Road to Inertial Fusion Energy

Fusion Power Associates Meeting
Washington DC
16 December 2014

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ICF Research supported by the Department of Energy, NNSA

We need to have a U.S. Fusion Energy Program

Centered on the developing a path to economical and safe fusion energy.

- This includes technological and system engineering advances in addition to the applied sciences.

Decisions on paths and priories for fusion science need to be integrated with technological and engineering efforts

- Otherwise the decisions are effectively blind to the fundamental goal of fusion energy.

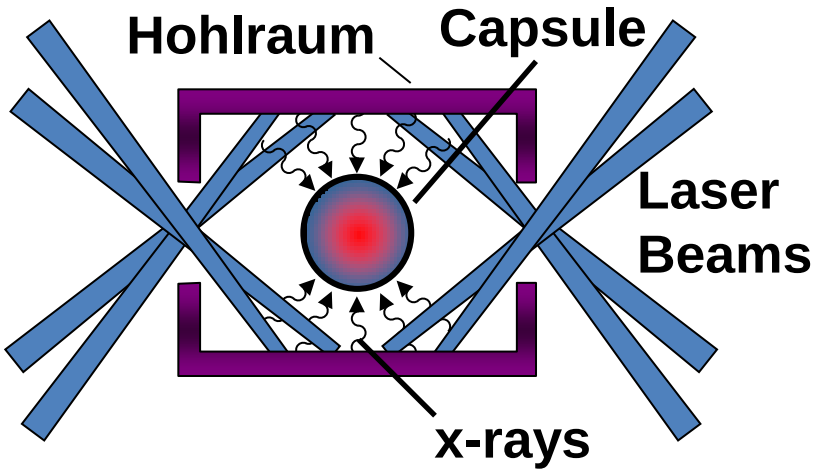
IFE would complement MFE in a fusion energy program

- We don't yet know the best path forward
- IFE and MFE have different physics challenges
- Yet there is significant commonality in the technology and materials needs.
- But also differences – e.g. high-rep rate durable IFE drivers.
- An IFE program in the U.S. could initially be modest cost given the large ICF program that is developing target physics. (The HAPL program was 5% of the ICF budget).

Highlights of recent work at NRL

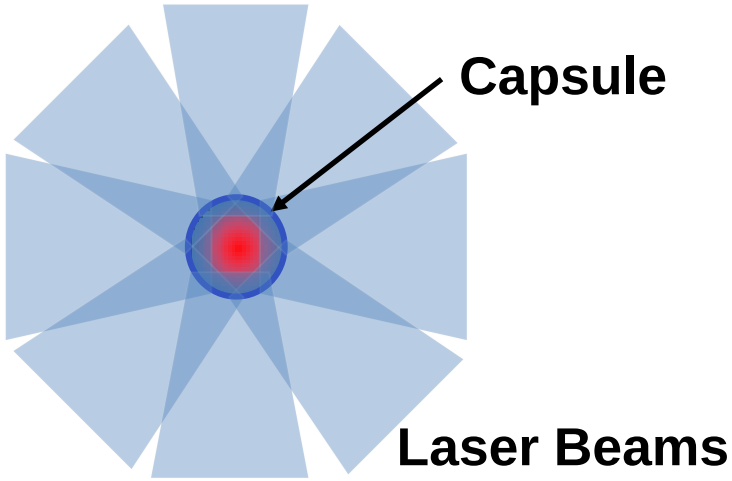
Direct and Indirect drive have their respective advantages – is there a way to combine the advantages?

Indirect Drive



- Relaxed laser uniformity requirements
- Higher mass ablation rate inhibits hydro-instability.
- Less Laser Plasma instability with near vacuum hohlraums.

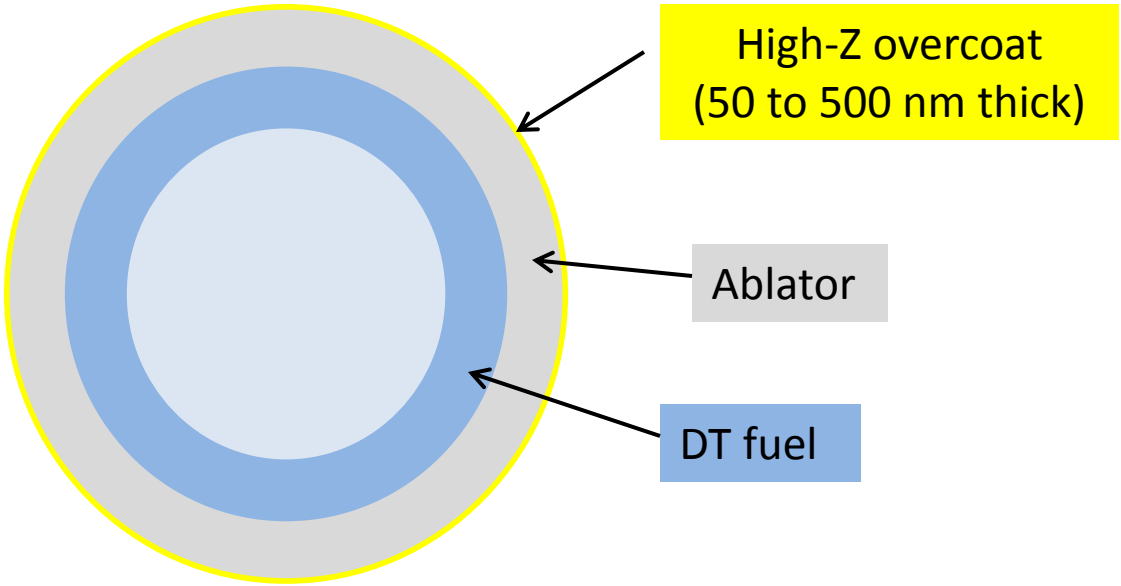
Direct Drive



- Much more efficient (7 to 9 x) use of laser light.
- Simpler physics
- Much higher predicted performance (gain)
- Simpler target fabrication

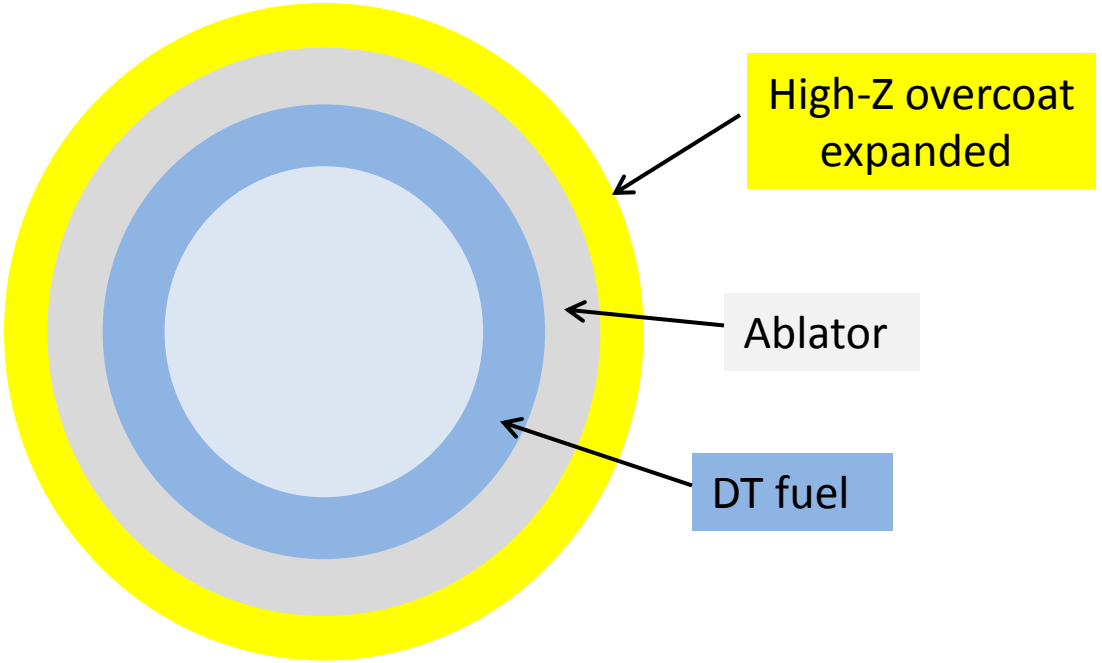
Hybrid x-ray –direct drive (1 of 4)

Conventional direct drive design but with a thin high-Z overcoat



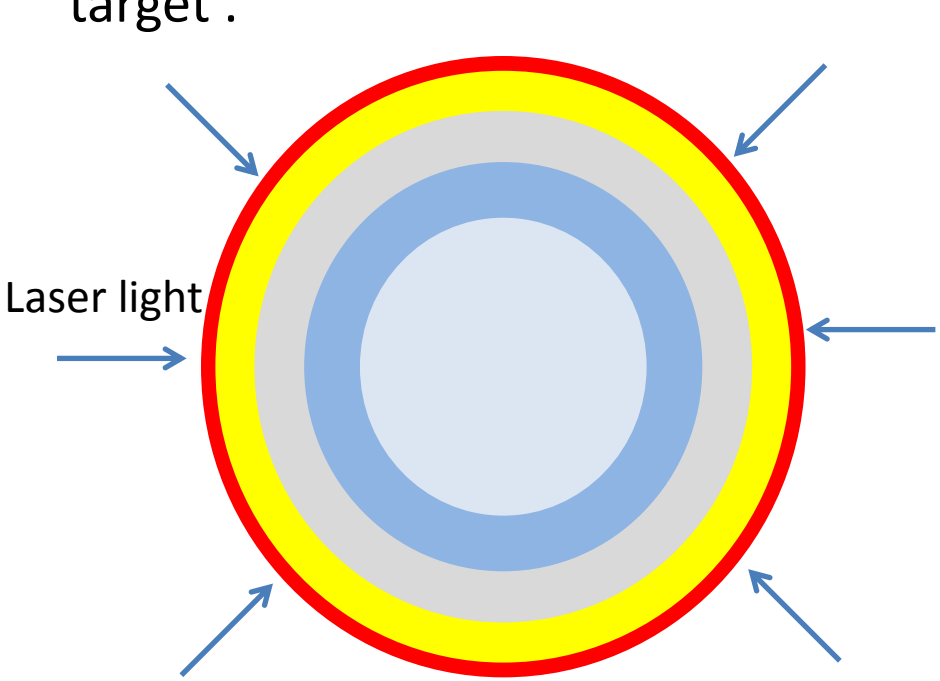
Hybrid x-ray –direct drive (2 of 4)

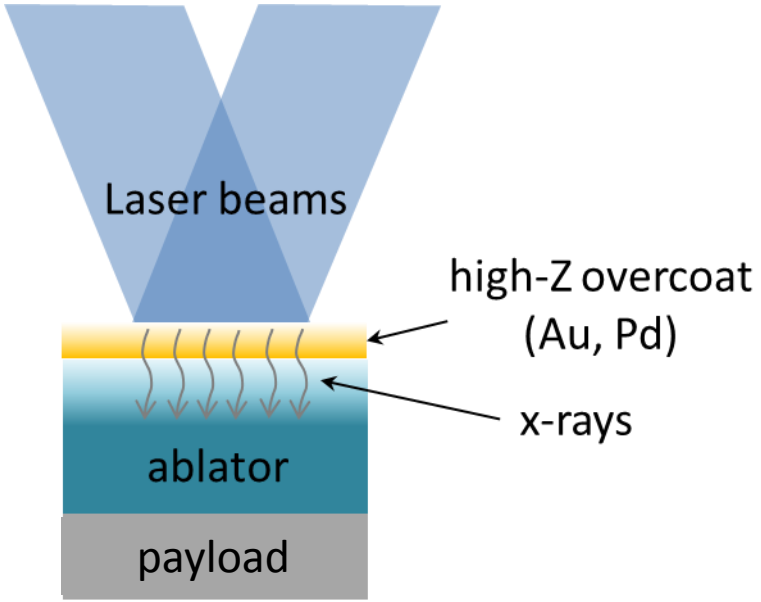
Low energy laser beams heat and expand high Z-layer (few J/cm^2 on target)
(this step is desired but may be optional)



Hybrid x-ray –direct drive (3 of 4)

Main drive is initially absorbed by high-Z plasma and resulting x-rays ablatively drive the target .

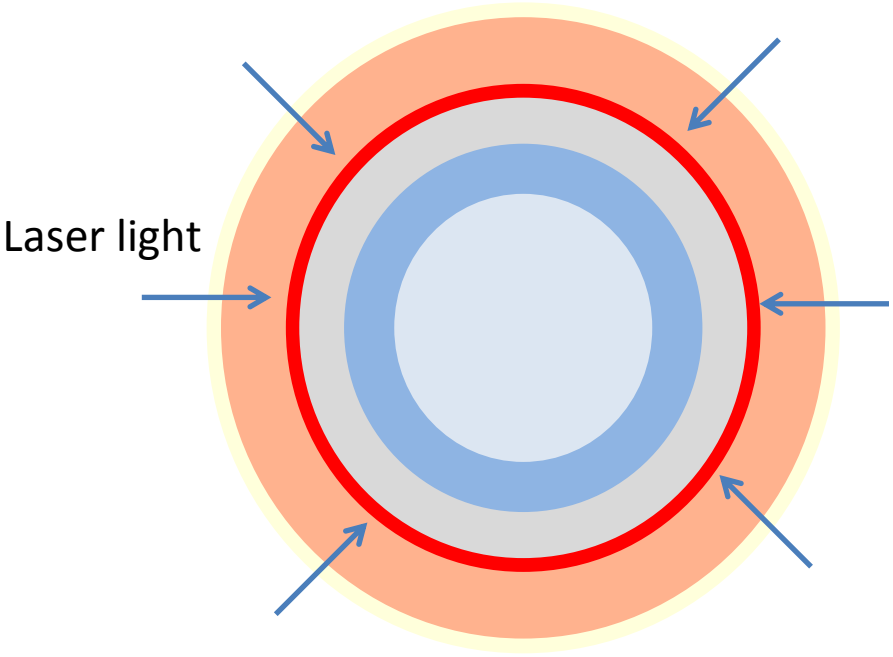




Early time x-ray drive reduces imprint and hydro instability

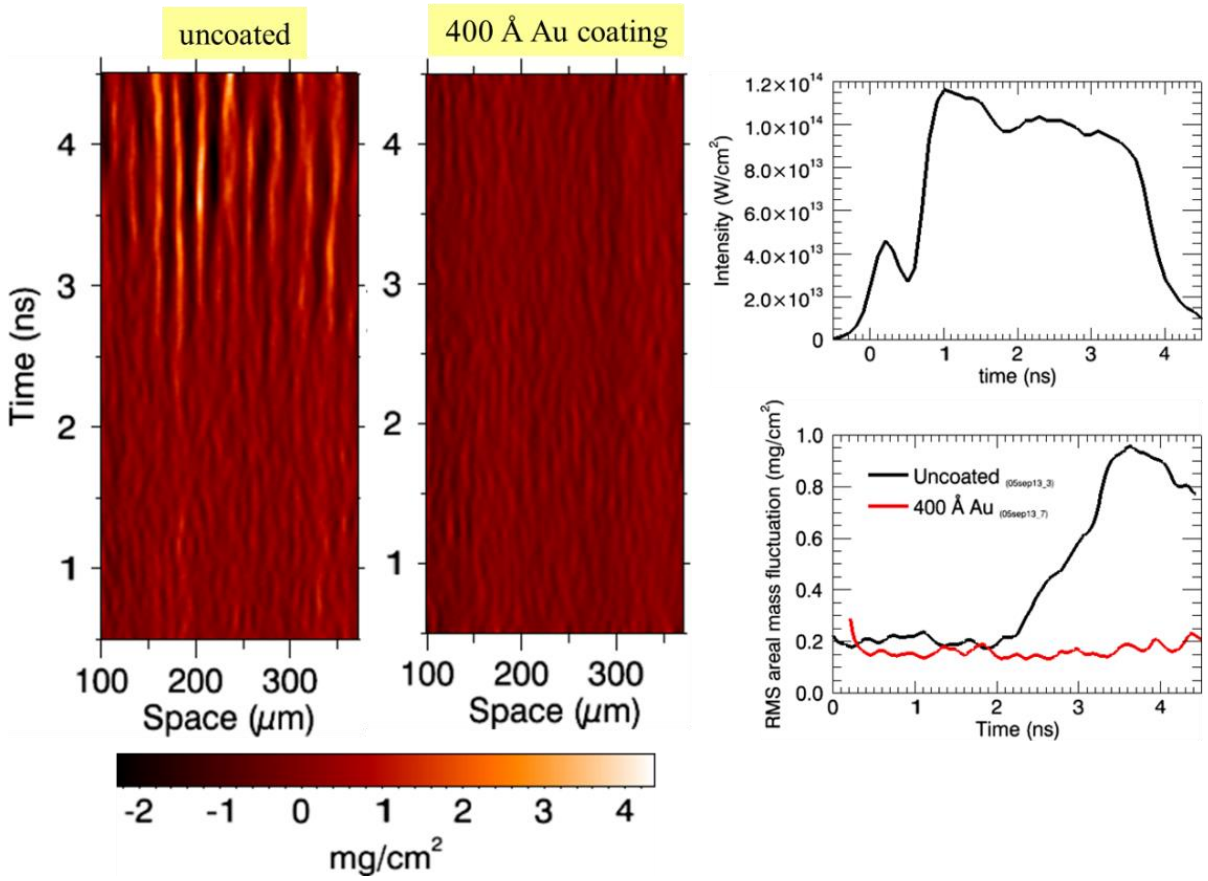
Hybrid x-ray –direct drive (4 of 4)

Later in the implosion the laser light penetrates the expanded high-Z plasma, and more efficient direct drive commences.



Experiments confirm imprint reduction and suppression of hydro instability with this approach

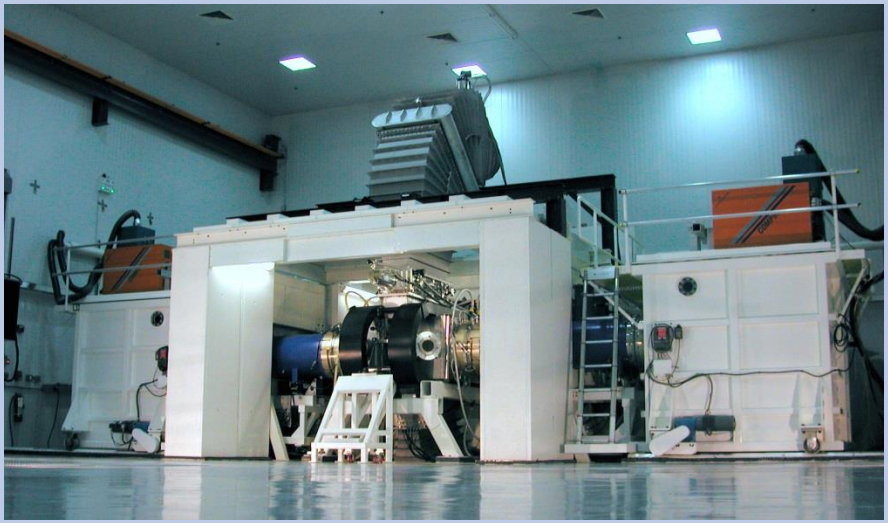
Nike planar Experiment



Similar experiments are ongoing on OMEGA and planned for NIF

NRL researchers and collaborators in industry developed high-rep rate pulse power and electron beam sources to pump KrF amplifiers for IFE

Electra electron beam KrF laser. 700 J @ 5 pulses per second with λ=248 nm.



Compact 200 kV, 4.5 kA solid state pulse generator, 10 pulses per second

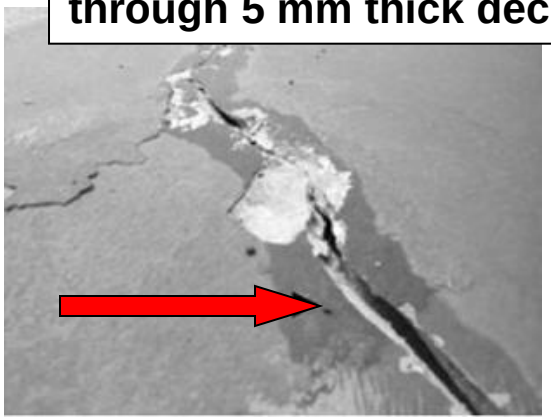
Are there other applications for this high power pulsed electron beam technology?

Pulsed E-beam technologies developed to reverse environmentally driven corrosion in aluminum alloys.

Sensitization: Magnesium migrates to grain boundaries due to hot weather, Leads to corrosion/ cracking

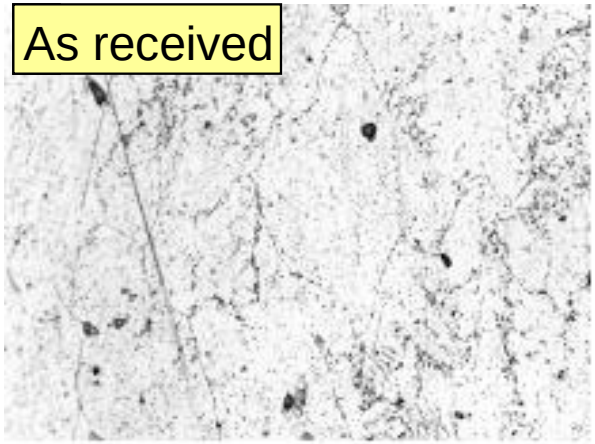
Electron Beam: drives Mg back into alumimum. E-beam heats just surface, keeps material properties same

Crack in deckplate of Ticonderoga Class cruiser. Crack is clear through 5 mm thick deck plate

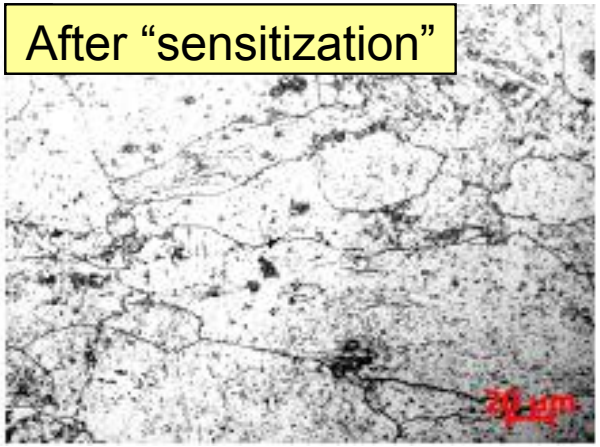


A series of metallographs of the same sample:

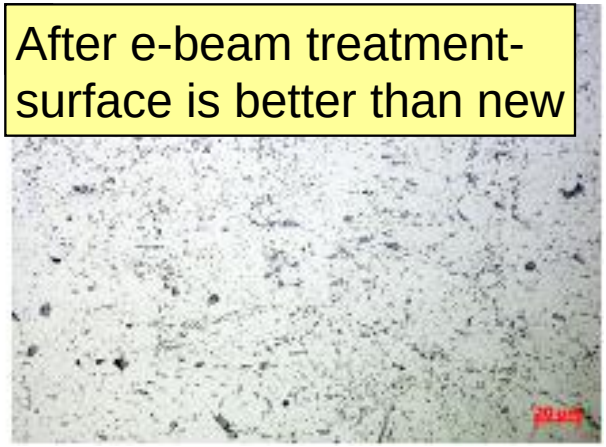
As received



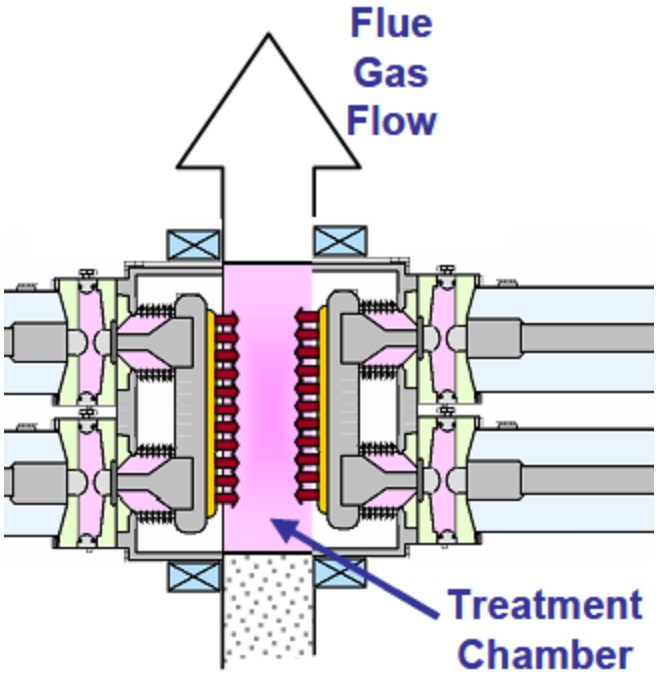
After "sensitization"



After e-beam treatment- surface is better than new



Coal-fired and KrF laser fusion power power plants have a need for pulsed electron beams.



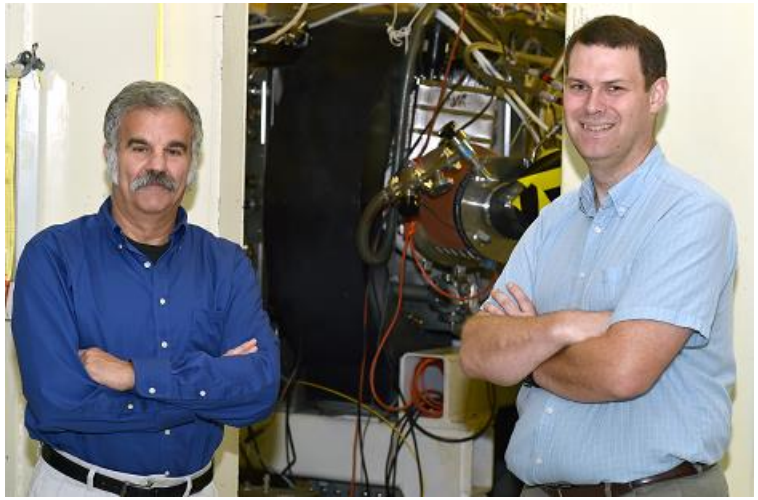
Electra experiments indicate shorter duration electron beams are more efficient at removing Nox from synthetic flue gas.

KrF electron beam technologies are being developed for fossil fuel pollution control

With Electron Beams, NRL to Clean Up NO_X Emissions from Coal Power Plant

11/17/2014 07:00 EST - 79-14r
Contact: Kyra Wiens, (202) 767-2541

The U.S. Naval Research Laboratory (NRL) has partnered with a power company to apply its pulsed electron beam technology to reduce the nitric oxide and nitrogen dioxide (NO_X) emitted by coal power plants. "This is an opportunity for NRL to a get a technology that we developed here out in the real world," says Dr. John Sethian, the plasma physicist leading the project at NRL, "not only to show the technology works, but that NRL's contributing to cleaner energy."



NRL has a Cooperative Research and Development Agreement with Zerronox Corporation to pursue solutions for reducing NO_x from coal-fired power plants and other combustion-based energy sources. Further developing the pulsed electron beam and implementing a working system is additionally supported by their parternship with a large power company.

See: http://www.nrl.navy.mil/media/news-releases/2014/with-electron-beams-nrl-to-clean-up-nox-emissions-from-coal-power-plant