Preliminary design of tungsten wire calorimeter for CRAFT NNBI

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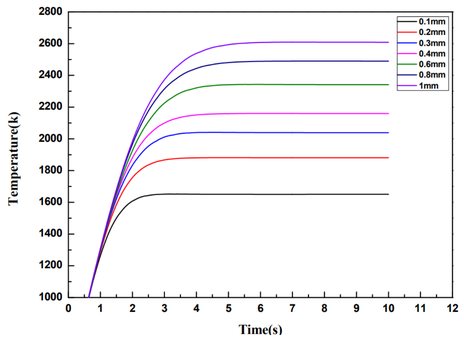
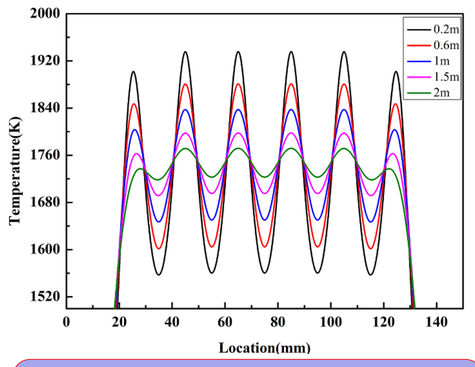
- The tungsten wire calorimeter with double-layer tungsten wire is placed in the beam channel. When the beam bombards, the tungsten wire will emit bright visible light. The visible light CCD camera installed in the observation window is used to photograph the tungsten wire calorimeter. The beam profile can be obtained by digitizing the light intensity distribution map, which can direct the conditioning of ion source
- In order to determine the design of tungsten calorimeter, a set of simulation is carried out. the wire diameter and installation position of tungsten wire calorimeter is determined and the relationship between the spatial resolution and beam divergence ,beam energy is also researched.
- On the NNBI test platform, the tungsten wire calorimeter is tested experimentally, and the luminescent images of the tungsten wire calorimeter is obtained as bombardment by a beam with the 15-40keV beam energy

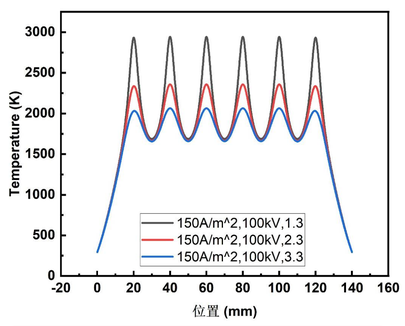
FEM simulation



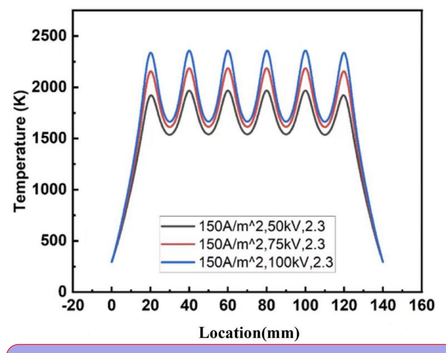
Comparison of thermal balance time of tungsten wire with different diameters (150A/m^2 ,100keV,7mrad)



Temperature at different distances between tungsten wire and GG (150A/m^2 ,100keV,7mrad)



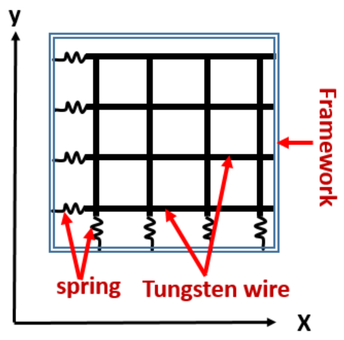
Temperature comparison of tungsten wire at 150A/m^2 and 100keV with different beam divergence angles



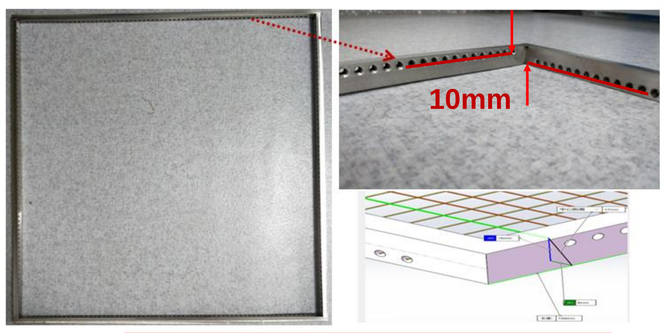
Temperature distribution of tungsten wire under different beam energies

Through simulation, the tungsten wire selection type of tungsten wire calorimeter is determined, and the effects of beam parameters (beam power density, beam divergence) on the spatial resolution of tungsten wire calorimeter is obtained. It lays the foundation for the design and installation of tungsten wire.

Design of tungsten wire calorimeter



Fixing mode of tungsten wire



Frame design of double-layer parallel network

The tungsten wire calorimeter adopts a double-layer mesh structure to meet the requirements of beam measurement in horizontal (X) and vertical (Y) directions. The two-layer mesh of X and Y do not intersect each other and the distance is 10mm

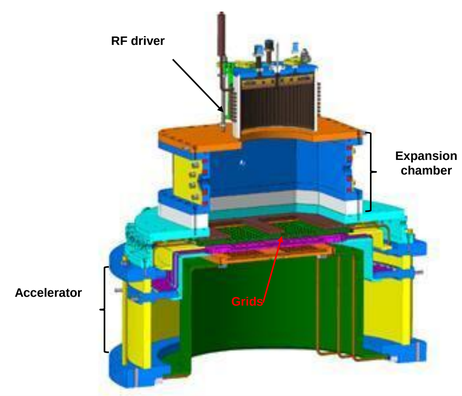
Tungsten wire and spring stress testing

Tensile stress-strain curve of 0.2mm tungsten wire at room temperature

Force-displacement curve of Inconel 750 alloy spring

- According to the calculation, when the tungsten wire reaches 2000 ℃ , the maximum tension of 0.2mm tungsten wire should not exceed 6.28N.
- After comprehensive consideration, the high temperature resistant material is selected as the base material of the spring, and the internal stress of the spring is removed by stress annealing process. This project intends to choose 0.6mm Inconel 750 high temperature resistant alloy wire as spring base material.

¼ Size high-power RF ion source test platform

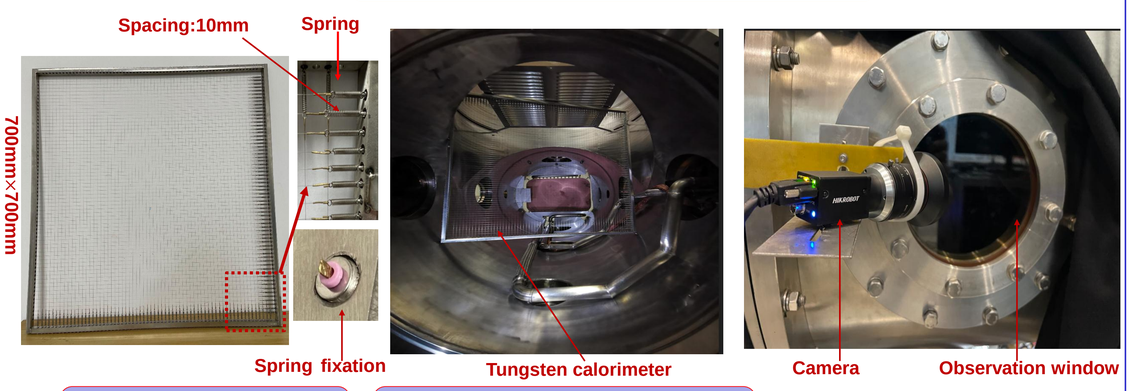


¼ Size *high-power RF ion source test platform*

Parameter	Value
RF Power(kW)	5-100
RF Frequency(MHz)	1
Antenna Radius(mm)	6.2
Coil turns	6
Gas	H_2
Pressure（Pa）	0.3-2
RF driver Height(cm)	13.4
RF driver Diameter(cm)	24
Bucket chamber(cm)	45(L)×45(W)×19(H)
Diagnostic flange(cm)	85(Diameter)×9.8(H)

The main parameters of the RF negative ion source

Installation of tungsten calorimeter

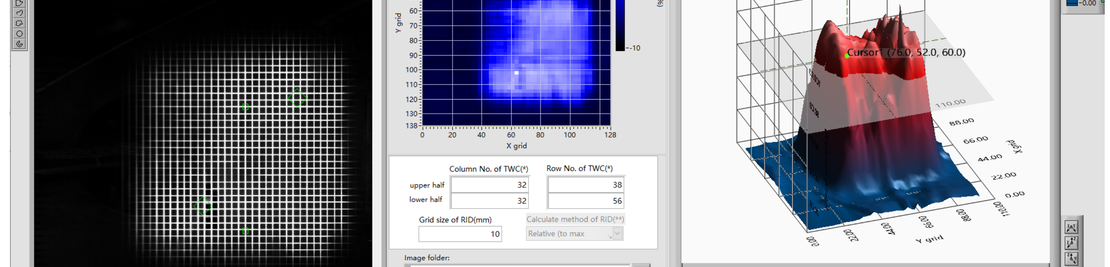


Tungsten filament calorimeter

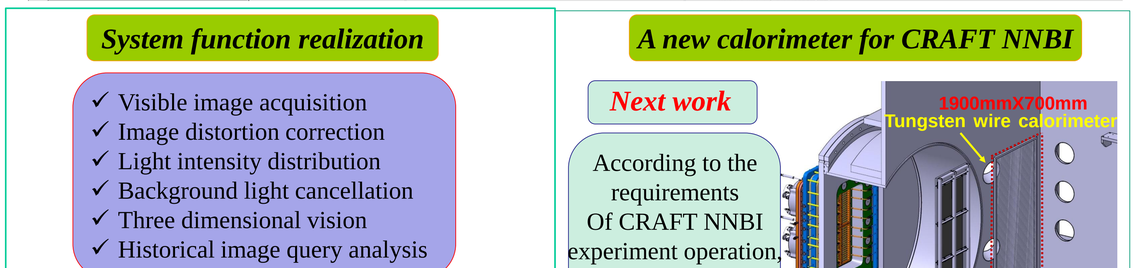
Tungsten filament calorimeter installation

Visual system

Preliminary experimental results



The light intensity of tungsten wire varies with time during beam bombardment (Beam energy 38keV; beam current 0.57A, exposure time is 1200 μm, and aperture is f/5.5)



The light intensity distribution of tungsten wire under different beam energies (Beam current is about 0.5A; exposure time is 1200 μm, sampling rate is 1 F/s, and aperture is f/5.5

Image processing and analysis

System function realization

- ✓ Visible image acquisition
- ✓ Image distortion correction
- ✓ Light intensity distribution
- ✓ Background light cancellation
- ✓ Three dimensional vision
- ✓ Historical image query analysis

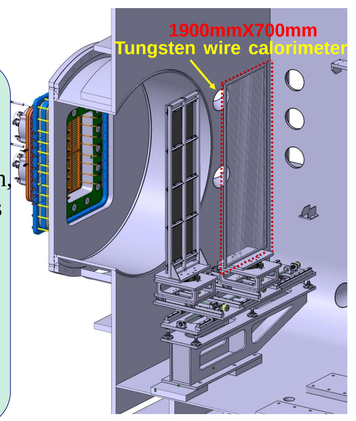
Conclusion

The optimum wire diameter, working time and spatial resolution of tungsten wire under beam bombardment with different parameter are simulated and analyzed. The tungsten calorimeter experiment was carried out on the ¼ size RF source test platform, and the real-time image acquisition, analysis and processing were realized. On this basis, the design and processing of 1900mm×700mm tungsten calorimeter suitable for CRAFT NNBI is completed, which provides technical means for CRAFT NNBI source training.

A new calorimeter for CRAFT NNBI

Next work

According to the requirements Of CRAFT NNBI experiment operation, the image diagnosis system of 1900mm×700mm tungsten wire calorimeter will be completed and optimized.



Acknowledgement

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