The Various Shape of Nano-Polycrystalline Transparent $ZnWO_4$ Scintillator by Thermal Evaporation Method

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Introduction

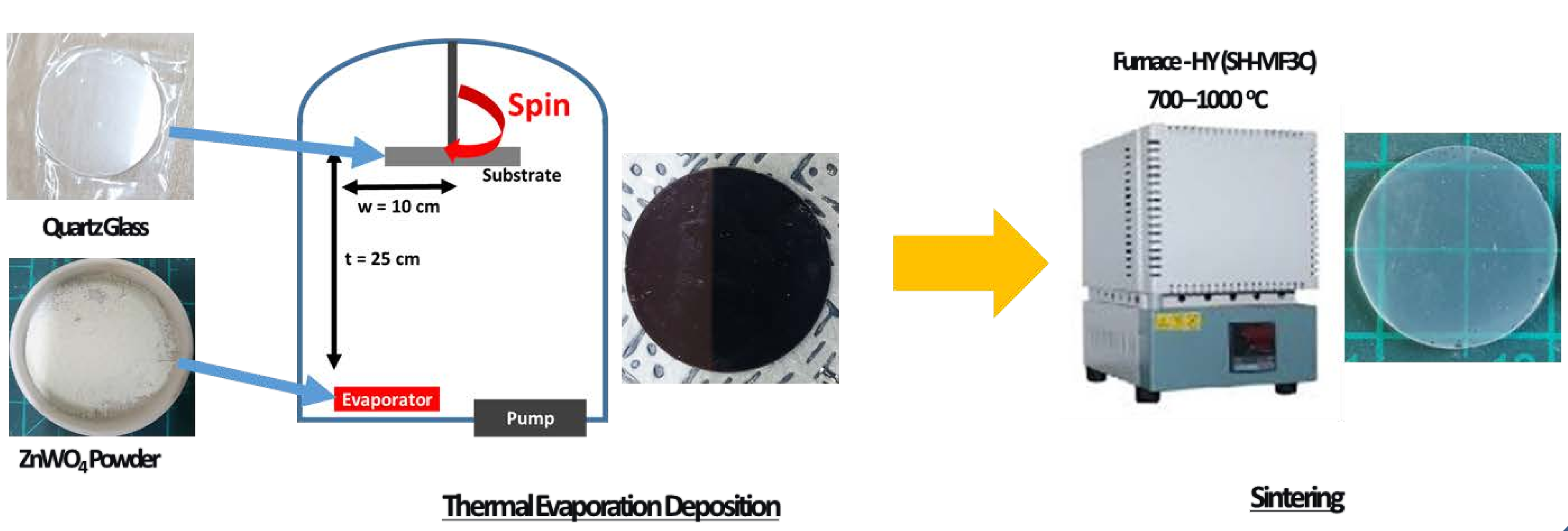
High-resolution X-ray imaging is promising applications in field of X-ray micro-radiography of biology, archeology, materials and non-destructive test. [1-3] The spatial resolution is the one of the most important parameters in high-resolution X-ray imaging. [4] It is affected by the thickness of a scintillator because the optical detector with small effective pixel size is highly sensitive to the light spread phenomenon. [5] To minimize the light spread phenomenon, many researchers have tried to fabricated several micrometers thin-layer scintillators for high-resolution X-ray imaging.

In this study, the transparent thin-film scintillator composed of nano-polycrystalline zinc tungstate ($ZnWO_4$) was fabricated on quartz glass using thermal evaporation method with sintering. $ZnWO_4$ has been used for a long time as an X-ray scintillator because the crystallized $ZnWO_4$ has 2.3 times more luminescence characteristics than $Bi_4Ge_3O_{12}$ (BGO) under X-ray irradiation [6] In addition, It is high density (ρ = 7.87 g/cm3), high effective atomic number. (Z_{eff} = 61) Since $ZnWO_4$ has high X-ray absorption capability relative to ρZ^4_{eff}, it has the potential to be utilized in thin-film scintillators. There have been a growing body of research to fabricate transparent ceramic thin-films using the thermal evaporation method with sintering. The thermal evaporation method is the efficient approach to facilely deposit the thin and uniform film on complex structure. The main purpose of this study is to demonstrate that nano-polycrystalline $ZnWO_4$ thin-film scintillator can be applied to the high-resolution X-ray imaging. In addition, This method can fabricate various shapes of thin-film scintillators, showing the possibility that it can be used in various fields of high-resolution X-ray imaging.

Experimental

- **Fabrication of $ZnWO_4$ Powder**

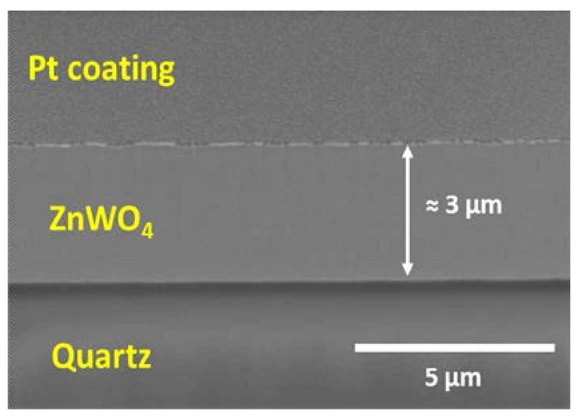
- **Fabrication of Transparent $ZnWO_4$ Thin Film**



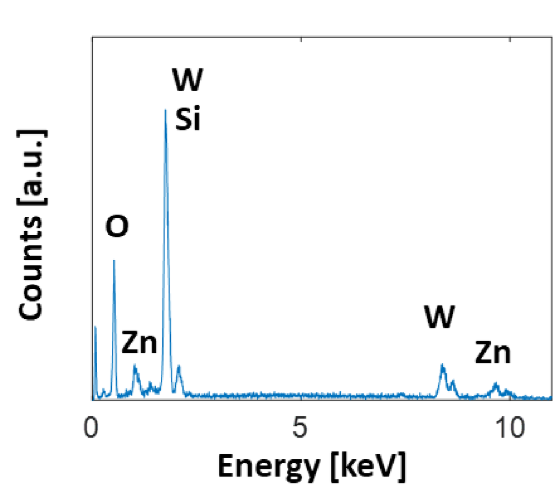
Results

- **Characterization of Evaporated $ZnWO_4$ Thin Film**

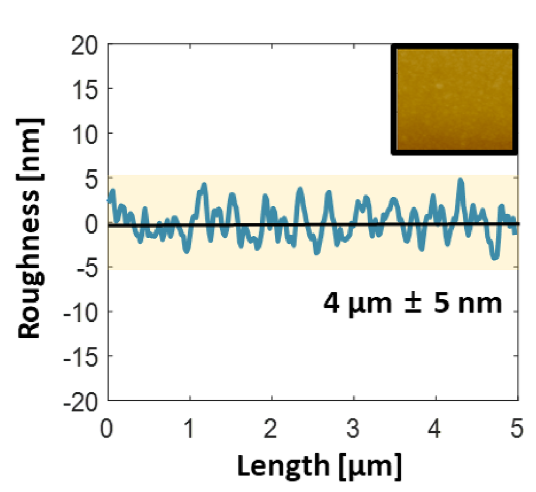
>> FIB with SEM



>> EDX

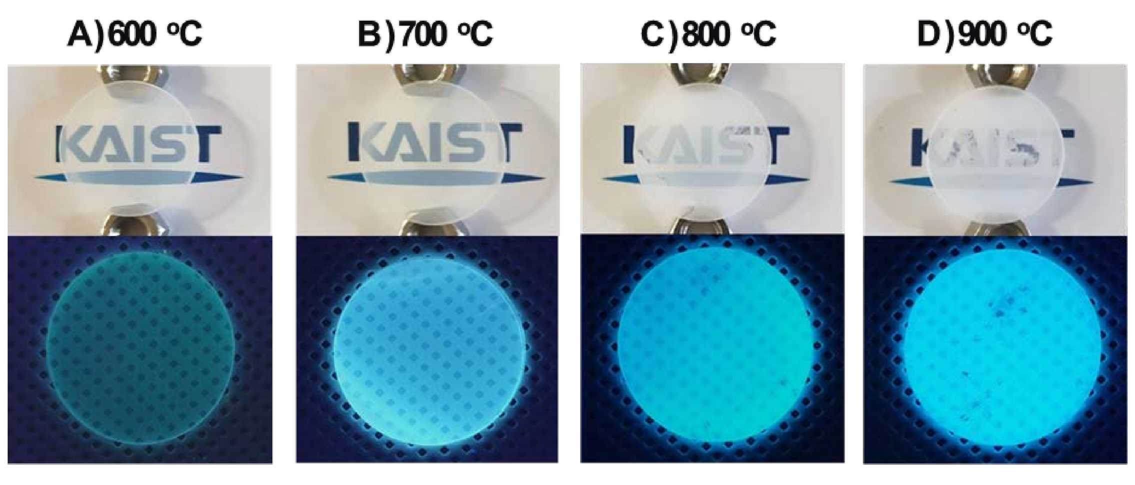


>> AFM

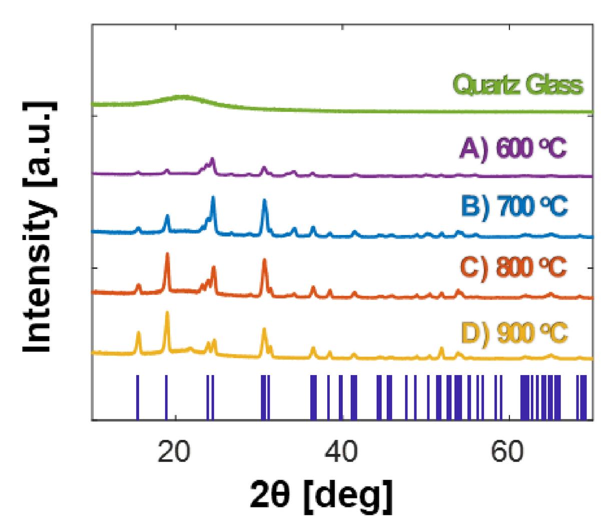


3 μm Thickness | Composed of Zn, W, O | High Uniformity

- **Sintered $ZnWO_4$ Thin Film**



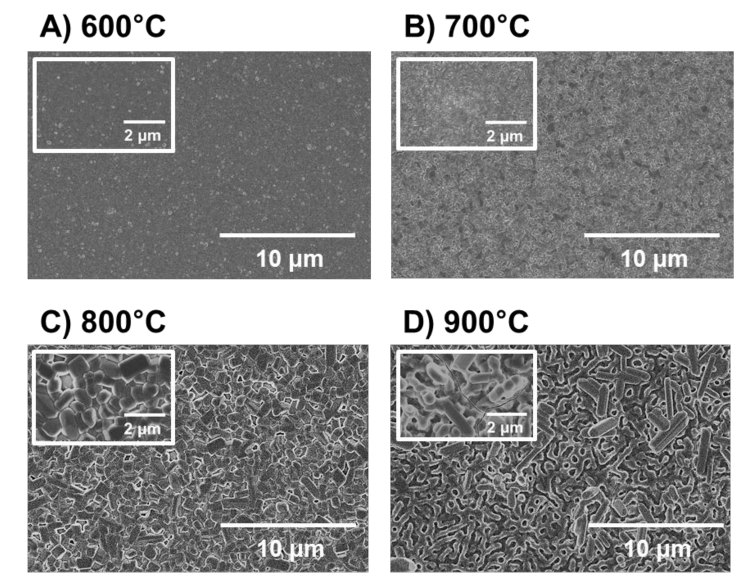
>> XRD



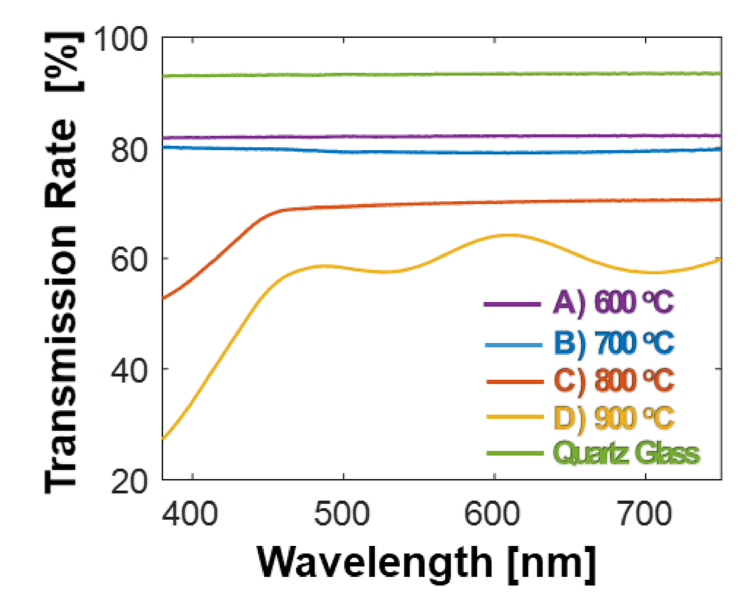
Results

- **Characterization of Sintered $ZnWO_4$ Thin Film**

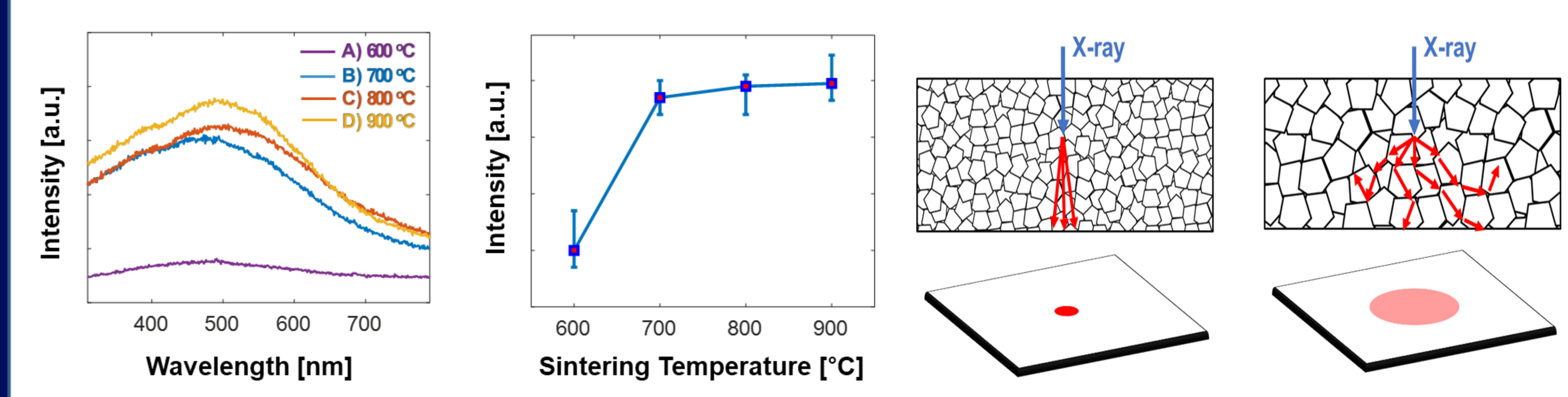
>> SEM Image



>> Transmission Rate



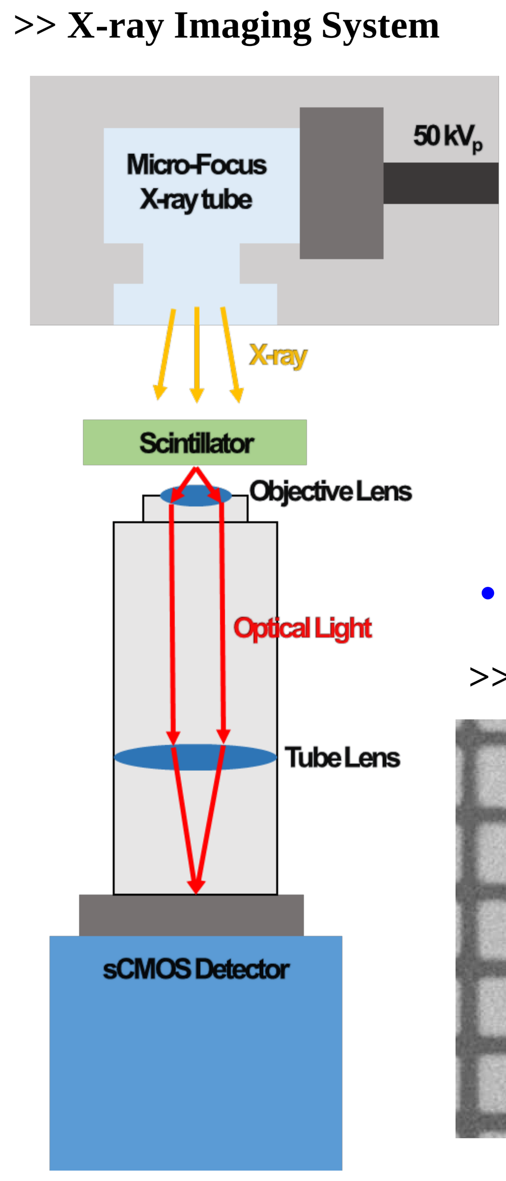
- **Optimization**



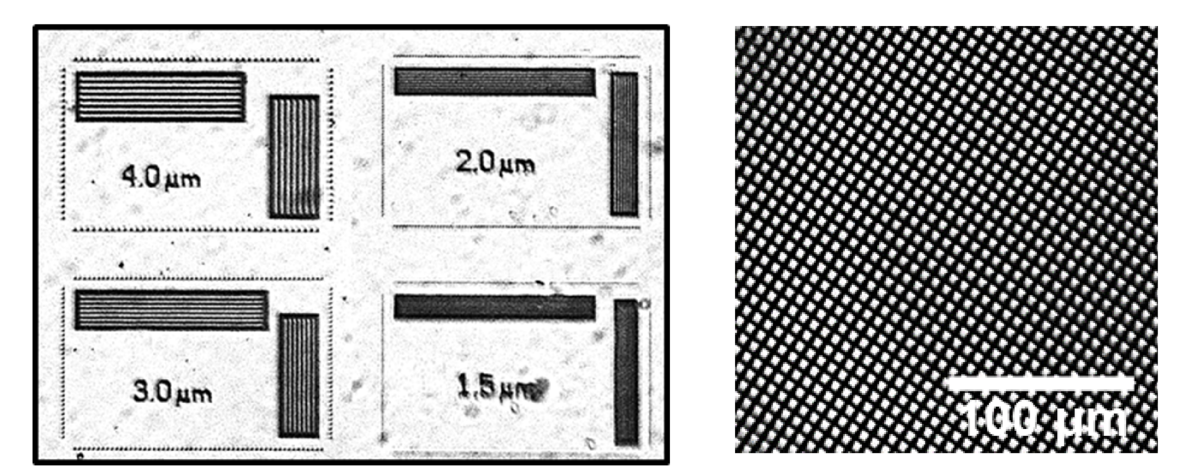
700 °C is optimized sintering temperature

- **X-ray Imaging**

>> X-ray Imaging System

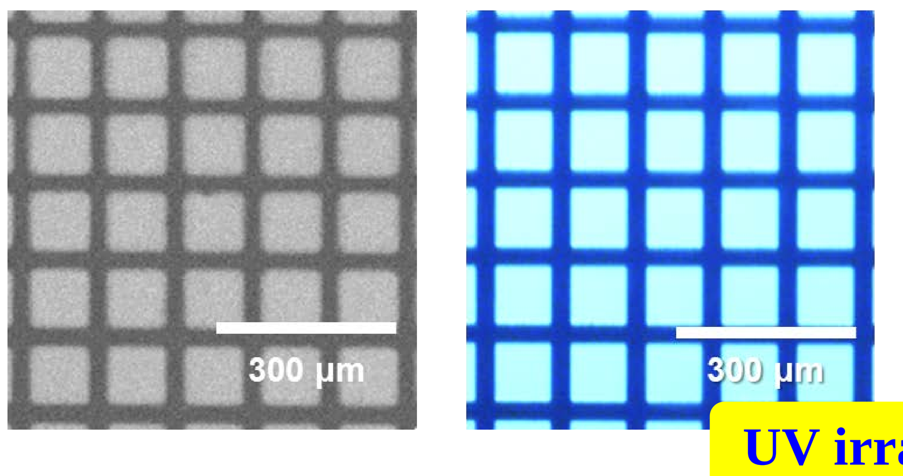


>> High-Resolution X-ray Images

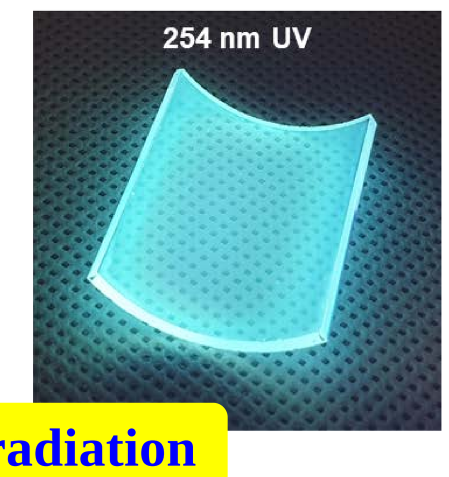


- **The Various Shape of $ZnWO_4$ Scintillator**

>> Microscope Images of Pixelated Scintillators



>> Curved Scintillators



UV irradiation

Conclusion

The nano-polycrystalline transparent $ZnWO_4$ thin-film scintillator was fabricated by thermal evaporation method and it was successfully utilized in high-resolution X-ray imaging. Since it has the average grain size of 157.3 nm smaller than optical wavelength, the optical light scattering is suppressed. The optimized 3 μm ZnWO4 thin-film has high optical performance with a transmission rate of 78% at 480 nm wavelength. It was analyzed by high-resolution X-ray imaging system composed of micro-focus X-ray, an optical lens, and sCMOS detector; the effective pixel size is 650 nm. The X-ray image of 2 μm line and space patterns were resolved. In addition, the thermal evaporation method is facile approach to fabricate the various shapes of thin-film scintillators, so it can be used in the various fields of high-resolution X-ray imaging. Nano-polycrystalline transparent $ZnWO_4$ thin-film scintillator is expected to be used effectively in X-ray micro-radiography.

Reference

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