Development of plasma photonic device generating high-intensity electromagnetic radiation toward diagnostics of electronic device

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-Electronic Devices Innovation -
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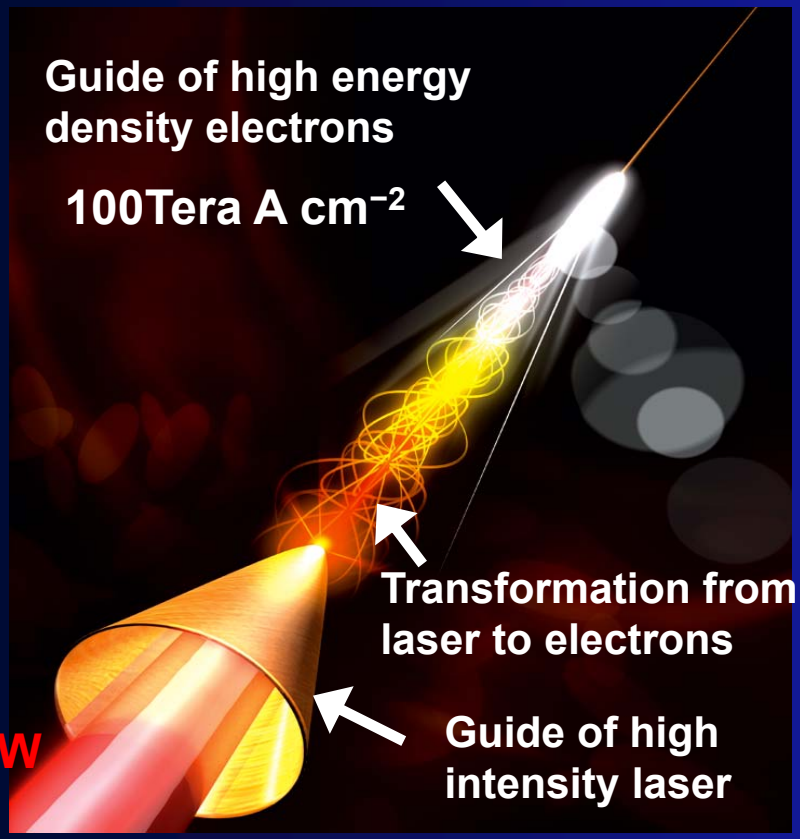
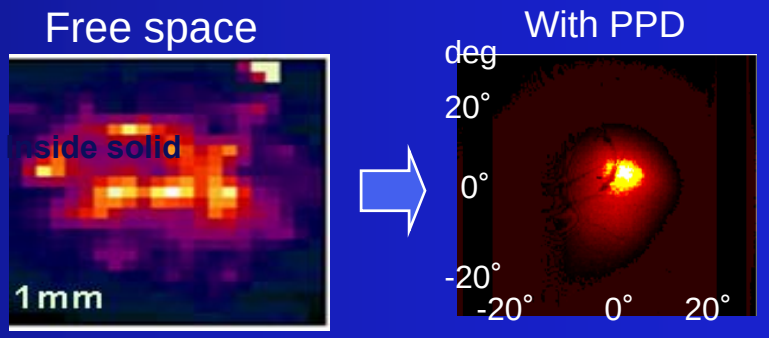
What is “Plasma Photonic Device” ?

- “Plasma Photonic Device” is a new concept of novel devices which enable to generate and control photons, from THz light to γ-rays, and/or high energy density electrons and ions, by using plasma as medium.





Peak intensity : x **10 – 20**

Divergence : **< 5 deg**

(>30- 40deg inside solid)

R.Kodama *et al*., Nature 432, 1005(2004)

Purpose of our Unit: development of a small / compact electromagnetic radiation source

In this research, small electromagnetic radiation sources using Plasma Photonic Devices produced by ultra-high intensity laser pulse is developed toward novel diagnostics of electronic devices.

Plasma photonic devices to control lasers and electrons

i) Plasma mirror (Nakatsutsumi, LULI)

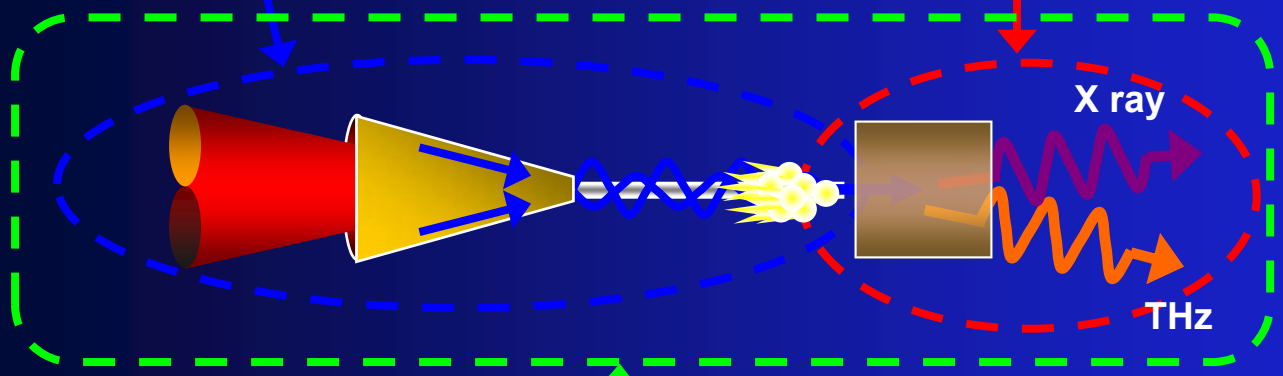
ii) Device for generation and control of high energy density electrons (Habara, RAL)

Plasma photonic devices to generate electromagnetic radiations

iii) Wavelength tunable radiation source by Smith-Percell (IOP)

iv) Generation and control of high intensity Teraheltz radiation (Jin, U. Utsunomiya)

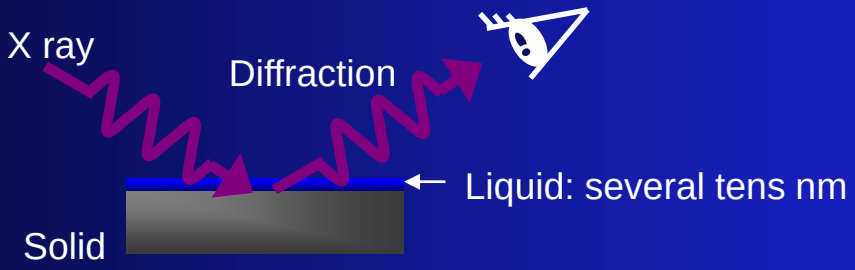
v) Mono-energetic EUV radiation (Inubushi)



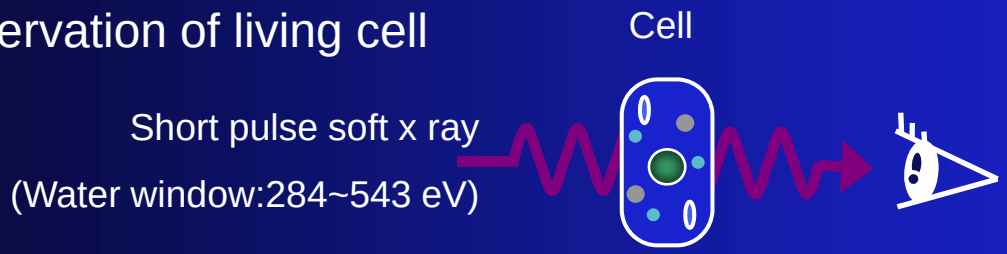
Integration of plasma photonic devices toward diagnostics of electronic devices (Inubushi, Aoki)

Expected applications of small radiation sources

- Diagnostic of surface structure of solid-liquid interface

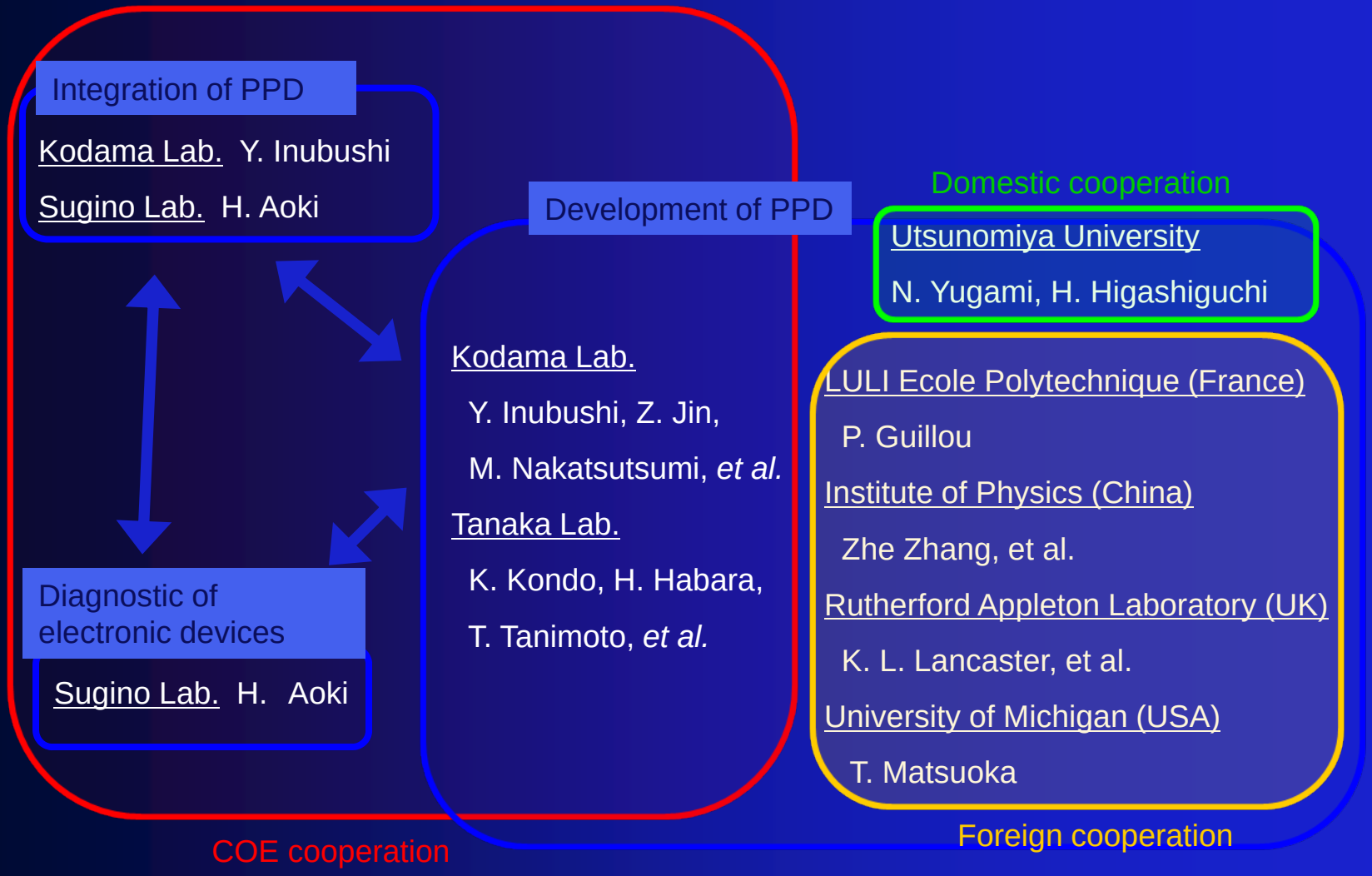


- Observation of living cell

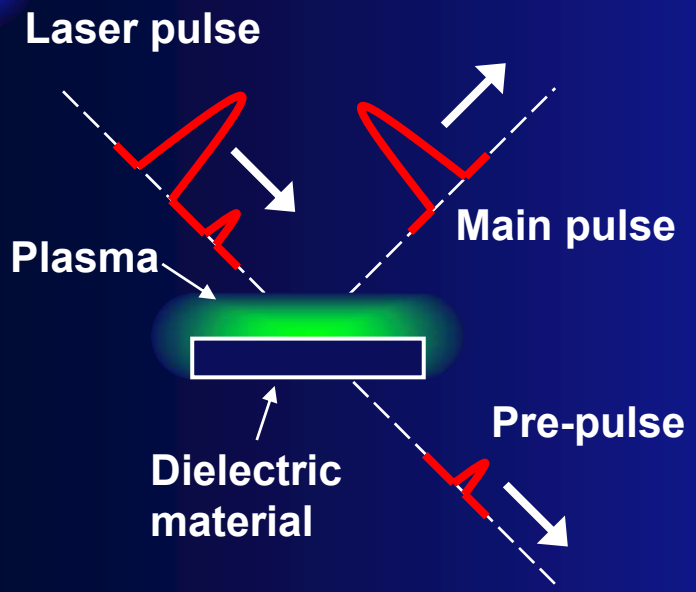


- Diagnostics of electronic devices using Cherenkov radiation

This research has been performed by the cooperation of domestic and foreign research laboratories.



Pre-pulse of ultra-high intensity laser can be suppressed by using “plasma mirror”.



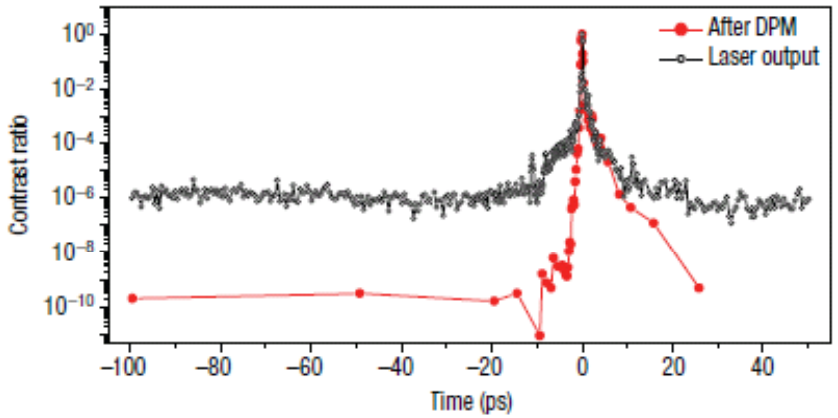
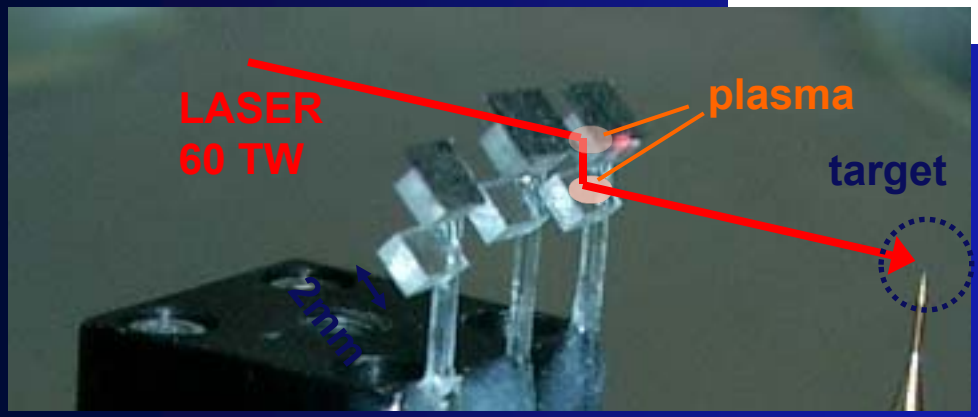


Figure 1 Temporal profile of the laser pulses delivered by a 10 TW, 60 fs laser system, in logarithmic scale, with and without the DPM. The signal at time 0 is set to 1 in both cases for an easier comparison between the two curves.

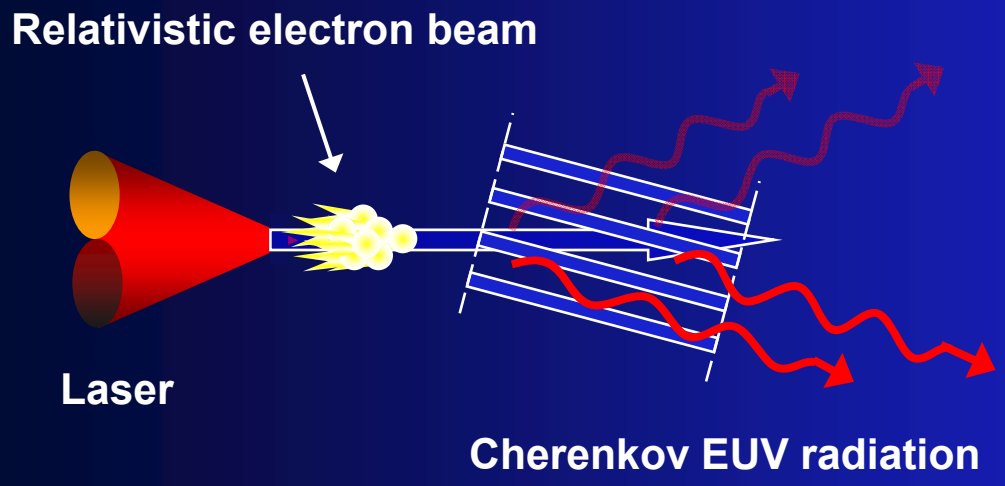


C. Thaury, et al., Nature Physics **3**, 424 (2007).

Cherenkov EUV radiation is useful for various application due to its mono-energy and directivity.

Cherenkov EUV radiation

Mono-energetic and directive EUV source based on Cherenkov radiation is developed by using index of refraction near absorption edge and controlled laser-produced relativistic electron beam. This wavelength is selected by changing emitter material.

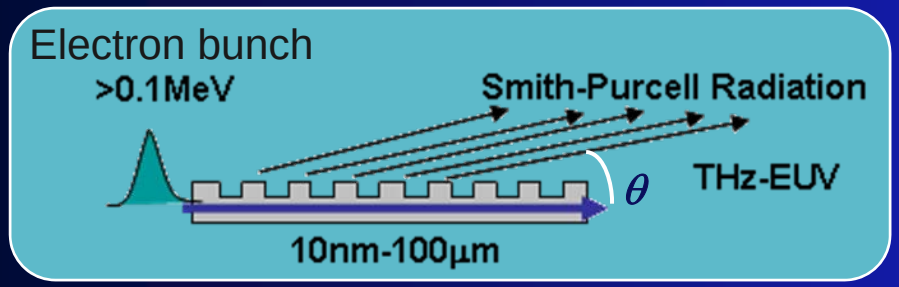


Photon energy

Target	$h\nu$ (eV)
Mg	50
Al	73
Si	100
Ti	454
Cu	933

Smith-Purcell processes can emit a monochromatic radiation from THz to EUV region.

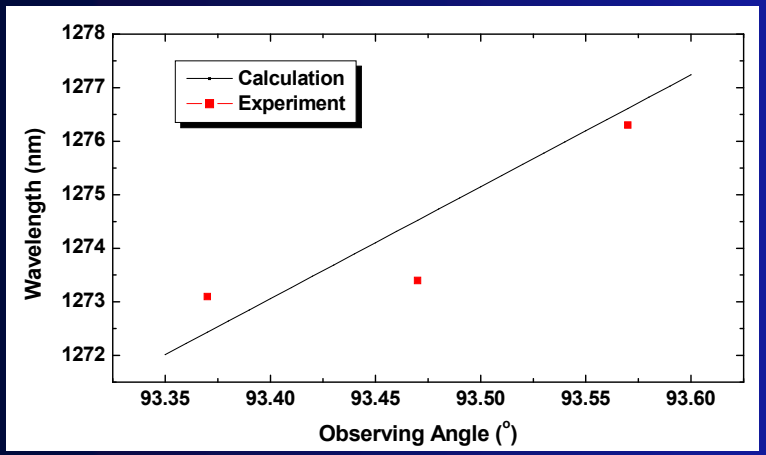
- Radiation is emitted when high energy electrons pass through periodical structure (Smith-Purcell radiation) with angle dependence

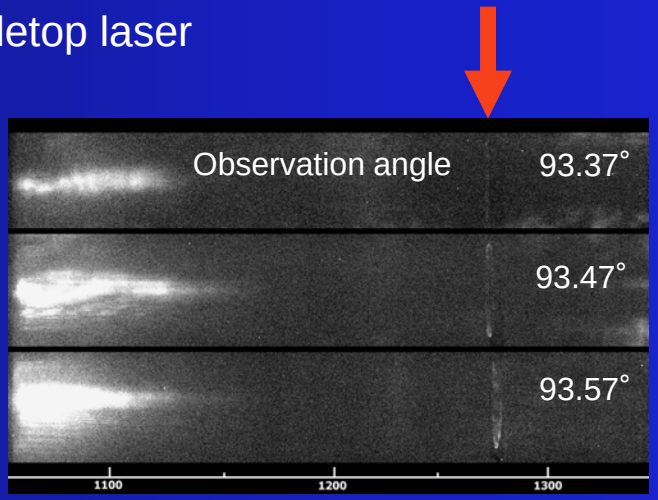


$$\lambda = \frac{l}{n}\left(\frac{1}{\beta} - \cos\theta\right)$$

S.J. Smith & E.M. Purcell, Phys. Rev. **92** 1069 (1953)

Preliminary experimental results using Tabletop laser





wavelength

Summary

- Plasma photonic device generating high-intensity electromagnetic radiation toward diagnostics of electronic device have been developed.
- Plasma mirror can suppress pre-pulse of ultra-high intensity laser. We started plasma mirror experiment.
- Cherenkov EUV radiation can be a novel EUV radiation source. Dependence of Cherenkov EUV spectrum on emission angle is calculated.
- Smith-Purcell radiation has a capability of a radiation source whose wavelength is from Teraheltz to EUV. Smith-Purcell radiation in IR region was observed in laser plasma experiment.