Google: [Leonid Zakharov] $\longrightarrow$ http://w3.pppl.gov/~zakharov

Thermal regime of LLD

Leonid E. Zakharov

Princeton Plasma Physics Laboratory, MS-27 P.O. Box 451, Princeton NJ 08543-0451

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Litium retain Hydrogen in a limited window of tempertures

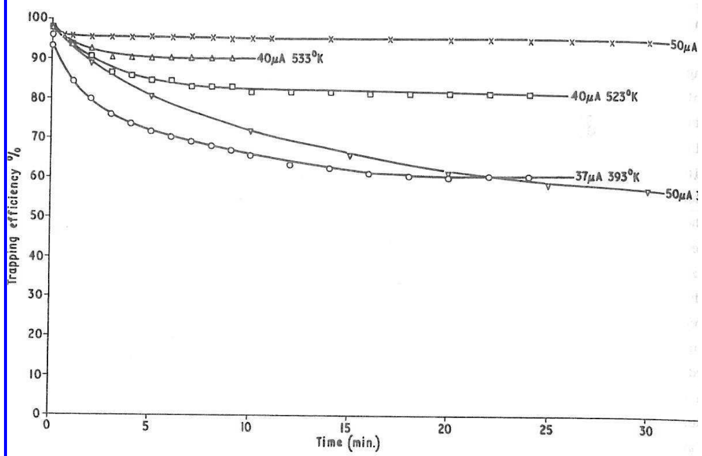


Fig.5 (a) Trapping of D^+ ions in lithium. Trapping efficiency as a function of dose at various temperatures.

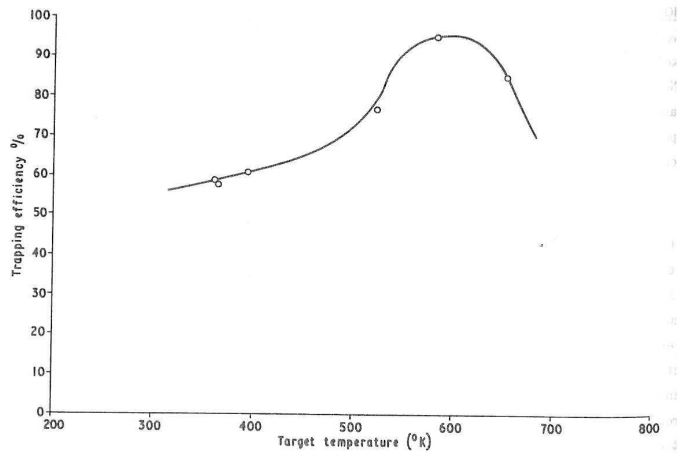


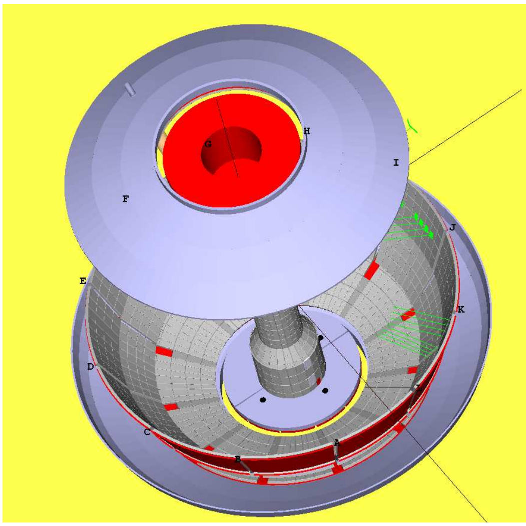
Fig.5 (b) Trapping of D^+ ions in lithium. Variation of trapping efficiency with temperature at a constant dose of 2×10^{17} ions/cm^2.

"Ion Burial in the divertor of a fusion reactor" *by G.M.McCracken (B.N.E.S. Nuclear Fusion Reactor Conference at Culham Laboratory, Sept. 1969) and S.K. Erents (Sept. 1969 Nucl.Fus. Reactor Conf., Culham, UK)*

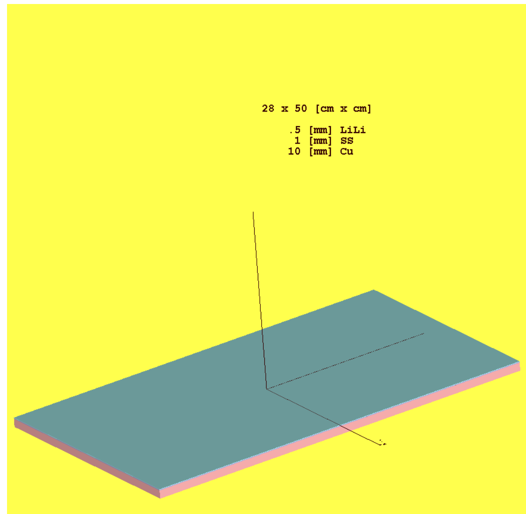
A remarkable property of lithium to pump hydrogen in a very limited range of temperatures was spelled out explicitly

Probably short lasting retention allows temperatures above 350^{o}C (R.Majeski)

Molten Li is necessary to provide 10000 active monolayers or $\simeq 3\mu k$ of Li. Li loaded plate is an interim step toward LLD



Li coated plate in low inner divertor



Li/SS/Cu (0.5mm/1mm/10mm) sandwich with a trenched surface

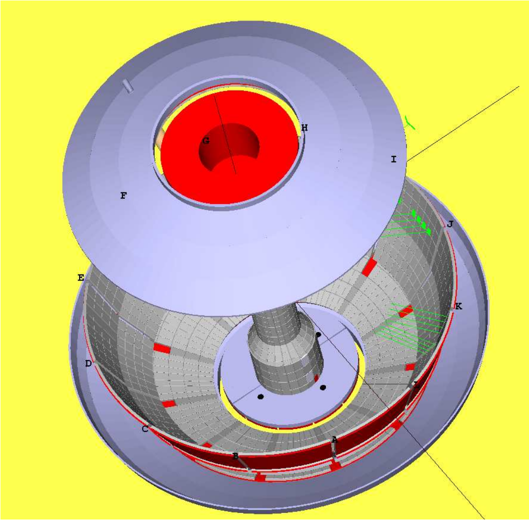
$$\begin{aligned} S &\simeq 0.75\ [\mathrm{m}^2], \\ L_{SOL} &= 2.5\ [\mathrm{m}], \\ V_{Li} &\simeq 0.35\ [\mathrm{L}], \\ M_{Li} &\simeq 175\ [\mathrm{g}] \end{aligned} \tag{1.1}$$

Velocity of the viscous motion of a thin Li film by electromagnetic forces

$$\begin{aligned} \nu_{Pa\cdot sec} &= 4.2\cdot 10^{-4}, \quad I_{ion,MA} = \frac{(0.4-1)\cdot 10^{-3}}{1.6}, \\ V_{Li,\|} &= (2-5)\cdot B_{tor}\frac{h^2_{Li,mm}}{0.01}\frac{0.1}{w_{SOL}}\frac{I_{SoL,MA}}{I_{ion,MA}}\frac{cm}{sec} \end{aligned} \tag{1.2}$$

Electromagnetic forces have small effect on thin films of Li

The design of LLD is restrained by low Li thermo-conductivity



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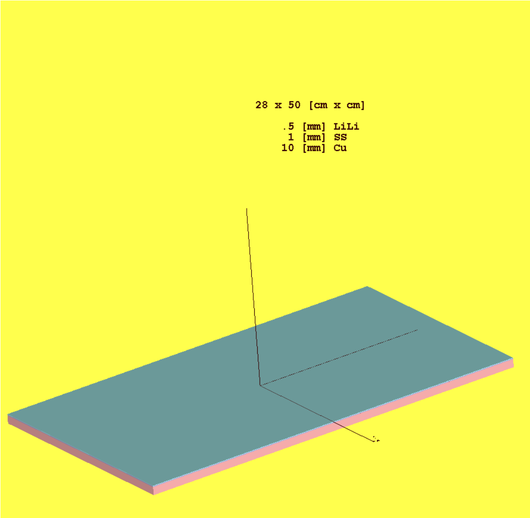

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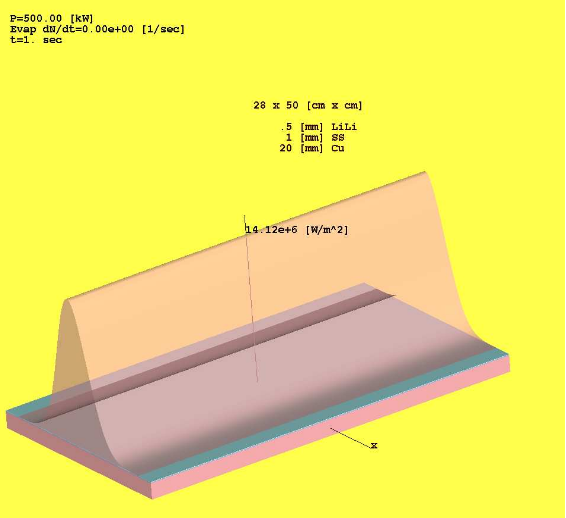
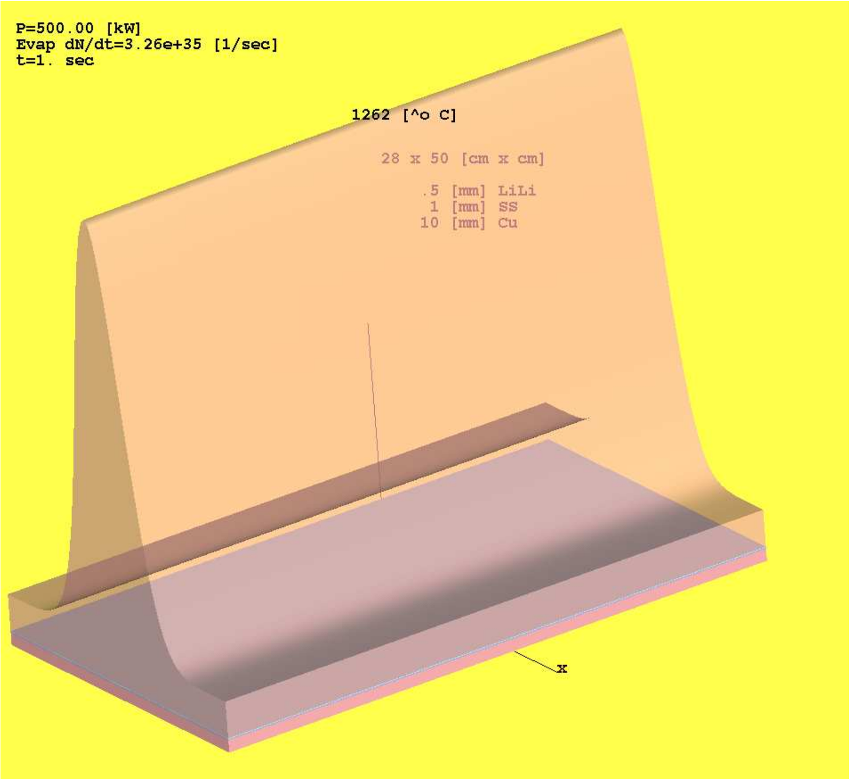


Gaussian (8 cm wide) heat deposition profile

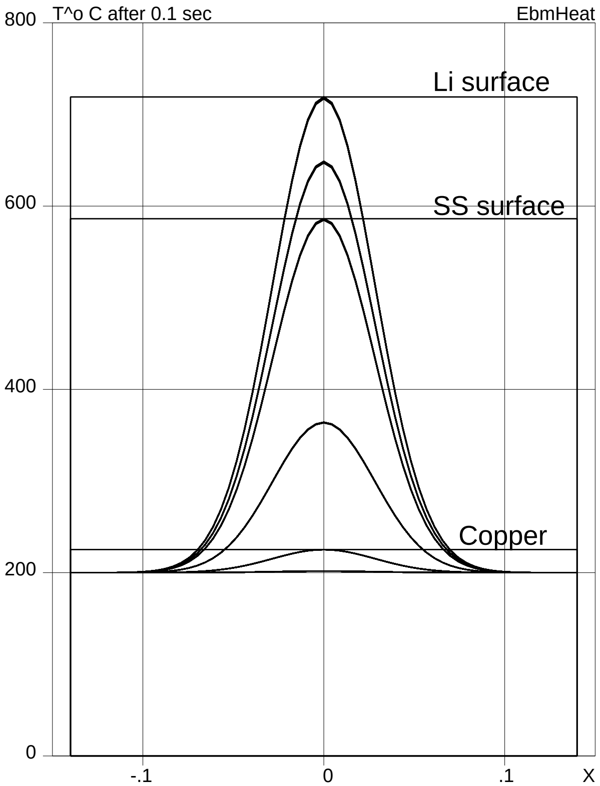
Thermal conductivity	$\frac{W}{m \cdot K}$	
Li Lithium	47.6	Lithium conducts $\simeq$ 5 MW/m^2
Cu Copper	379	at temperature drop 100^{o}C
W Tungsten	137	through 1 mm lithium layer.
SS Stainless Steel	20	ub-mm layers of Lithium are consistent
Mo Moly	126	with reactor requirements

Li-SS-Cu sandwitch is a ready to go material for NSTX Li divertor plate

Cbebm code was created to simulte the thermal regime in sandwich-like material, including liquid Li



Surface temperature profile after 0.1 sec

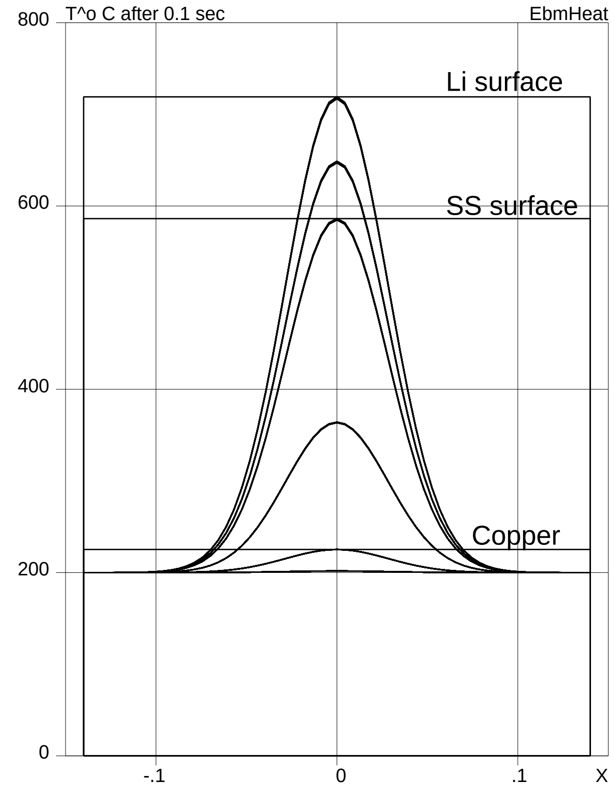


Temperature profile inside the plate

Three cases with 2.5, 1.25, 0.5 MW from the SOL to the plate are presented

SS layer limits the heat transport into the plate body

Plate can have different thermal inertia regimes



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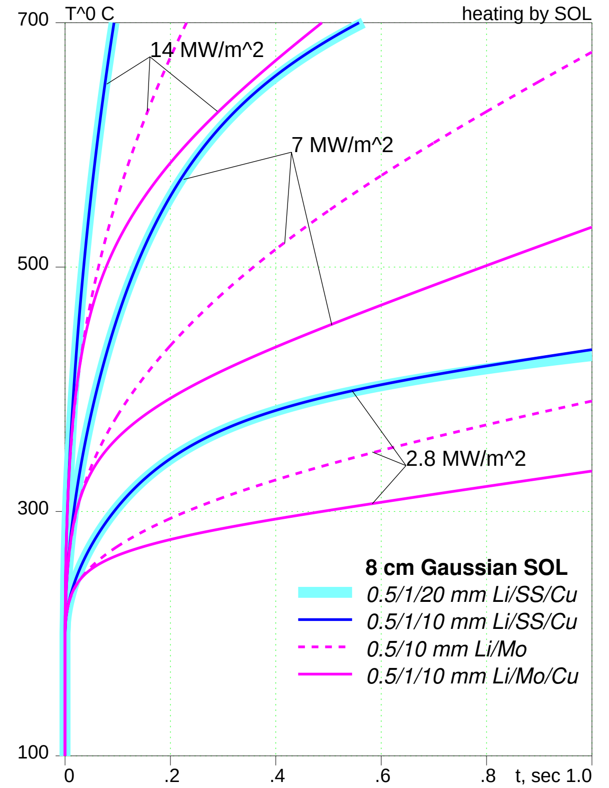

Waveforms of the surface temperature

Li, SS, Cu, Mo cases with 2.5, 1.25, 0.5 MW from the SOL to the plate

Power deposition from the plasma controls the Li surface temperature

Lithium loaded plate in NSTX can provide crucial data on thermal regime for LLD

Co-planar motion is restricted by viscosity and Harman forces

Thickness of the Hartmann layer

$$\sigma = 3.3 \cdot 10^6, \quad \nu = 4.2 \cdot 10^{-4}, \quad \delta^2 = \frac{\nu}{\sigma B_z^2} = \frac{1.3 \cdot 10^{-10}}{B_z^2},$$
$$B_H \equiv \frac{1}{h}\sqrt{\frac{\nu}{\sigma}} = \frac{1.13 \cdot 10^{-2}}{h_{Li,mm}}. \tag{2.1}$$

The stationary lithium velocity is given by

$$v = \begin{cases} \dfrac{I_\parallel B_\perp h}{2 L_{SoL} \nu} = \dfrac{v_E}{2}\dfrac{B_\perp}{B_H}, & B_\perp < B_H \quad \text{viscous flow} \\ \dfrac{I_\parallel}{L_{SoL} h \sigma B_z} = v_E \dfrac{B_H}{B_\perp}, & B_\perp > B_H \quad \text{Hartman flow} \end{cases}, \tag{2.2}$$
$$v_E \left[\frac{\mathrm{cm}}{\mathrm{sec}}\right] \equiv \frac{I_\parallel}{L_{SoL}\sqrt{\nu\sigma}} = 2.7 \frac{I_{\parallel,A}}{L_{SoL,m}} \left[\frac{\mathrm{A}}{\mathrm{m}}\right].$$

Lithium loaded plate will specify the Li flow regime