

Control of EUV spectral shape and conversion efficiency by the use of low-density SnO₂ targets

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Guideline of the research

Generation of a clean and efficient EUV radiation source

Formation of uniform (in terms of density and temperature) plasma

Essentially small amount of target mass



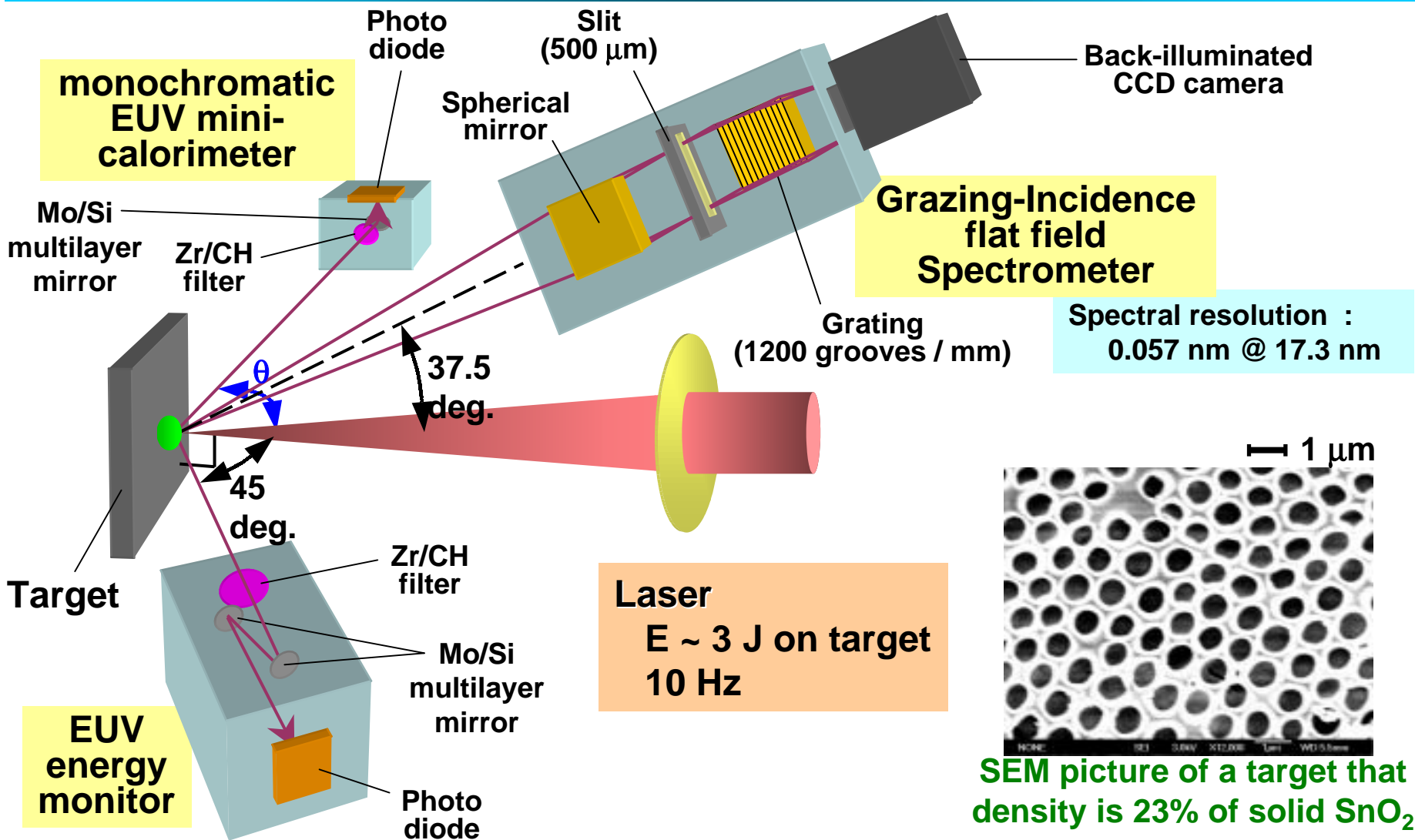
A low-density target is possible to satisfy these demands

Emission properties from low-density SnO_2 targets have been experimentally investigated.

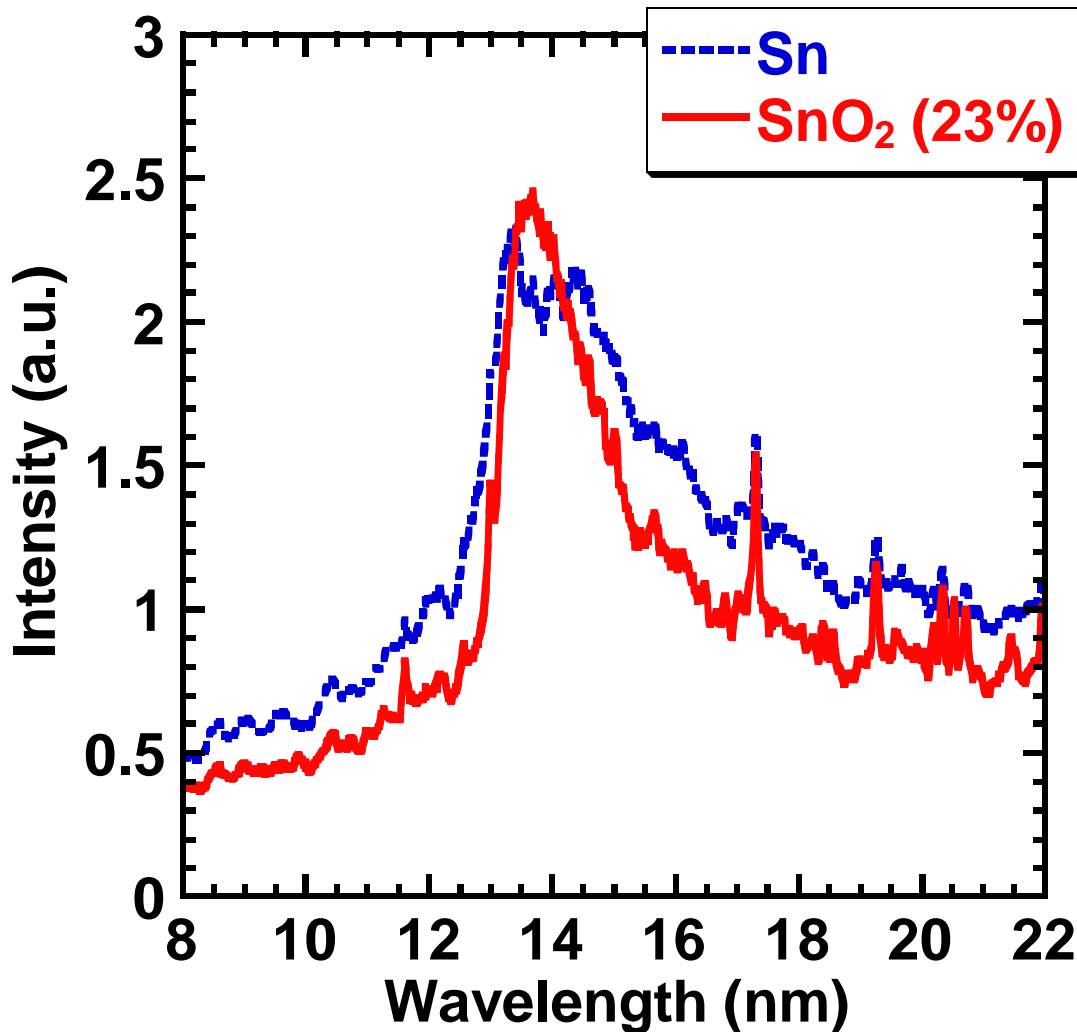
1. Spectra and Conversion Efficiency (CE)
2. EUV emission region



Experimental setup for spectra and conversion efficiency measurements



With decrease in target density, spectrum become narrower but peak intensities are kept constant.



The hollow structure is observed with a Sn target, however it is disappear with a low-density target.

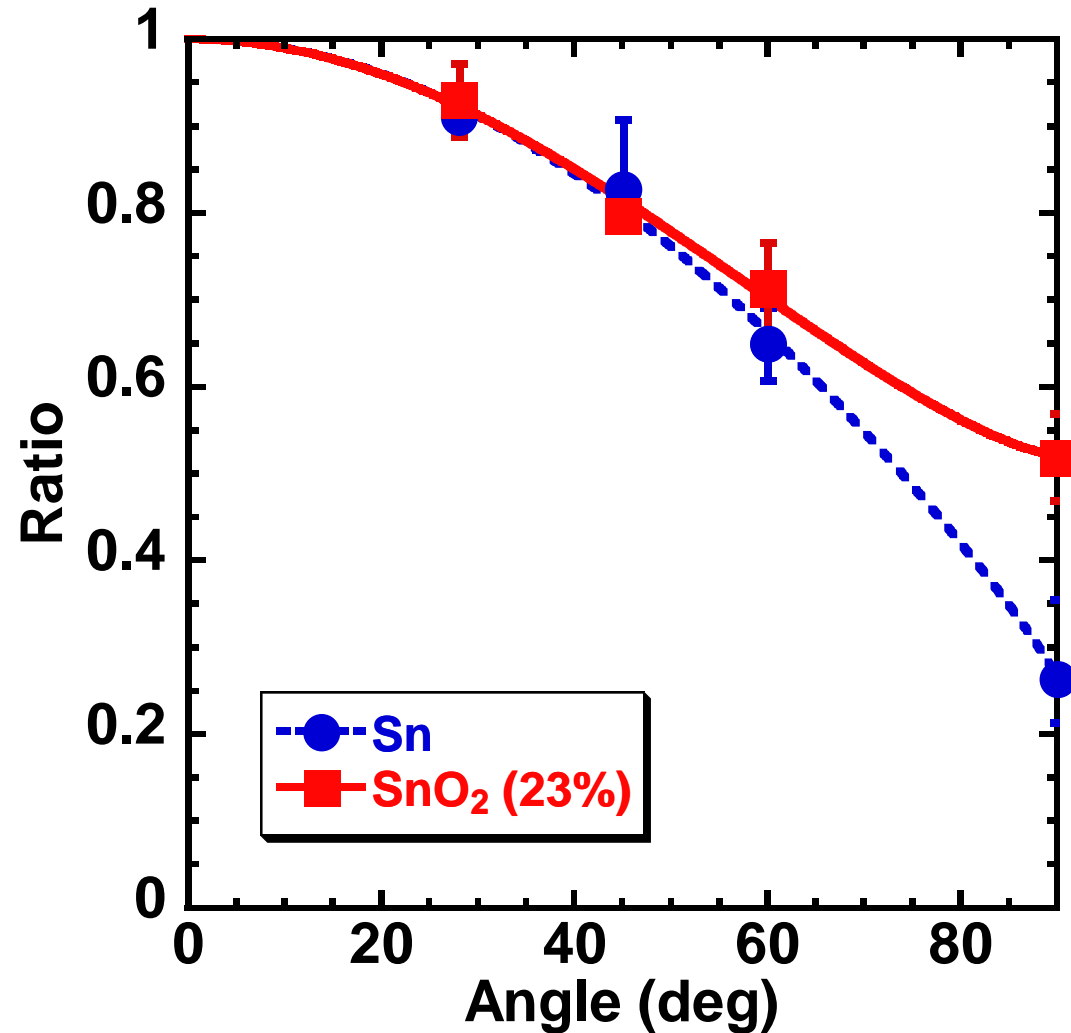
These results are possibly due to self-absorption by surrounding plasma.

Irradiation Conditions

wavelength	=	(1064 nm)
pulse width	=	10 ns
spot size	=	500 $\mu\text{m}\Phi$
laser intensity	=	1×10^{11} W/cm ²



Angular distribution of EUV emission was measured by a monochromatic EUV mini-calorimeter.



Although EUV radiation is observed at 90 degree, the following fitting equation is suitable for angular distribution of EUV plasmas.

$$a + b (\cos \theta)^r$$

In this case,

$$\text{Sn} : 0.26 + 0.74 (\cos \theta)^{0.89}$$

$$\text{SnO}_2 (23\%) : 0.52 + 0.48 (\cos \theta)^{1.4}$$

Irradiation Conditions

wavelength	=	(1064 nm)
pulse width	=	10 ns
spot size	=	500 $\mu\text{m}\Phi$
laser intensity	=	$1 \times 10^{11} \text{ W/cm}^2$



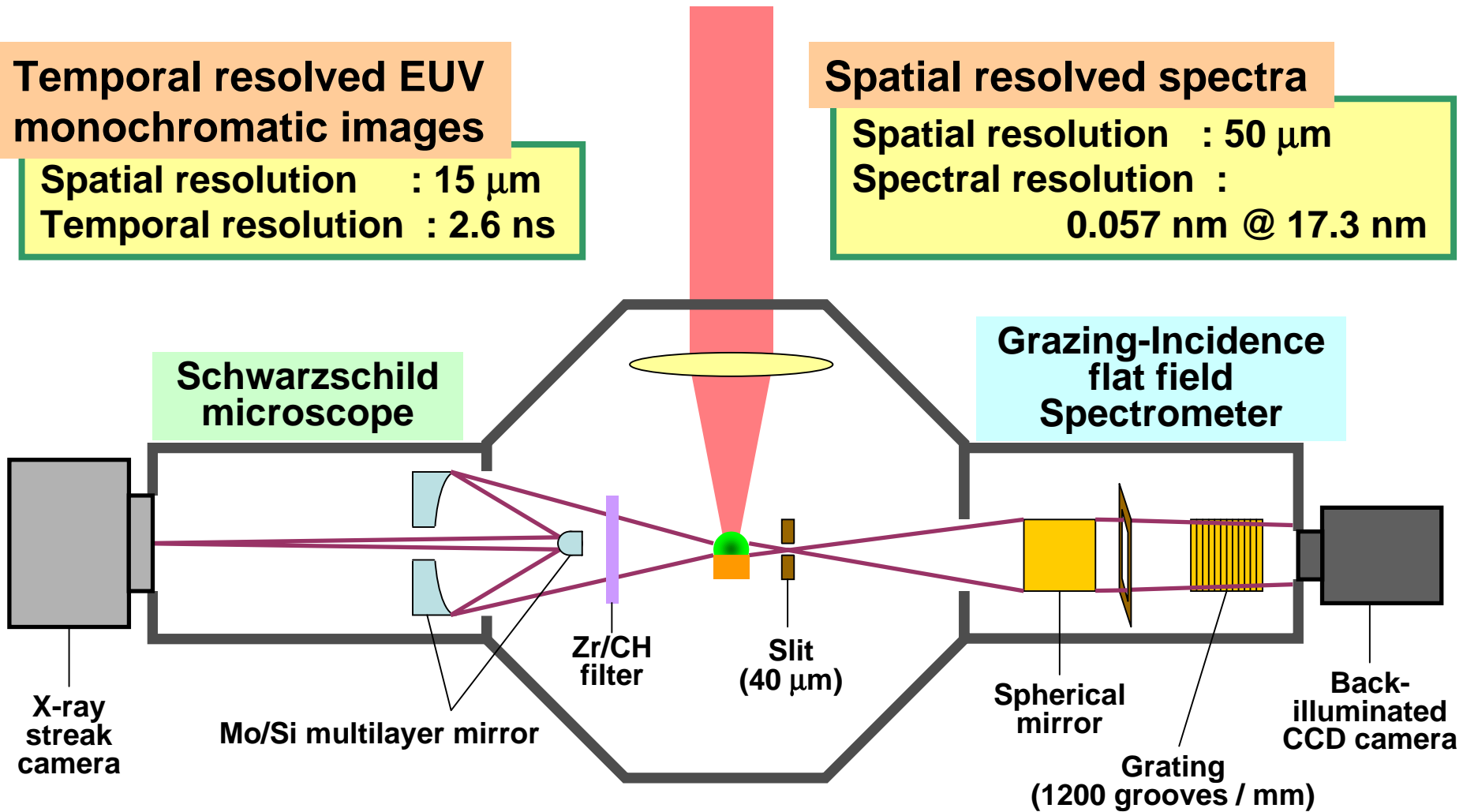
Experimental setup for dynamics measurements

Temporal resolved EUV
monochromatic images

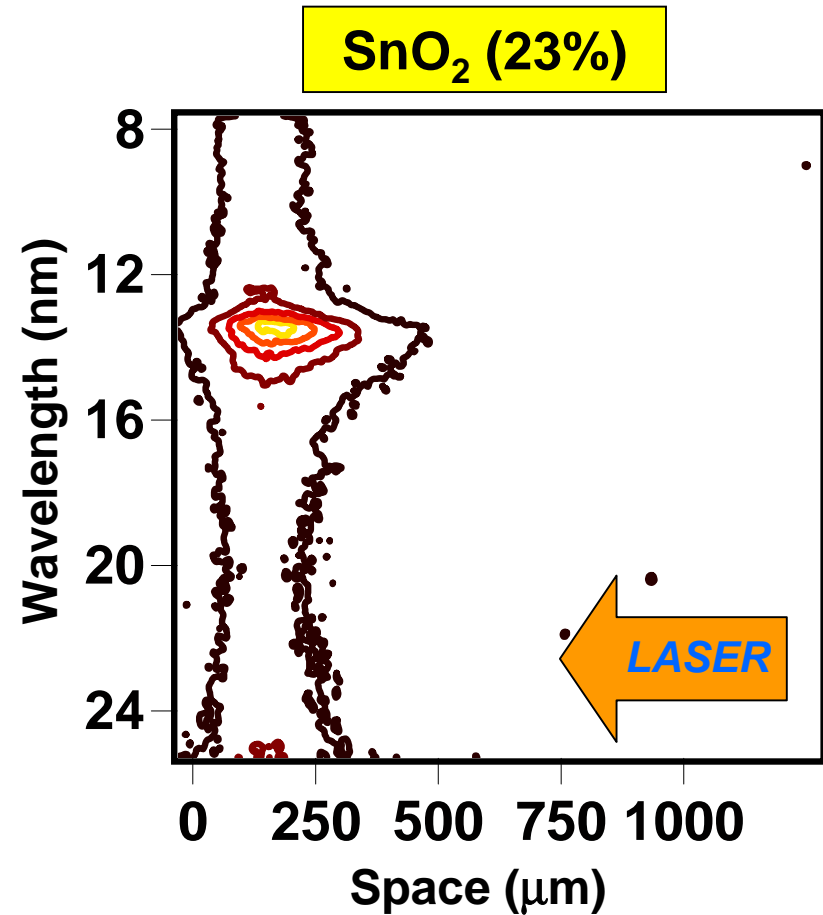
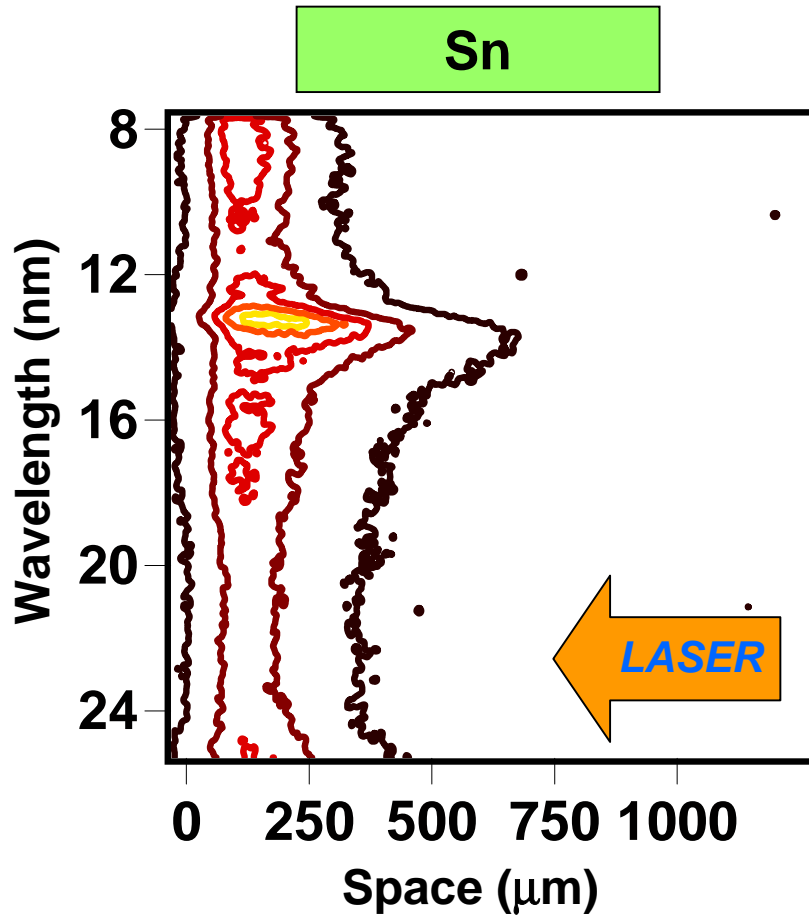
Spatial resolution : $15 \mu\text{m}$
Temporal resolution : 2.6 ns

Spatial resolved spectra

Spatial resolution : $50 \mu\text{m}$
Spectral resolution :
0.057 nm @ 17.3 nm



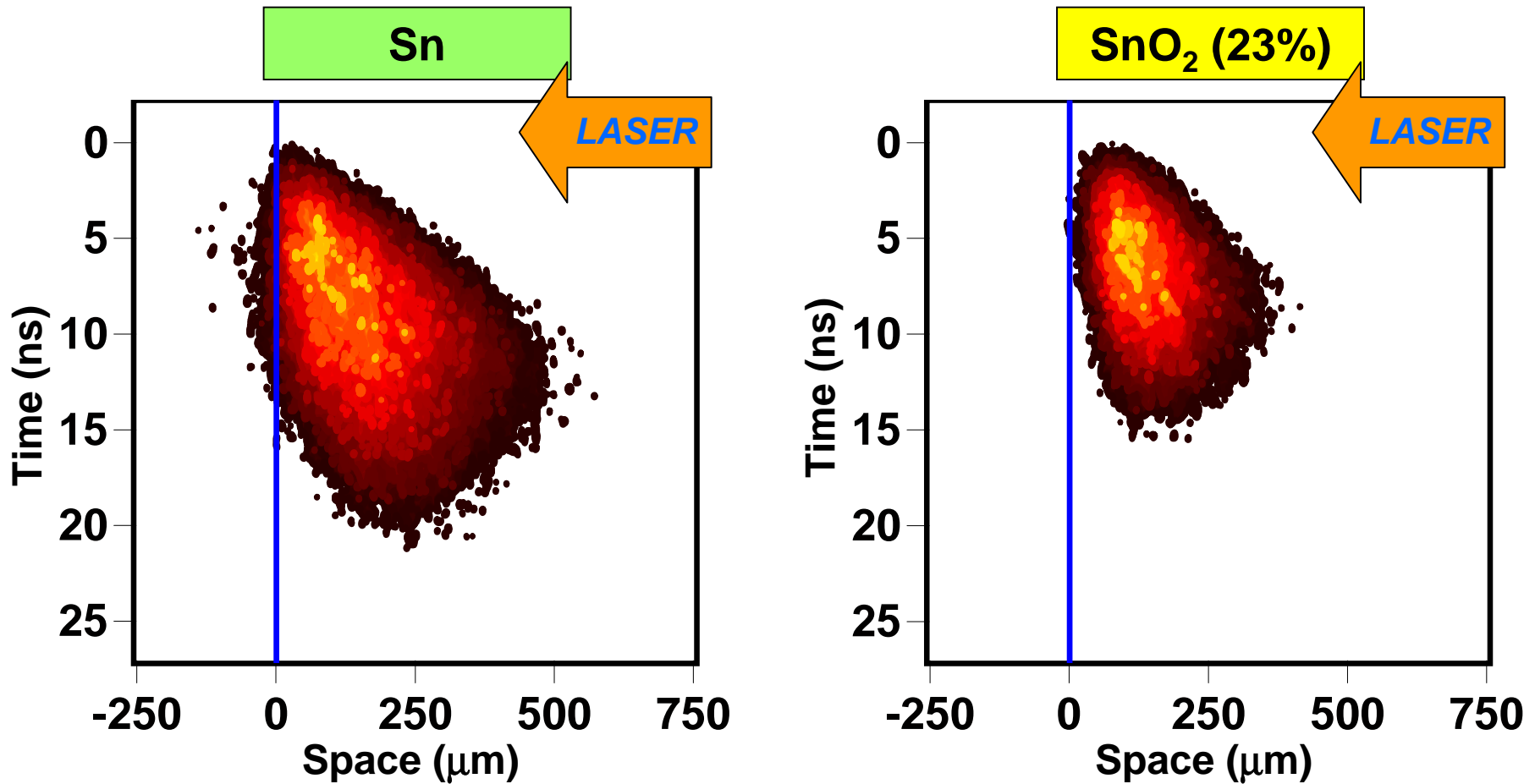
Spatial extension tends to be smaller for the low-density targets.



**Irradiation
Conditions**

(1064 nm), pulse width = 10 ns, spot size = 220 $\mu\text{m}\Phi$,
laser intensity = 7×10^{10} W/cm²

Temporal evolution of EUV emission region for solid and low-density targets.



Irradiation
Conditions

(1064 nm), pulse width = 10 ns, spot size = 220 $\mu\text{m}\Phi$,
laser intensity = 7×10^{10} W/cm²



Summary

- With decrease in initial density of a target, spectrum become narrower.
 - ➔ Reduction of heat load for the first collection EUV mirror
- Better CE at 13.5 nm has been obtained for the low-density SnO₂ target.
- EUV emission region in low-density SnO₂ targets have been spatially identified.
 - ➔ Further investigation is undertaken to derive density and temperature of emission region.

Acknowledgements

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