22.012 Presentation:
Materials in ITER and beyond!

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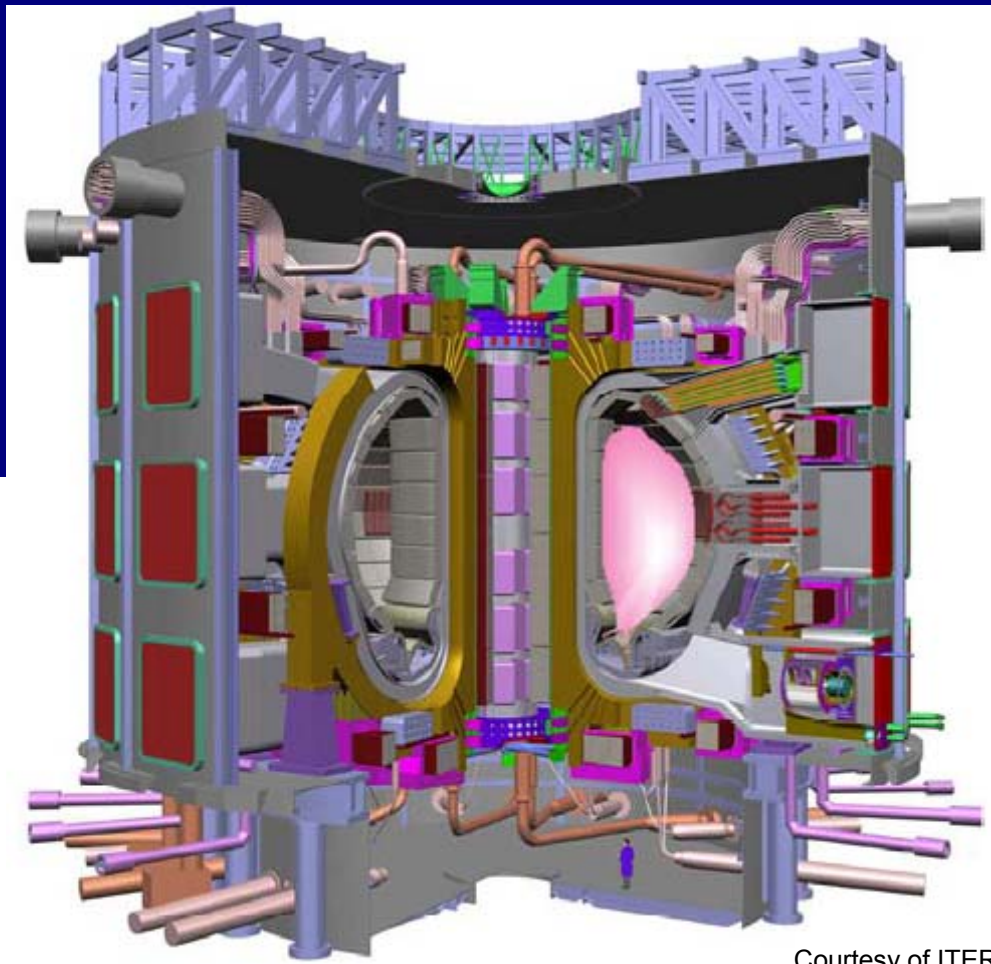

Courtesy of ITER.

Outline

- Vessel = materials for containing plasma
- Other random materials…
- Progress in Materials?
  - Going and going…

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Components and materials for ITER. From Max Planck Society for Advancement of Science

http://www.ipp.mpg.de/ippcms/eng/pr/forschung/iter/

Vessel Materials: containing the plasma[1,2]

- Must handle high heat loads
  - Steady and disruptions
- Radiation resistant
- Long-life (thousands of cycles)
- Cheap! (not going to happen)

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Source: START experiment at UKAEA, Culham.
http://www.fusion.org.uk/culham/start.htm

Vessel Materials in ITER[3]

Material	Material Grade	Components
Beryllium	S-65C VHP (backup DShG-200)	Armour tiles for first wall and limiter
Tungsten	Pure sintered W	Armour tiles for divertor components
Carbon fibre composite (CFC)	SEP NB 31, NIC 01 (back-up CX 2002U, SEP NS31)	Armour tiles for divertor vertical target
Cu and Cu alloys	CuCrZr-IG	Substrate for plasma-facing components (PFCs) and for heating systems
	CuAl25-IG	Substrate for PFCs (first wall)
	Nickel-aluminium bronze	Nuts, bearings and other friction parts
	Glidcop Al60	Compression collar of the flexible support bolts
Austenitic and precipitation hardened steels	316L(N)-IG1 plates and forgings	Shield modules
	316L(N)-IG2 plates and forgings	Vacuum vessel, blanket cooling manifolds
	316L(N)-IG3 cast	Some vacuum vessel components and back-up material for divertor body
	316L(N)-IG4 tubes	Thin walled tubes for first wall
	316L(N)-IG5 tubes	In-vessel cooling pipes
	316L(N)-IG6 powder HIP	Back-up material for shield modules
	AISI 660 (A-286)	Fastening components for the port plugs (e.g. fixing wedges and bolts)
	Steel 30467	Borated steel for in-wall shielding structures (plates)
Ni alloys	Inconel 718	Bolts for the flexible supports and electrical straps, blanket cooling manifold support
Ti alloy	Ti-6Al-4V	Flexible cartridges for the module support
Ferritic steel	SS 430	Ferromagnetic insert
Ceramic	Al_2O_3 or $MgAl_2O_4$	Electrical insulators of module attachment and limiter plates

Courtesy of ITER.

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Vessel Materials in ITER[5]:

- ITER First Wall:
  - Be- low Z
    - First used in JET
    - Disadv: Low melting point
- ITER Diverter:
  - Tungsten- low erosion
    - Disadv: high Z (causes power loss in the plasma)
  - CFC- can take very high heat
    - Erodes faster but can be thicker so lasts longer

Elevation view of ITER divertor.

Courtesy of Sandia National Laboratories.

Materials of the future[4]:

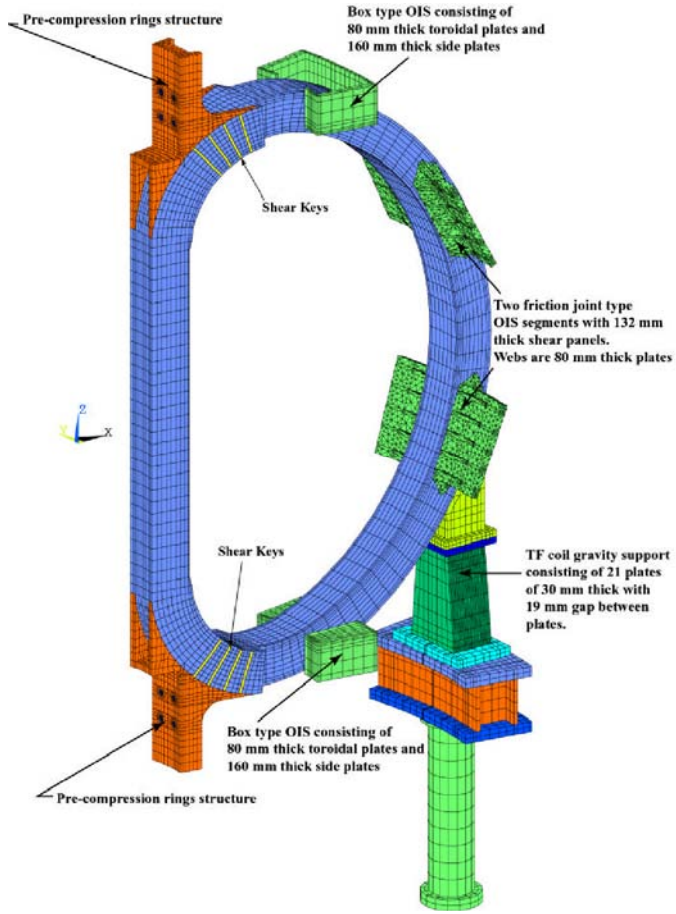
- EUROFER alloy:
  - elements have been substituted by more benign elements, e.g. Mo has been replaced by W; Nb by Ta and V.
  - Cr content: optimize corrosion resistance and low embrittlement under neutron irradiation.
  - expected to withstand neutron fluxes up to 150 dpa and an operational temperature range of 300°C to 560°C.
  - For DEMO (life after ITER)

A Blanket to Control the Warmth[7]

- to protect other materials from the radiation
- Cools other ITER components and collects heat
- To breed tritium fuel (in the second phase of ITER)
- Overall cannot exceed 5 tons
- Designed to last 10 years
- Must be easily removed remotely for maintenance

Magnets = Materials[6,3]

- Super large!
- Super high field!
  - ~13 T
- They're already super expensive!
- High Temp. Superconductors (HTS): T ~ 100K
- Niobium-Tin will most likely be used



ITER toroidal field magnet design

Courtesy of the U.S. Office of Fusion Energy Sciences.

Still more components made of materials

- Structural: to keep ITER from falling apart
- Testing instruments
- (not to mention that the plasma itself is a material)

In Conclusion…
Fusion Progress[2]

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See: graph on page 3 of Reference 2.

Materials Progress[4]

Graph figure removed for Copyright reasons.

http://www.iter.org

Bibliography

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Thank You!