HPT SBIR Possible Topics
Hurh/Zwaska
Oct 8 2015

1) Glassy carbon beam window development or maybe call it carbon based beam window (needs air-side protection layer for oxidation and hermetic seal).

What beam power density handling is required for the beam windows? What are the required dimensions of the window? Should it tolerate more than +/- 1 bar of pressure difference?

Carbon based beam window development:

Particle production facilities (target facilities) require "beam windows" to isolate the particle beam vacuum from the target facility atmosphere (usually air). Expected increases in beam power and intensity requires advancing beam window solutions, such as the use of carbon-based materials. Beam windows using carbon materials (such as glassy carbon) must withstand the interaction with the high power beam (1 to 4 MW; at a Gaussian beam profile sigma radius down to ~1.5 mm; 10 microsec pulses; ~1 Hz), the pressure differential (2 to 4 bar), and erosion caused by oxidation at elevated temperatures on the air-side of the window. Interaction with the beam has the potential to create thermal shock, radiation damage, and high temperatures. Cooling of the beam windows is considered critical to this development. Applications for the use of such beam windows require solutions for beam apertures ranging from 2 cm to 10 cm in diameter.

2) Remote and re-useable high current electrical connection (e.g. for strip line connection).

What currents, voltages, frequencies, and average powers must the "remote and re-usable high current electrical connections" be able to withstand?

3) Radiation resistant strain instrumentation (possibly using ultrasound wave guides).

What radiation dose must the "radiation resistant strain instrumentation" components withstand? What strain range must they measure?

Radiation resistant strain/vibration instrumentation development

Monitoring the health of a target component in situ requires strain

instrumentation that can withstand the high radiation environment in the vicinity of the high power target. The accumulated dose of a future target component during its lifetime may exceed 10 Giga-Gray. Instrumentation that can function near to this limit is needed that can resolve strains as low as 100 nano-strain and as high as 10 milli-strain (non-concurrently). Sampling frequency is potentially as high as 4 MHz in order to capture the dynamic response of a high intensity beam pulse (1 to 10 microsec). Exploration of the potential use of radiation hardened ultrasonic transducers and/or waveguides is encouraged.

4) Radiation shielding foam (crack filler and waste container packing filler).

What are the required properties of the radiation shielding foam?

5) Development of MAX phase materials as radiation and thermal shock tolerant beam window, absorber, collimator, and/or target material. {MAX Phases are layered, hexagonal carbides and nitrides having the general formula: M_n+1 AX_n , (MAX) where n = 1 to 3, M is an early transition metal, A is an A-group (mostly IIIA and IVA, or groups 13 and 14) element and X is either carbon and/or nitrogen.}

(same questions as (1) above) In addition: what peak stresses must the window endure during the thermal shock? For how many cycles?

MAX phase material development for high power targetry

Particle production facilities (target facilities) require thermal shock and radiation tolerant materials for use as beam windows, targets, collimators, and/or absorbers. Expected increases in beam power and intensity requires advancing material solutions, such as the evaluating the use of MAX phase materials. MAX Phases are layered, hexagonal carbides and nitrides having the general formula: M_n+1 AX_n , (MAX) where n = 1 to 3, M is an early transition metal, A is an A-group (mostly IIIA and IVA, or groups 13 and 14) element and X is either carbon and/or nitrogen. Previous work has indicated that the MAX phase Ti_3SiC_2 is potentially tolerant to radiation damage effects [1]. Targetry components must withstand the interaction with the high power beam (1 to 4 MW; at a Gaussian beam profile sigma radius down to ~1.5 mm; 10 microsec pulses; ~1 Hz). Interaction with the beam has the potential to create thermal shock, radiation damage, and high temperatures. Cooling of the material is considered critical to this development. Applications for the use of such targetry components require solutions for beam apertures ranging from 2 cm to 10 cm in diameter and effective thicknesses of 1 mm up to 1 m.

[1] **Effect of Neutron Irradiation on Select MAX Phases**, D.J. Tallman, E.N.

Hoffman, E.N. Caspi, B.L. Garcia-Diaz, G. Kohse, R.L. Sindelar, M.W. Barsoum, *Acta Materialia,* **85**, 132-143 (2015)

6) Thermo-mechanical finite element methods to simulate thermal shock response across large spatial dose gradients (spatially dependent material property gradients).

How does Ansys fail to meet this requirement?

7) Develop robust, high strain rate, high temperature strength and damage models for use in explicit Failure Effects Analysis (FEA) for candidate targetry materials such as beryllium, graphite, and tungsten.

(same questions as (6) above)

8) Metal joining techniques for light metals and alloys relevant to targets. For example, titanium to beryllium, beryllium to aluminum, aluminum to titanium.

What are the required properties for the joints? (e.g. tensile strength, thermal conductivity, density, porosity (e.g. vacuum-tight), etc.

9) Radiation instrumentation resistant to extremely high radiation fluxes. Also other instrumentation such as temperature, pressure, flow rate, imaging.

same question as (3) above)

10) Passivation coatings for graphite and metals to avoid oxidation, corrosion, or erosion (from high-flow rate coolants like water).

What the required physical and chemical properties of the coatings?