Feasibility Study of Visual and Measurement Technology for Innovative Approach ＜Fujikura Ltd.＞

Objective

FUJIKURA is one of the largest optical fiber and cable manufacturer in the world.
For more than three decades Fujikura has been developing and providing high radiation resistant optical fiber products for a variety of nuclear facilities in the world.
We believe our Radiation Resistant Optical Fiber Technology will contribute direct observation solution for Fuel Debris Retrieval process.
Our target is to achieve high radiation resistant fiber scope observation system for fuel debris retrieval process application. This is required to withstand more than 2MGy radiation.
We also conduct the conceptual study of the array fiber type scanning imaging system aiming for higher resolution, flexibility and long cable than image fiber scope.

Outline

We conduct Three themes of feasibility study of essential technologies aiming for the realization of visual technology under high radiation.

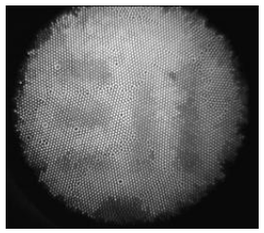
A: Near-Infrared fiber scope observation system for high radiation resistance
B: Fluorine-doped silica core image fiber scope development for high radiation resistant visible observation
C: Fiber array scanning imaging system development for high resolution and flexible observation system・
From our basic study, silica glass image fiber has lower induced loss under radiation at Near IR wavelength. Because of this characteristics, it can expect more than 2MGray durability by using NIR observation system. In addition, our Fluorine-doped silica core single-mode fiber performs highly radiation resistant transmission. Theme B is to apply this technology into the multi-core image fiber. It can expect to get visible color image under high radiation.

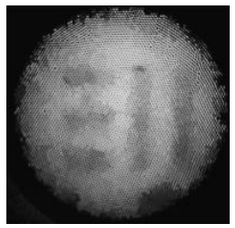
Results of study

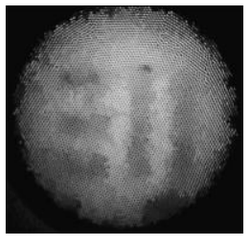
We conducted gamma ray irradiation test for silica glass image fibers to evaluate its durability up to 2MGy. We evaluated transmit image quality and characteristics of two types of image fiber samples under radiation.

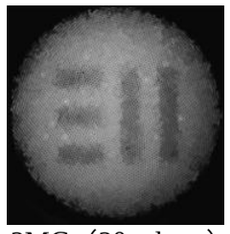
1. Image fiber prototype for radiation test
We completed image fiber design for both high OH content core type and fluorine-doped core type for the radiation test. Image fiber length requires total of 100m, 20m for radiation test and 30m x2 for laid down in the test facility. It needs to coil sample fibers at 100mm radius to get 10kGy/hr dose rate. Pixel number of this image fiber is 6,000 due to get 100m long sample and coil at small diameter. We manufactured both high OH content silica core image fiber for Near IR observation and Fluorine doped silica core image fiber for visible observation.
2. Gamma ray irradiation test (Examination period: 4/13/2015~4/23/2015)
Dose rate: 10kGy/hr, Accumulative dose: 2MGy (200hr), Radiation test fiber area: 20m long
Test fiber: High OH content silica core fiber for Near IR, Fluorine-doped silica core fiber for visible
We evaluated image quality and transmission characteristics during gamma ray irradiation for both sample fibers.
3. Irradiation test result

1）Near IR observation (High OH content silica glass core fiber)
There is no practical difference between initial and 2MGy post-radiation image in around 800nm~1000nm range observation.


Initial

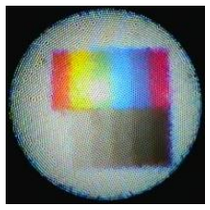

1MGy


2MGy

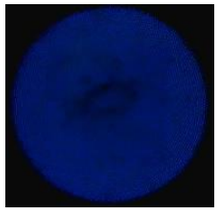

2MGy（20m long）

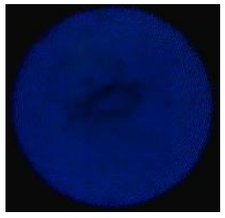
At long wavelength area , transmission image becomes blur due to light leakage from the pixel in 100m long fiber. It can get a better image in shorter length. (see picture of 20m long fiber) It is possible to make wavelength optimized image fiber for Near IR observation.

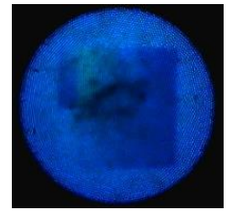
2）Visible observation (Fluorine doped silica core fiber)
It was shown image deterioration at visible observation in a short time. Image becomes darken especially at blue and red area due to absorption defects in glass fiber. Fluorine dopant has not enough efficiency for visual observation.


Initial


10KGy

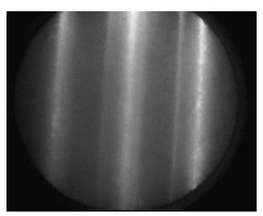

1MGy

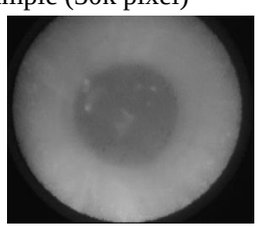

2MGy


2MGy (High Illuminance)

4. Summary
Near IR observation method with standard radiation resistant image fiber performs excellent durability after 2MGy irradiation. This system has the potential of observing metal structure like pipes or pipe inner surface.
Sample pictures are shown in right.

Near IR image sample (30k pixel)


SST pipe（3pcs）


SST pipe inner surface

Future subject

We conduct study for achieving the practical use of visualization technologies both Visible and Near IR observation system.

1) Fiber design optimization for Near IR image transmission
Need to optimize fiber design for Near IR to maintain good contrast for long length transmission.
Need to examine maximum pixel number and length capability for actual use conditions.
2) High radiation resistant fiber development for visible observation
Need to examine fluorine dopant optimization and other effective dopant materials for improving radiation hardness.
3) Fiber scope design and development for on-site installation
Need to design and develop fiber scope for actual site environment and access method. It is necessary for us to work with an engineering firm specializing in the construction method. Fiber scope will be custom designed for construction equipment as a visualization tool.