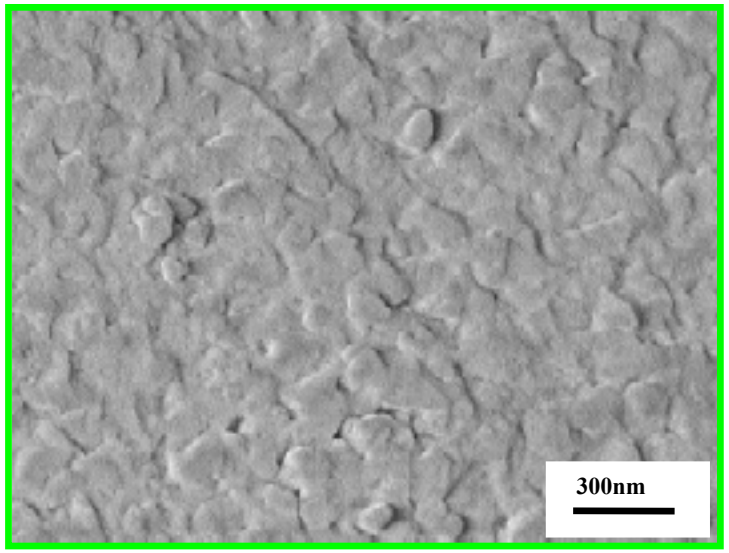
X-ray Diffraction

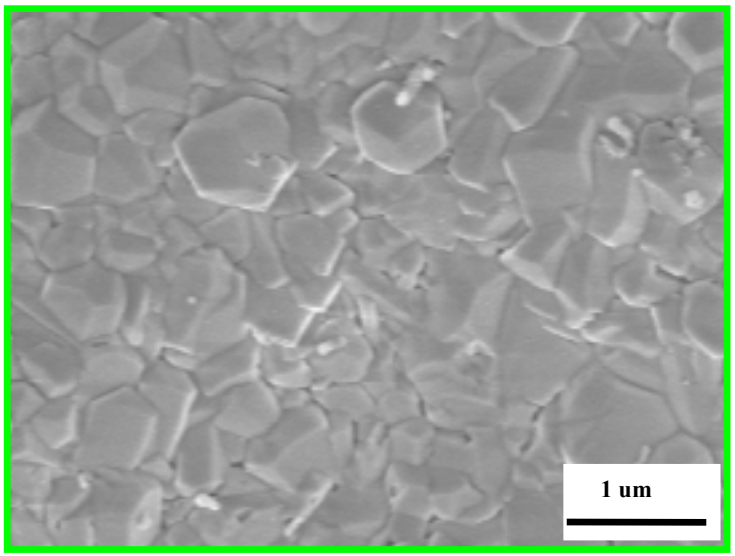


Standard XRD pattern of Zn_2SiO_4 and Zn_2SiO_4:4%Mn^{2+} samples prepared at temperatures between 750 and 1200 C

Surface Morphology

SEM images of $Zn_2SiO_4:Mn^{2+}$ film deposited on quartz glass at 1200°C

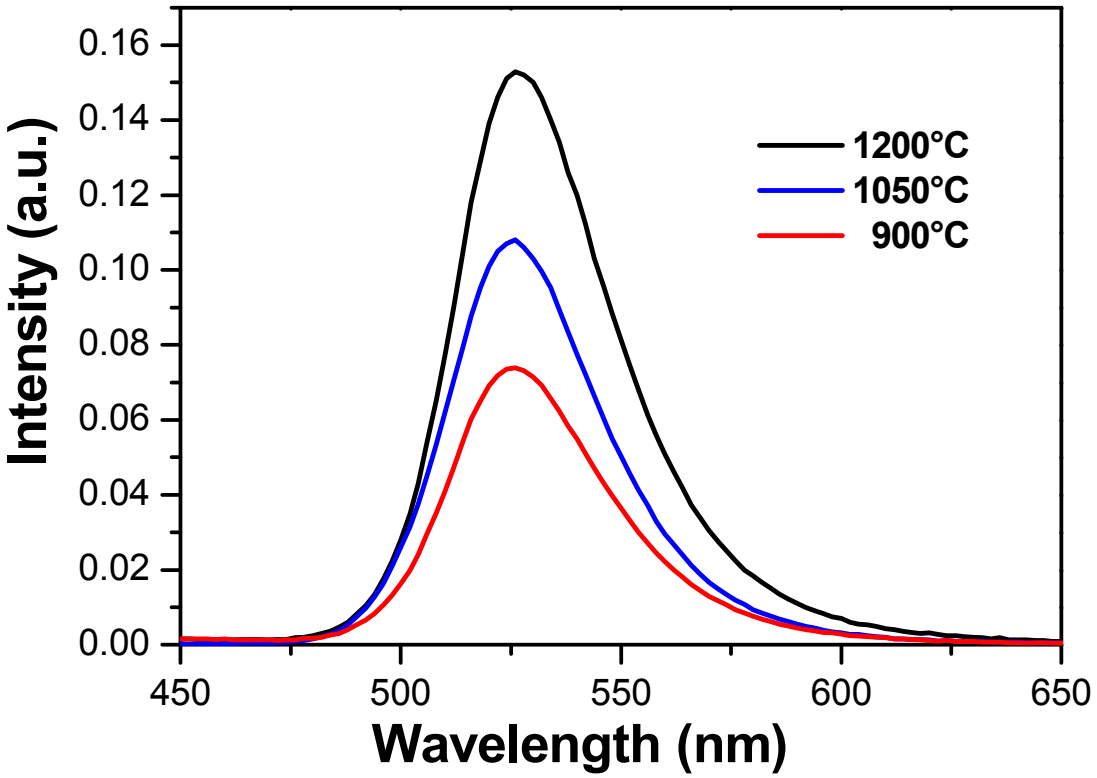




Outer region
100~200nm grains

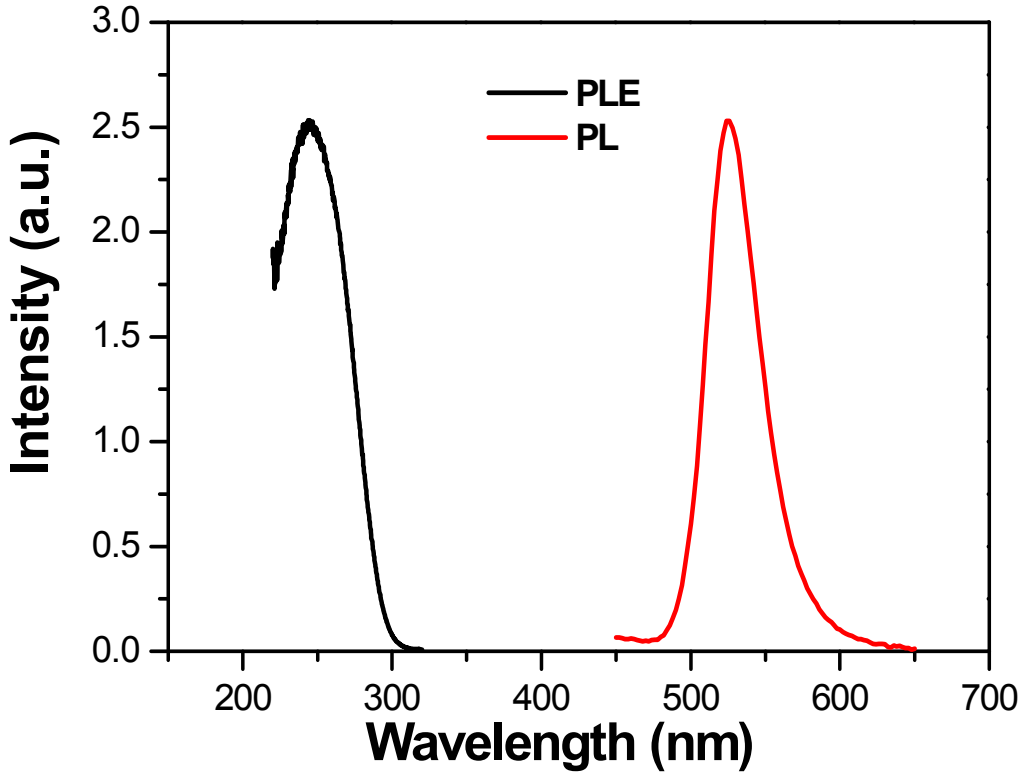
Central region
500~800nm grains

PL as a function of Temperature



PL spectra of Zn_2SiO_4:4%Mn^{2+} samples prepared at temperatures between 900 and 1200 C

PL and PLE

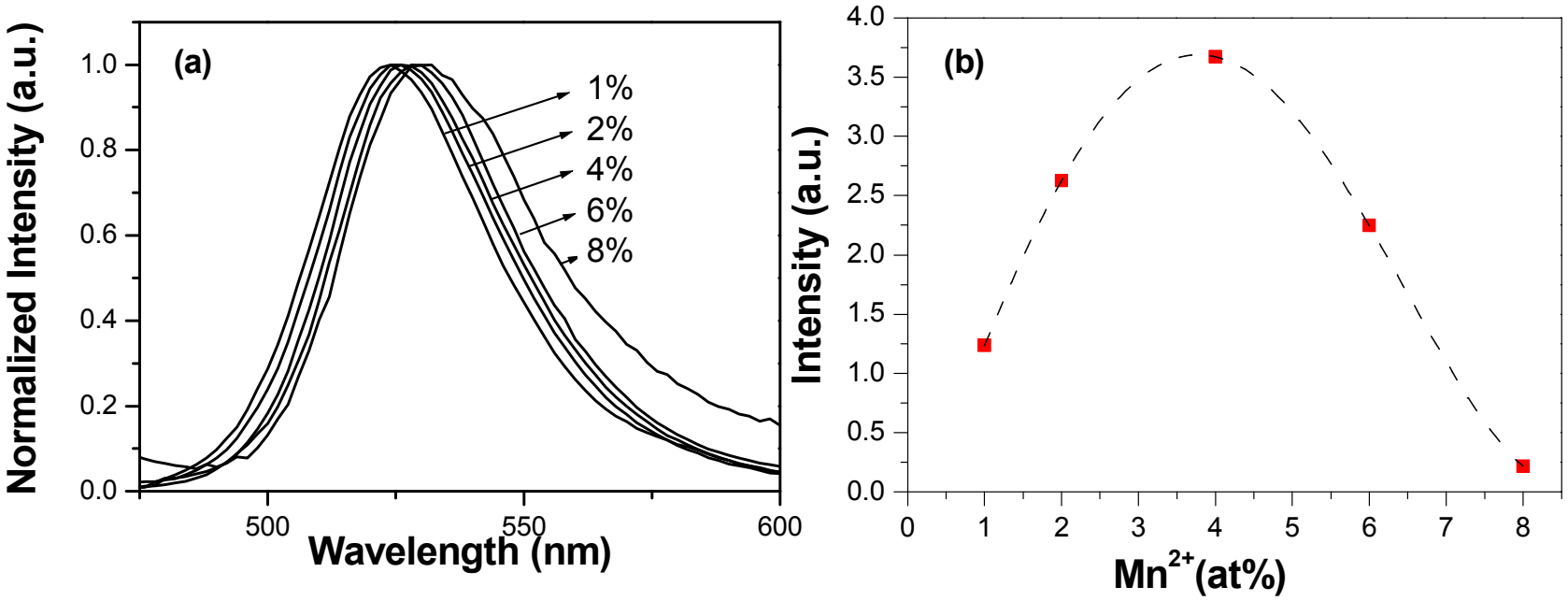


PL band centered at 524 nm with a half maximum width of 42 nm

PLE band ranged from 220 ~ 300 nm with a maximum at ~247 nm

Typical PL and PLE spectra of Zn_2SiO_4:2%Mn films prepared at 1200°C

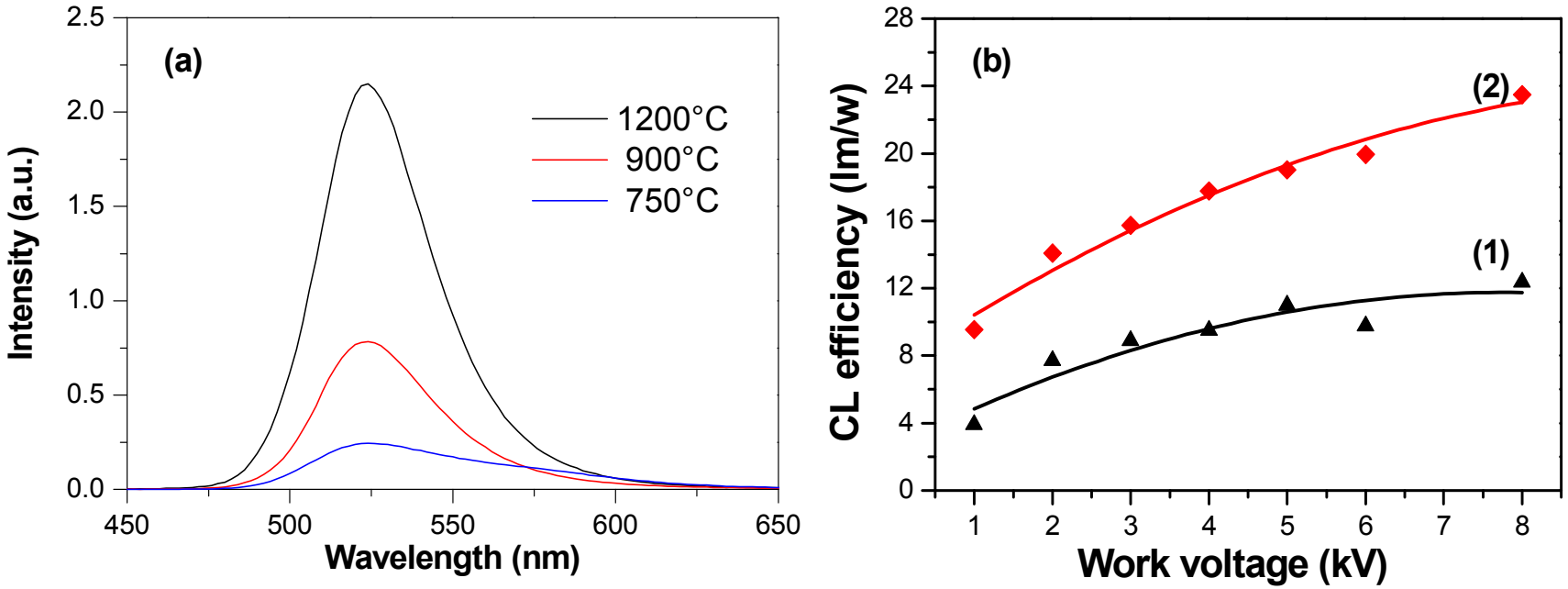
PL as a function of Mn^{2+} concentration



Normalized PL spectra of $Zn_2SiO_4:Mn^{2+}$ films

PL intensity as a function of Mn^{2+} concentration

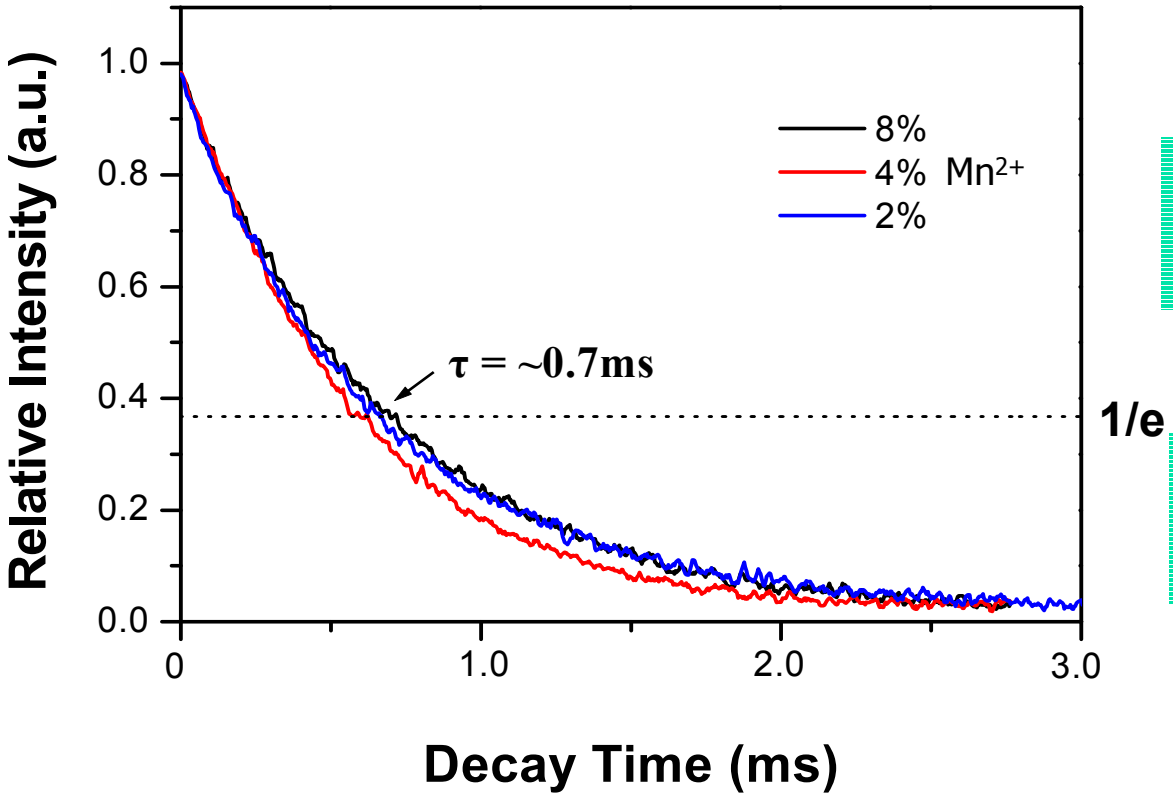
Cathodoluminescence spectra and efficiency



Left) CL spectra of $Zn_2SiO_4:Mn^{2+}$ phosphor films prepared by CCVD

Right) CL efficiency of $Zn_2SiO_4:Mn^{2+}$ as a function of electron voltage
(1) Zn_2SiO_4:4%Mn^{2+} film prepared at 1200°C; (2) commercial powder phosphor

CL Decay



Commercial phosphor
$\tau_{1/e}$ = ~4.5ms

Films by CCVD
$\tau_{1/e}$ = ~0.7ms

CL Decay curves of Zn_2SiO_4 with Mn^{2+} concentration from 2~8%

Conclusion

- $Zn_2SiO_4:Mn^{2+}$ phosphor films were successfully prepared by combustion CVD.
- The films were well crystallized at deposition temperature of 1200 °C and showed highest luminescent efficiency.
- The films consisted of densely packed particles with a fine grain size of several hundred nanometers.
- Strong PL and CL luminescence intensities were observed, with a maximum CL luminescence equivalent to 53% of the luminescence measured from a commercial powder phosphor.

Future Work

- Further optimization of this deposition technique and its extension to other oxide phosphor systems.
- Prepare multi-layer phosphor films with controlled color and refractory index.
- Investigate the possibility of building automatic **combinatorial material synthesis** system using CCVD technique.