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Three tier blistering tolerant neutron target for iBNCT by using 80kW proton linac.

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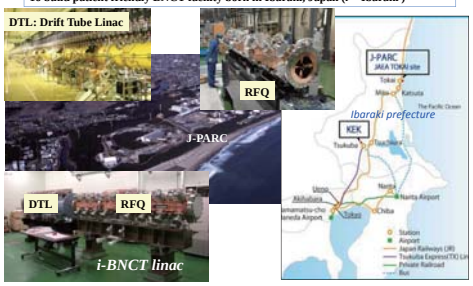
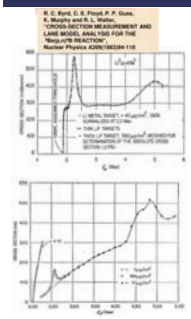
& iBNCT Target R&D group (MTC, NGK, MHI)

Outline of i-BNCT

Spin off of J-PARC frontend injector linac technology, RF design based on J-PARC
To build patient friendly BNCT facility born in Ibaraki, Japan (*i* = Ibaraki)



Why beryllium is the only solution?



In case of *Li*, the cross section is very attractive,
- ◆ Sharp rise below 2.5MeV
- ◆ Neutron energy spectrum is fine (< 300keV)

Serious demerits: Production of radioactive elements
- ◆ $^{7}Li(p,n)^{7}Be$ → ^{7}Be is radioactive (53 days)
- ◆ Tritium production → $^{6}Li(n,t)^{4}He$

Further serious demerits: chemical problems
- ◆ Melting temperature is only 180 ℃
  - ➢ No way of water cooling
- ◆ Very active and hydrogen gas production with H_2O

Lithium target is too dangerous for the hospital use.

Heat issue

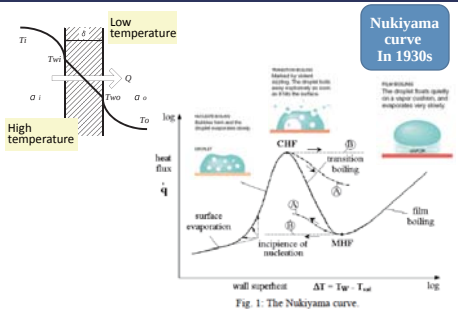
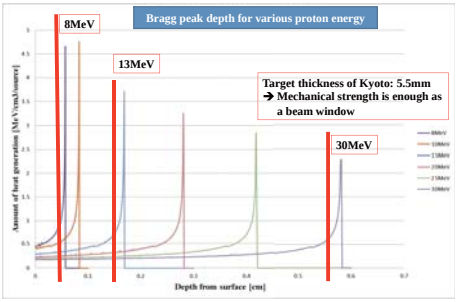


Fig. 1: The Nukiyama curve.

Target thickness of i-BNCT : 0.5mm not enough mechanical strength as a beam window



Candidate of Target related materials

Experimental Studies of Blistering of Targets Irradiated by Intense 200 keV Proton Beam[1]

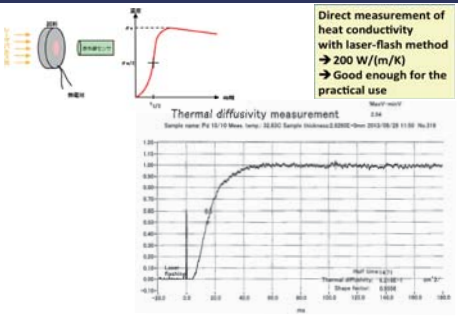
Element	Yield point, 10^{7} Pa	Diffusion activation energy E_D, eV	Dissolution energy E_S, eV	Blistering threshold, 10^{16} cm^{-2}
Cu	20–50	0.4	0.37	0.4–0.1
W	50–90	0.39	1.03	2–4
Fe	12–15	0.05	0.27	80–150
Pd	20	0.23	~0.11	200–300
V	31	0.045	~0.34	not observed up to 120
Ta	57	0.14	~0.35	not observed up to 230

Direct measurement of heat conductivity with laser-flash method
➔200 W/(m/K)
➔Good enough for the practical use

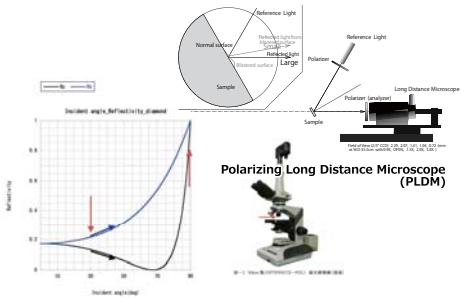
Blistering mitigation metal

Yes, we can overcome blistering problem and high heat density!!!

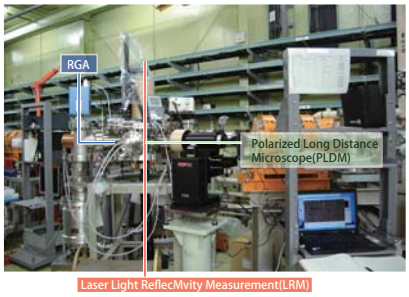
Laser flashing



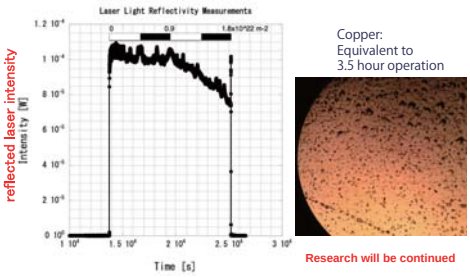
Surface observation with PLDM
— Incident angle dependency of reflectivity of s, p polarized light —



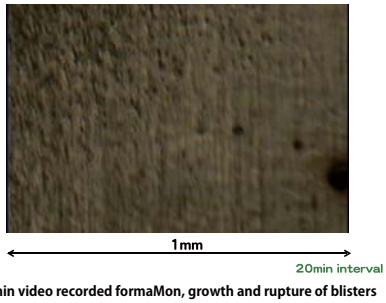
In situ observation of blistering



Blistering observation using reflection laser light

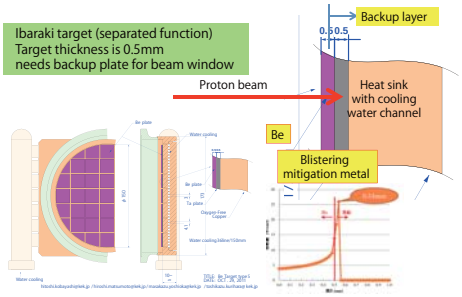


Direct observation of proton induced blistering using light-polarization and -reflectivity



180min video recorded formaMon, growth and rupture of blisters

Design of the blistering tolerant neutron target

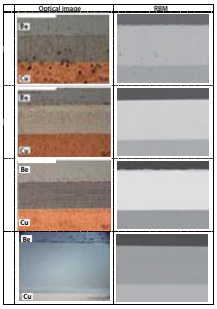


White powder on Be Target Sample

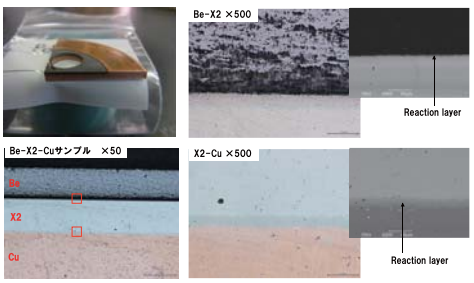
Sample in transparent case 2013.5.30
Something powder like was found.
Be powder is extremely dangerous.

As fabricated 2012.11.4
No powder was found.

Cross sectional observation of candidate materials



Cross sectional observation of diffusion bonded layers



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