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Investigation on high conversion efficiency and Tin debris mitigation for laser produced plasma EUV light source.

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- Ø Summary
- Ø Aim of investigation
- Ø Setup of experimental apparatus
- Ø Observation results

Summary

- A experimental apparatus are made to clarify elemental phenomena on Laser Produced Plasma light source.

- Some observation results are shown with above apparatus.

Aim of investigation

- Ø Physical phenomena confirmation
  - ü Phenomena on Laser produced plasma (LPP)
  - ü Investigation of Tin droplet behavior
  - ü Investigation of Tin fragments (debris) behavior

- Ø To confirm possibility and ability of EUV light source
  - ü Tin debris mitigation process
  - ü Main-pulse to EUV light conversion efficiency (CE)

- Ø Tool : Experimental device building up
  - ü Operation : Simple
  - ü Meteorology : Extra information

Experimental apparatus

- Device concept
- Device components
- Metrology

Concept

- Ø Operation : Simple
  - ü Compact size
  - ü Less maintenance

- Ø Meteorology : Extra
  - ü Tin particle (fragment, neutral, ion) measurement
  - ü Distribution easement

Components

- Ø Simple but sufficient for LPP
- Ø Same ability of mass production machine.

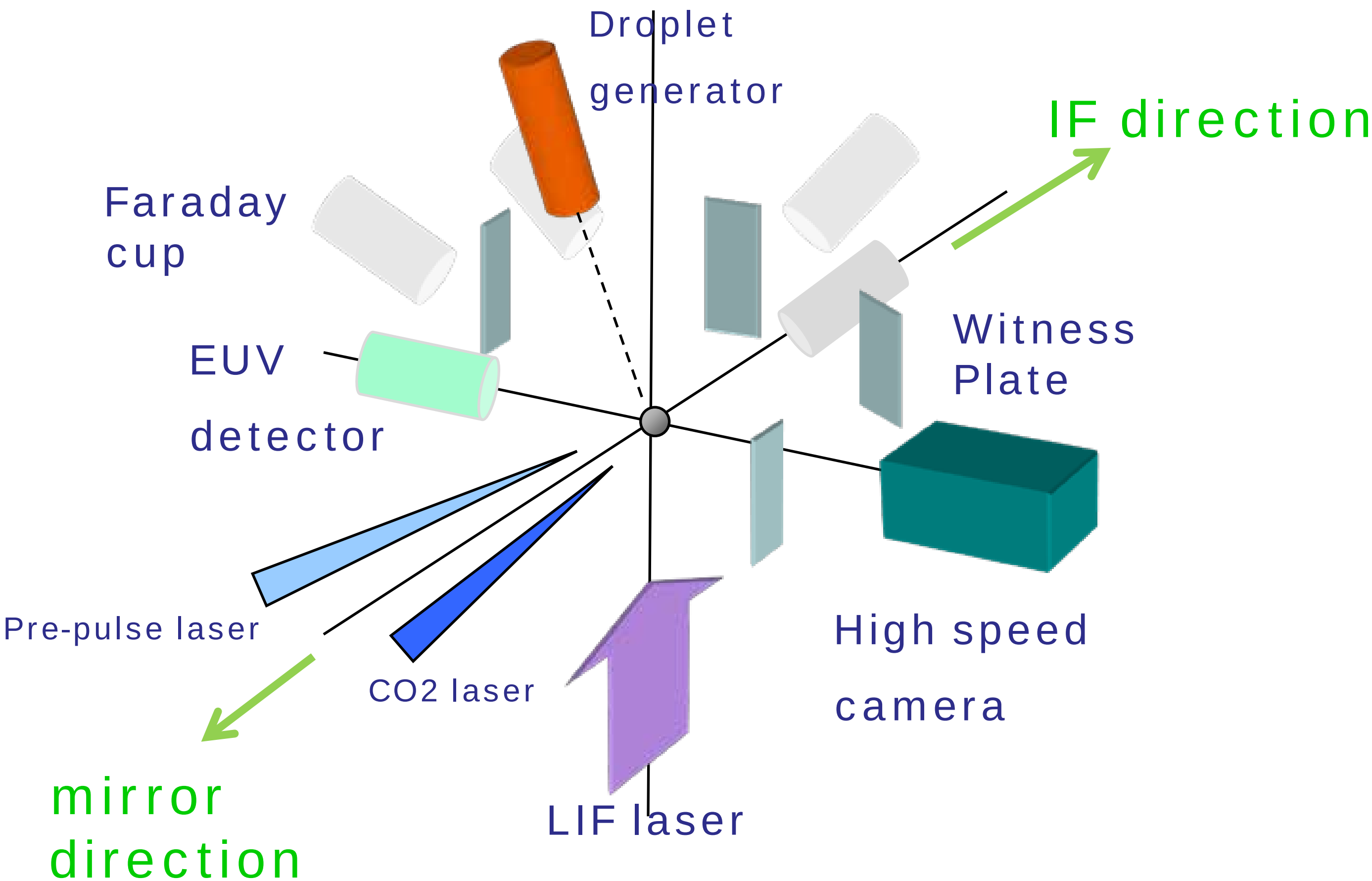
- Ø Difference : Repetition rate, single shot

- Ø Equipped Components
  - ü Droplet generator
  - ü Pre-pulse laser
  - ü Main pulse laser
  - ü Magnetic field
  - ü No Collector mirror

	Production machine	This apparatus
Droplets	100 kHz	10Hz
Pre-pulse laser	100 kHz	10 Hz
Main-pulse Laser	100 kHz	10 Hz

Metrology setup

Ø Subject to measure: Tin Fragments, Neutrals, Ions

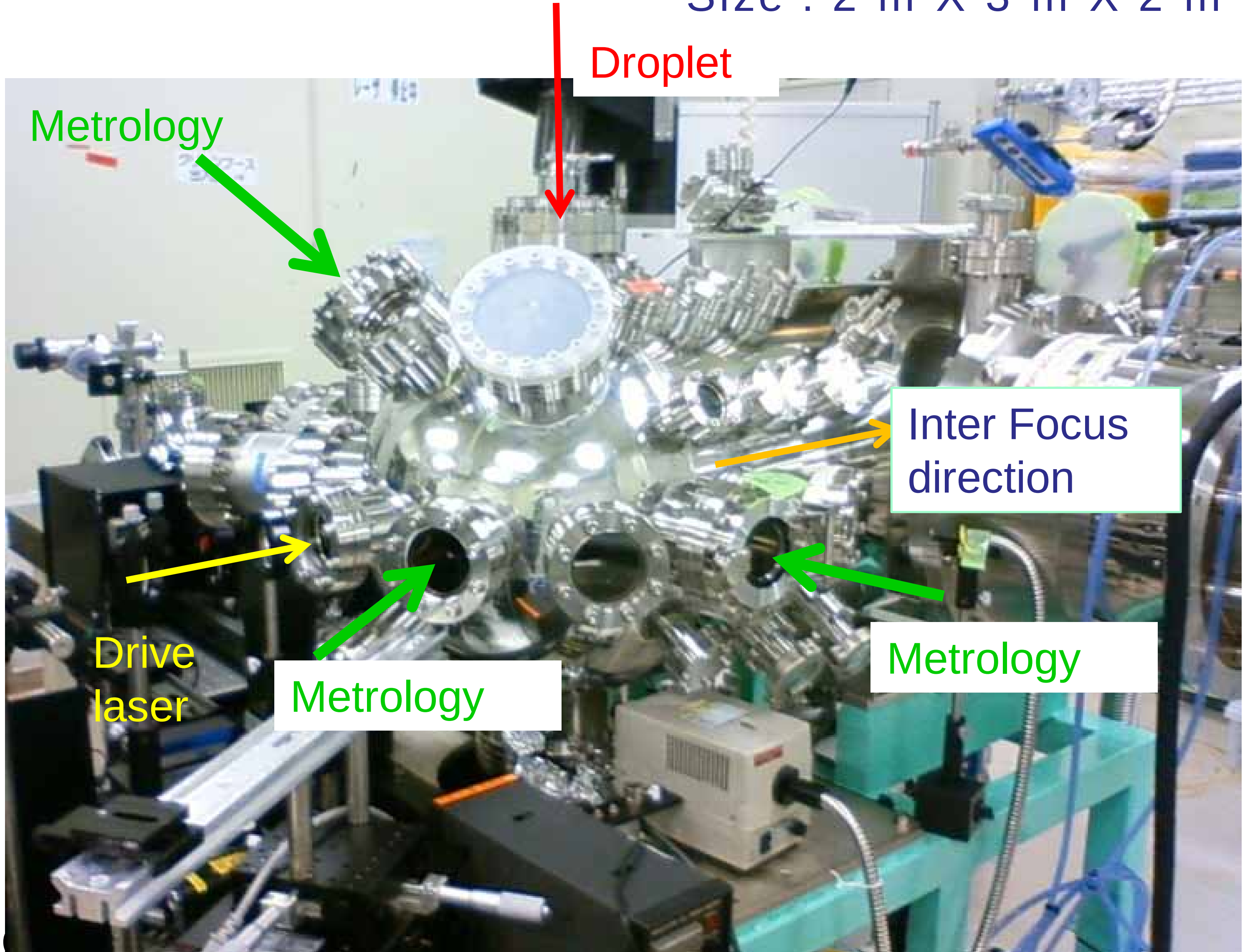


Metrology : Measurement property and method

	Method	Measured
Tin Fragments	Witness plates High speed camera	Diameter Spatial distribution
Tin Neutrals	Laser induced Fluorescence (LIF)	Density Speed Spatial distribution
Tin Ions	Faraday cup LIF	Density Spatial distribution
EUV light	Flying circus	Energy
CO_2 laser	Power meter	Transparent of CO_2 laser Reflect of CO_2 laser

Outlook

Size : 2 m X 3 m X 2 m



Observation results

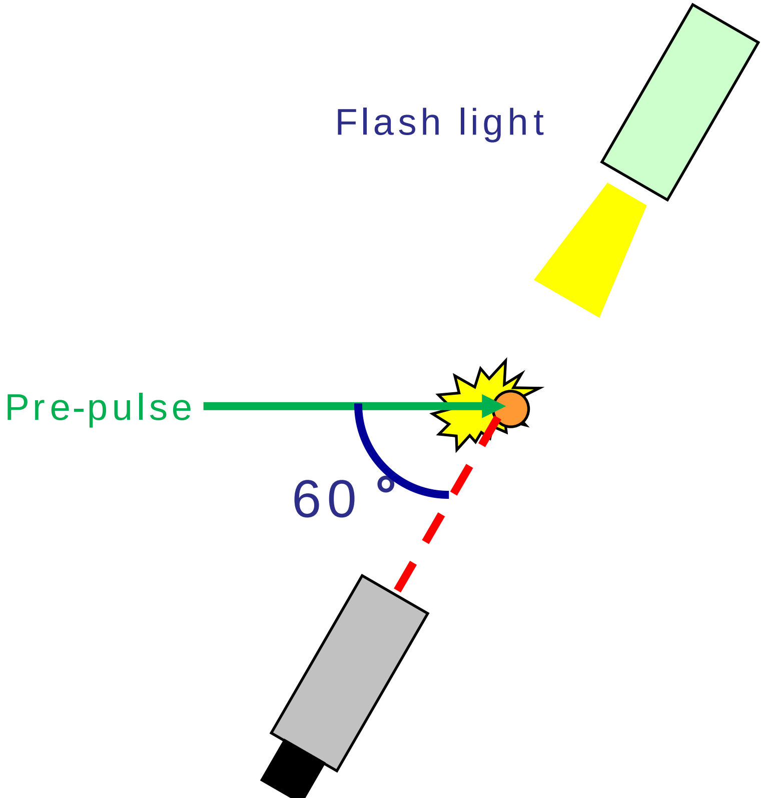
High speed camera results

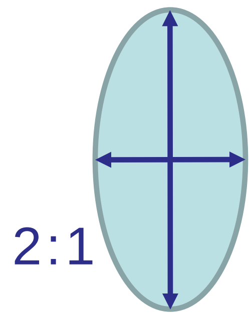
Tin droplet dispersion by pre-pulse irradiation

Tin fragment behavior by main pulse irradiation

High speed camera measurement results

- Camera and short duration flash light measurement
  - Time resolution ~ 40 nsec
  - Spatial resolution ~ 6 um
  - 60 degree observation angle to laser axis

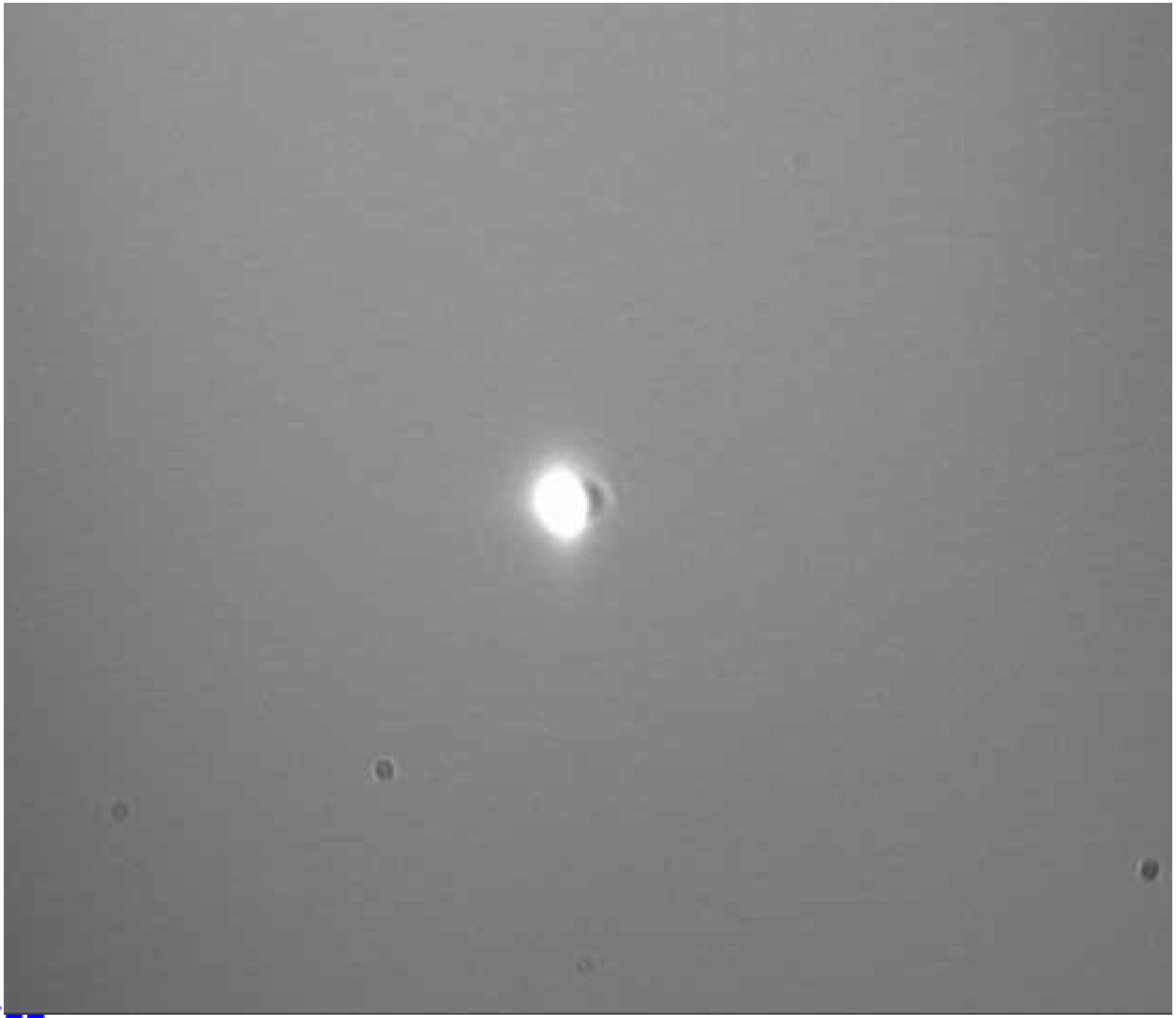




True circle
looked like this ellipse
in this configuration

Pre-pulse laser irradiation

Droplet dispersion timing change

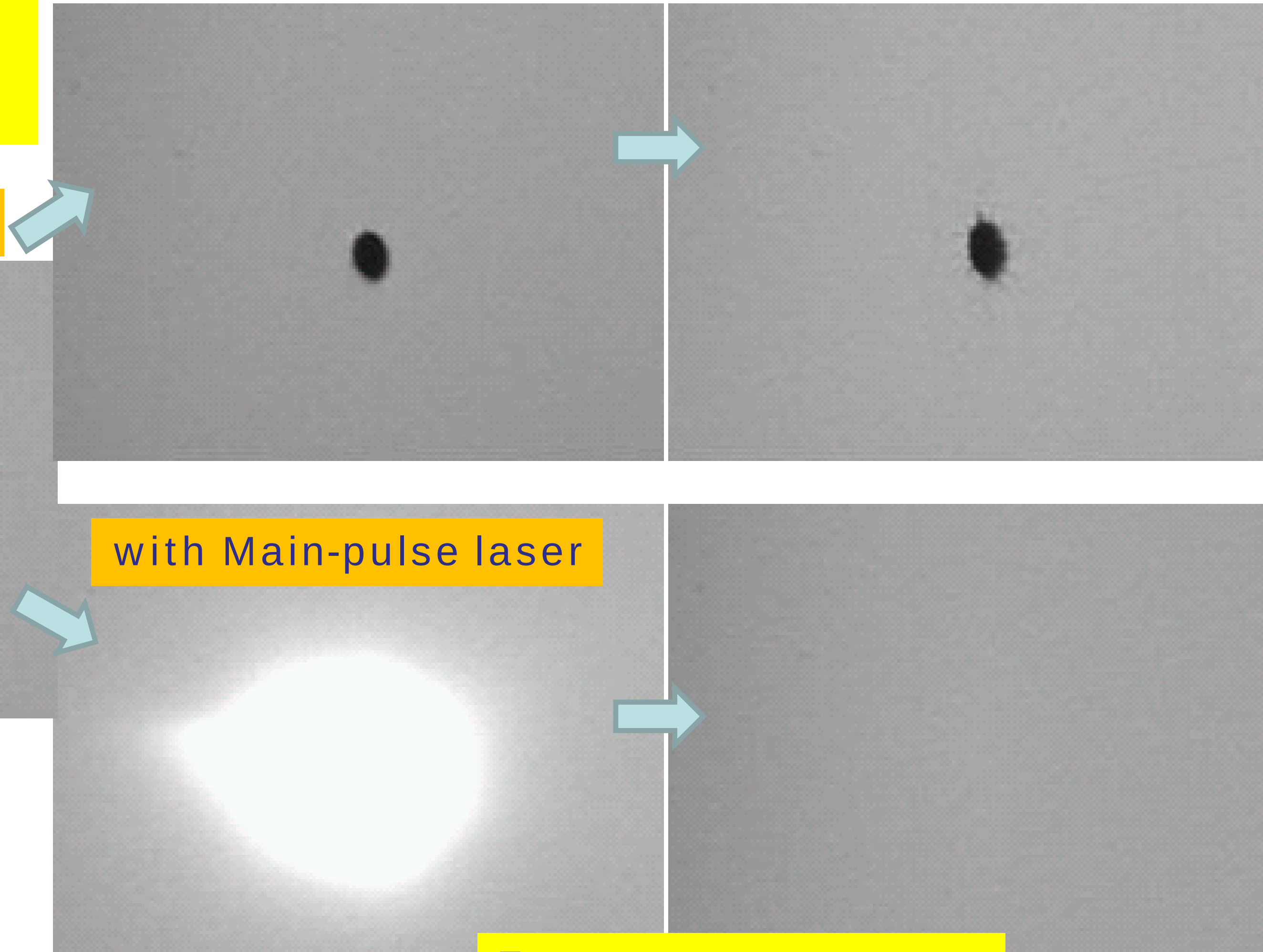


Pre-pulse +Main-pulse laser irradiation : one condition

One dispersion state

Smaller fragments
Spread wider

Pre-pulse irradiation



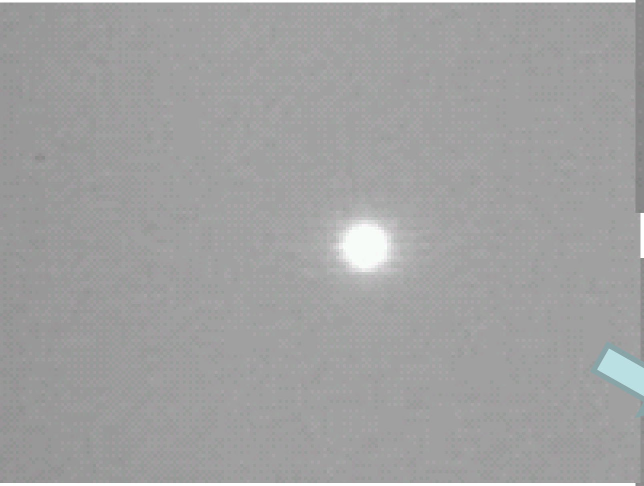
Fragment :
vanished -> Vaporized

Pre-pulse+ Main-pulse laser irradiation : other condition

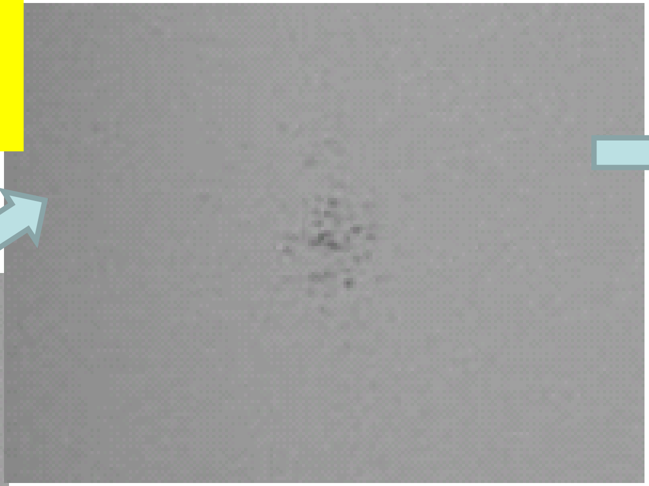
other dispersion state

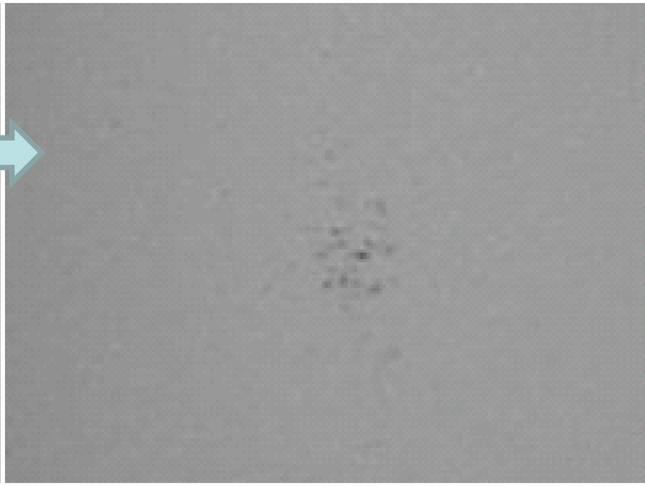
larger fragments
Spread too wider

Pre-pulse irradiation

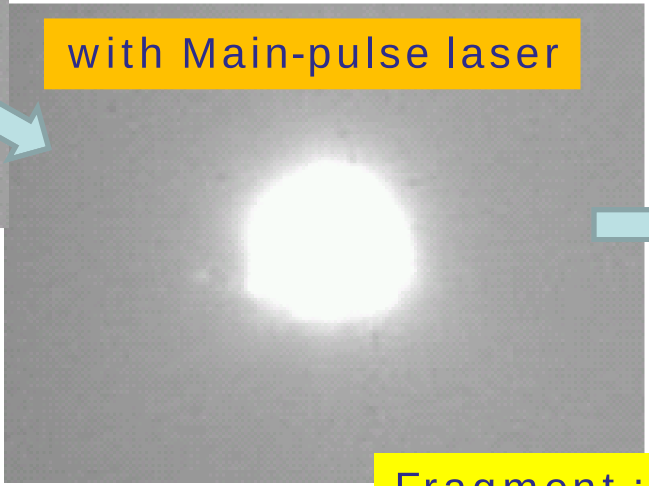


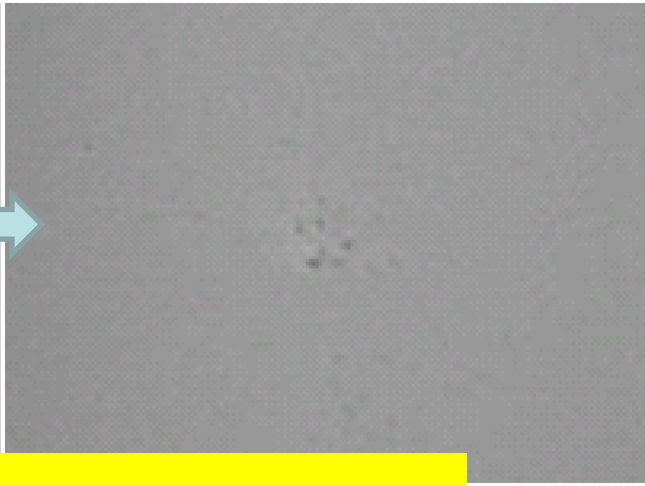
w/o Main-pulse laser





with Main-pulse laser





Fragment :
Not vanished -> not vaporized

Plan

- Ø Using obtained data,
  - ü Confirmation of debris mitigation concept
  - ü Confirmation of CE improving concept
- Ø Getting other parameters
  - ü Optimization of EUV source operation condition
- Ø Expanding to next generation machine

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