Development of a linear electron accelerator-based neutron source for analysis of structural materials

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Introduction

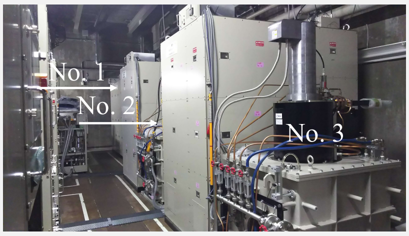
Neutrons are a powerful probe of structural materials due to their high penetration. As part of the Innovative Structural Materials R&D project funded by the New Energy and Industrial Technology Development Organization (NEDO), the Innovative Structural Materials Association (ISMA)[1] is developing a dedicated, compact electron-accelerator based neutron source at the National Institute of Advanced Industrial Science and Technology (AIST) in Tsukuba, Japan, for the characterization of structural materials.

The accelerator is designed to have a maximum electron beam power of ~10 kW (~36 MeV and ~275 mA), which will be incident on a water-cooled Ta target. The electron beam will have a maximum pulse length of around 10 µs at a repetition rate of 100 Hz. Neutrons produced through photo-nuclear reactions will be cooled by a decoupled solid methane moderator. Using this pulsed, low-energy neutron beam we plan to perform various imaging spectroscopies of structural materials including Bragg-edge imaging.

Outline of the Neutron Source

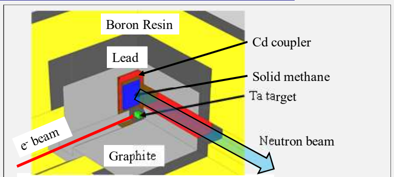
Klystron

Pulse width: 10 µs (max)
Rep. Rate: 100 Hz (max)
RF Power: 7 MW (max)

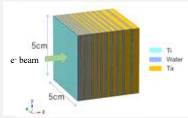


Klystron and power supply unit (x3)

Neutron Production Target

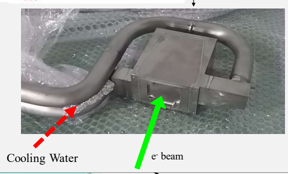


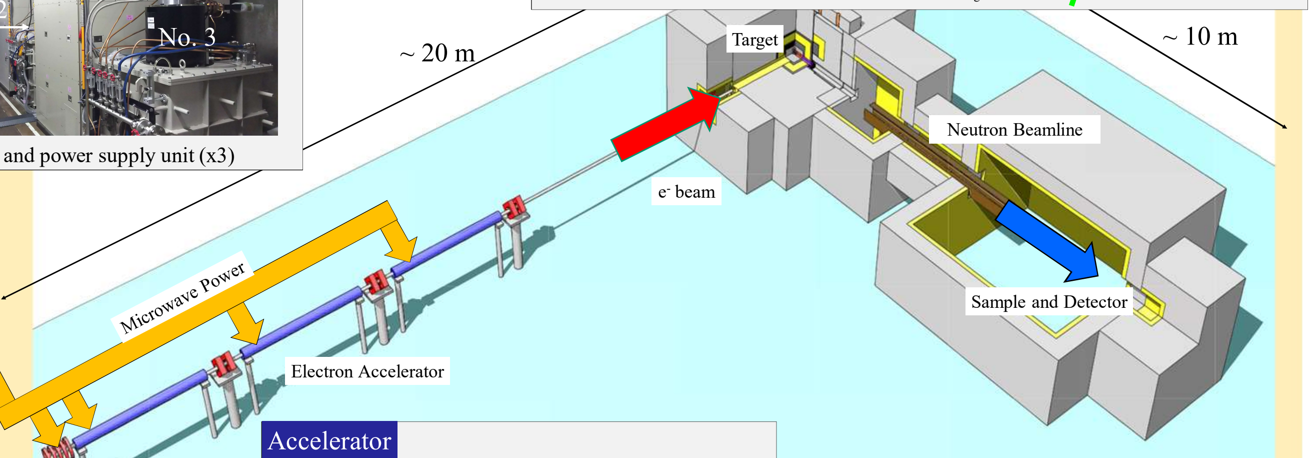
Cross Section of Neutron Target



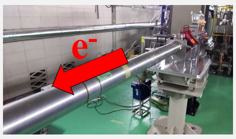
Target Model

Constructed Target



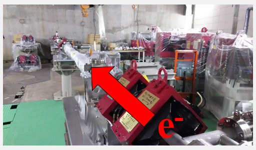


Accelerator



RF freq. : 2.856 GHz
Est. Energy : ~35 MeV (Max)
Beam Current : ~275 mA (Max)

Pulse Width : 10 µs (Max)
Rep. Rate : 100 Hz (Max)
Beam Power : ~10 kW (Max)



Accelerator Beamline

Electron Gun

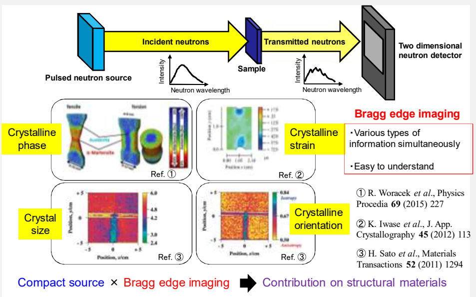
Acc. Energy :
- 3 MeV

RF Input Power :
- 1.4 MW

Beam Power :
- 750 W (Max)

Installed e- gun

Bragg Edge Imaging



Overview

We have optimized the design for Bragg edge imaging

- High power electron beam (Max ~10 kW)
- High rep. rate (100 Hz) and short pulse (<10 µs)
- High neutron energy resolution (decoupled solid methane moderator)
- Compact neutron beamline (length: 8 m)

Industrial Use

- By measuring the intensity of neutrons transmitted through a sample as a function of neutron wavelength (energy) using a large 2-dimensional detector, we can characterize the crystalline phase and strain, crystal size and orientation etc. in a single measurement.
- We plan to apply this technique to various structural materials in order to help with the development of new, lightweight materials for transport vehicles.
- In collaboration with materials manufactures and researchers, we plan to provide a dedicated, user friendly, neutron source for materials analysis.

Reference: [1] http://isma.jp/en/index.html

This paper is based on results obtained from Innovative Structural Materials R&D Project commissioned by the New Energy and Industrial Technology Development Organization(NEDO).