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Progresses of inertial fusion energy program at GPI Hamamatsu toward mini-reactor CANDY

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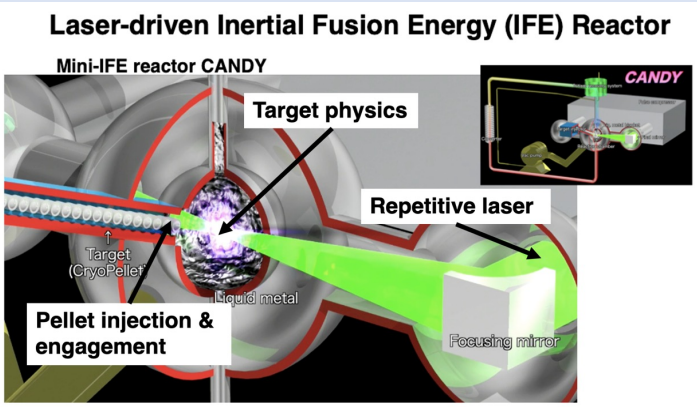
ABSTRACT

- A mini-reactor CANDY [1,2] that based on kJ-class diode-pumped solid-state laser (DPSSL) is proposed to perform feasibility studies of the power plant in fast ignition scheme fusion .
- The paper describes progresses of inertial fusion energy program at GPI Hamamatsu toward the CANDY focusing on (i) pellet injection & laser engagement [3, 4] and (ii) Target physics.
- First issue is achieved using repetitive laser system, (i) succeeded in 10 Hz injection of deuteride polystyrene beads longer than 2 minutes, which was demonstrated for the first time using inserter that works at the same frequency of laser toward the reactor.
- Second issue is achieved using a world-class, single-shot ultra-intense laser LFEX at ILE, Osaka university, here we demonstrated (ii) an additional heating of counter imploded core of a density of 2.8±0.3 g/cc with temperature upto 0.9 keV.
- Results (i) and (ii) are foundations toward the future compact reactor development.

Mini-Reactor CANDY

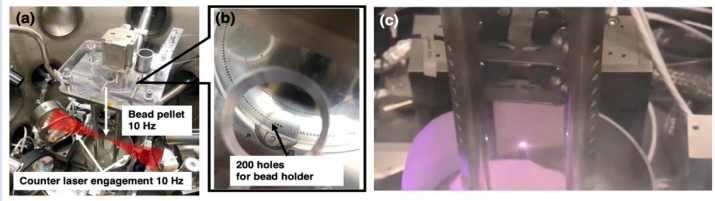
- The CANDY is a laser fusion mini-rector to demonstrate fusion energy extraction with energy gain bellow 1 toward the power plant [1, 2].



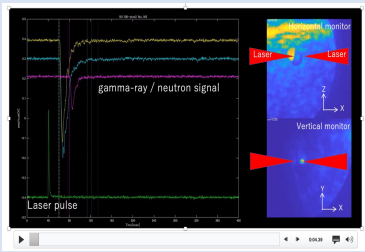
Concept of laser fusion mini-Reactor CANDY

Progress 1: Pellet injection & engagement

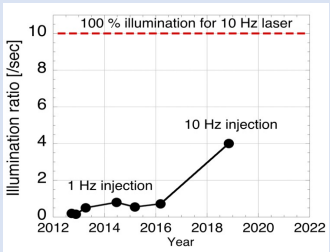
- Progress of pellet injection and engagement is 10 Hz operation of bead pellet, the same frequency with laser repetition.
- The laser system is 10 Hz BEAT laser with on-target energy of 0.16 J per beam, pulse duration of 110 fs, focal spot of 15 μm, and the focal intensity of 7×10^{17} W/cm^2.
- The 10 Hz operation, beyond 2 min. operation results in illumination shot ratio of 40% per sec.



10 Hz bead injection system installed in counter laser illuminating chamber



Pellet injection & engagement monitor



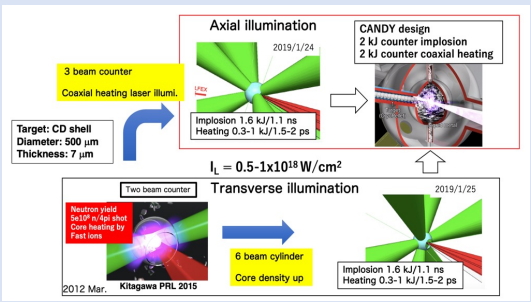
Illumination ratio history

Specifications of achieve values toward IFE

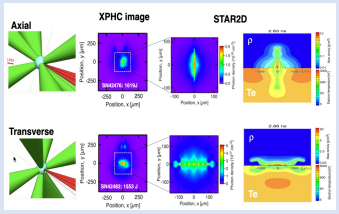
	Achieved values in Hamamatsu	mini-Reactor CANDY	Test Reactor LIFT
Laser			
Implosion	5 J/1 Hz, 50 J/0.5 Hz	2 kJ/10 Hz	0.5 MJ/4-16 Hz
Heating	0.4-1 J/1-10 Hz	2 kJ/10 Hz	0.15 MJ/4-16 Hz
Pellet injector			
Repetition	1 Hz/10 Hz	10 Hz	2 Hz x2
Pellet design	CD bead (ϕ 1 mm)	Tsuzumi-shell (ϕ 1 mm)	Cone-in-shell (ϕ 2.5 mm)
Operation duration	28 min./ 2 min.	24 hours	0.5 year
Injection precision	0.9 mm	No description	30 mm
Shot probability	70%/40%	No description	No description
Fusion power	0.2 nW	190 W	160 MW

Progress 2: Target Physics

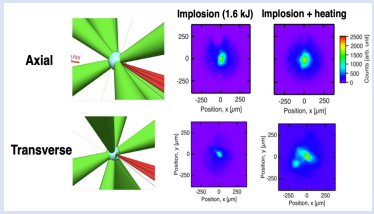
- An imploded core heating using kJ-class ultra-intense laser LFEX at ILE, Osaka University were conducted by improving imploding laser beam energy from the previous experiments [5, 6].
- Implode cores indicate elliptic shapes both in experiments and simulations with core density of 3 g/cc, bulk ion temperature of T_i 0.7-0.9 keV.
- LFEX laser with energy/pulse duration of 0.3-0.9 kJ/1.5-2 ps was successfully illuminated into the counter-imploded core of density 3 g/cc, ion temperature of T_i ~ 0.7-0.9 keV along axis or transverse of the imploding laser bundle.



Two laser illumi. configuration "Axial" and "Transverse" applied for LFEX experiments.



Implosion: Experiments and Simulation



Heating of the imploded core

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