Nermeen

88

①

8/8

1- helium coolant
2- fuel flexibility
3- Thermal / fast options
4- High temperature
5- high temperature outlet coolant which can be used in edothermal chemical reactions

②

13/14

① fuel kernel → has fuel UO_2 or UCo

② Buffer → it pourous to help in sustain the pressure coming from the fission gases. -also swelling of kernel

③ IPyC → inner pyrolitic carbon layer it's used to protect the sic layer from its outer side to keep the fission products away from the sic to prevent its corrosion for an example. -stresses also

④ SIC → Silicon Carbide layer

- it's mainly to withstand the pressure build up from Co formation after irradiation + fission gas products
- with stand the irradiation stresses and high temperature thermal creeks
-

⑤ OPyC → outer pyrolitic carbon layer it protects the outer side of SiC layer to prevent any fission products release to the core. -SiC is primary FP barrier

8/10

③_ oxide fuel kernels like UO_2 cause formation of CO which cause a problem of overpressurization in Triso particle

— also oxide fuel kernels have a problem of fission products attacks like Pd, CS and Ag.

• UO_2 retains fission products more effectively than UC_2

— Carbide fuel kernels prevent CO formations as UCO has less oxygen so the oxygen coming from UO_2 oxide rare earth fission products and the low oxygen affinity fission products turn into more dense carbides than CO.

— Carbide fuels solved the problem of CS release except for high temprature as cesium carbide becomes a source of CS vapour and graphite at high temperature.

— ~~but palladium attacks still exist in UCO fuel and fis~~

11/12

④_ At low temperature, black dots which intersitic atomic cluster forms and swelling starts to happen due to immobile defects and differential stain of ~~solt~~ single interstitial and due to accmulation of strain till amorphization happens.

~~at lower te~~

$\uparrow$ in BSD regime, $\uparrow T$ leads to lower swelling due to recombination

— at higher temperature, swelling reaches saturation and this called point defects swelling regiem.

— At high temperature vacancy formation happens due to vacancy thermal diffusion after frank loops are turned to glissile dislocations so voids continue swelling after neutron irradiation and this is called void swelling regiem

[redacted]

7/10

(5) The thermal conductivity change with irradiction as silicon thermal conductivity with phonon interactions. Phonon - Phonon, Phonon - intestitial scatteing

At low temperture the defects formation due to irradiction compinsate the temperture dependence as defects phonon scatteing dominates.

compensate what?

and themal defects resistance ✓

$$1/k_{thd} = 1/k_{irr} - 1/k_{nonirr}$$

in that case the thermal defect resistance is ✓ a simulation of the mateial dose and defect type.

when the dose is higher the thermal conductivity show no saturation with swelling and thermal conductivity is more affected with the defect point swelling regiem than it's affected in the void swelling regiem.

depends on the temperature

The primary phonon scatteres

- phonon - phonon, defects - phonon, fission products - phono vacancy - phonon.

DSAs - defect clusters, are main defects that scatter phonons

[redacted]

(6) fission product, rare earth products can easily solute but other ~~ear~~ fission products not soluble so ~~got~~ they diffuse the grain boundaries and they may migrate out of the kernel layer and if they reach ~~they~~ the SiC layer it may under go corrosion.

8/10

- Kernel swelling also, wanted to see Pd corrosion of SiC specifically mentioned

(7) graphite under irradiation go under turnaround. ✓

turnaround is that graphite shrinks then it starts to swell. ✓

The reason behind that, the graphite can't handle or accommodate the defects so it starts swelling.

9/10

As known graphite is a high porosity material and when the defects forms, the expansion of the c direction ✓ is neglected because of the porosity and a direction has cracks due to fabrication thermal cracks so the graphite starts to shrink till the defects increases (voids and interstitial) ✓ so graphite swelling happens.

- yes, but kind of. interstitial causes c ↑, a ↓

vacancy causes a ↓

Mrozowski cracks

Scanned with CamScanner

(8)

8/8

(a) fission products attack ✓

(b) SiC layer thermal decomposition ✓

(c) kernel migration ✓

(d) mechanical interaction of triso layers when the gas gaps are closed ✓

(e) detaching between SiC and PyC layers. ✓

- I mentioned during the exam I wanted one sentence for each.

- Since not in text of question, I won't take points

8/8

(a) ZrC layer instead SiC layer ✓

as ZrC is stable ~~at~~ at 3000 K ✓

so ZrC show high stability at high temperature high operational temperature and normal operation and temperature spikes. ✓

ZrC showed it can stop Pd attacks but not Ru. ✓

⑩

4/6

1- fuel migration - not required, but is a specific failure mode

2- thermal conductivity degradation ✓

3- CO pressure ✓

4- detaching between SiC layer and PyC layer. ✓

- what is the data need?