Tungsten Behaviour at High Temperature and High Stress

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Tungsten Target for a Neutrino Factory

At the Neutrino Factory the target operates at very high mean power dissipation and extremely high energy density. This high power density creates severe problems in dissipating the heat and the short pulses produce thermal shocks due to the rapid expansion of the target material. These shocks can potentially exceed the mechanical strength of solid materials.

More than sufficient lifetime demonstrated:
- > 10 years for 2 cm diameter target
- > 20 years for 3 cm diameter target

This conclusion is (partly) based on simulation results.

Several targets which potentially can withstand the huge power density are currently being considered worldwide:
- Liquid metal jets
- Contained flowing liquid metal
- Solid target – tungsten bars
- Granular solid target

UK activity

Can we measure tungsten properties directly?
Can we benchmark simulation results?

Laser Doppler Vibrometer (LDV) for measuring the displacement and velocity of the surface of the wire during pulsing.

Experiment

Coaxial wires (current from power supply)
Test wire
Vacuum chamber
LDV

Radial and axial vibrations can be measured

Temperature monitoring and data taking

Optical pyrometer

Surface velocity
Characteristics frequency
Current pulse

Characteristic frequency of the wire vibration can be used to directly measure Young’s modulus of tungsten as a function of temperature.

Results

Thermal expansion of the wire as a function of applied current
Radial velocity of the wire as a function of temperature
Radial velocity of the tungsten wire under extreme conditions
Characteristic frequency of radial oscillations

Young’s modulus of tungsten

5 measurements with different wires

Nice agreement between experiment and simulations!
Young’s modulus of tungsten remains high at high temperature and high stress!