THE UNIVERSITY OF TOKYO

AIST
NATIONAL INSTITUTE OF
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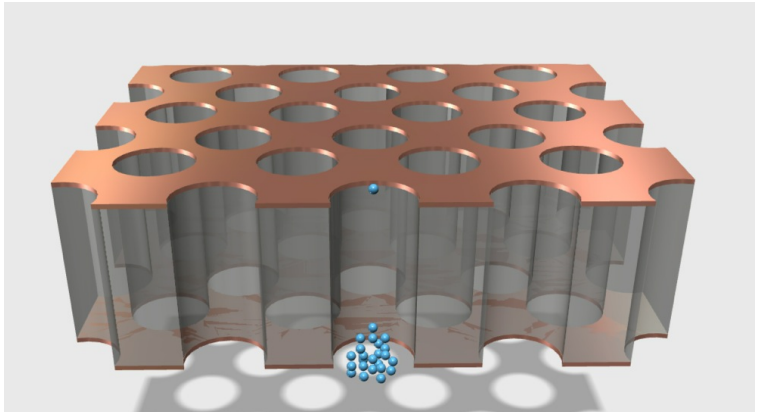
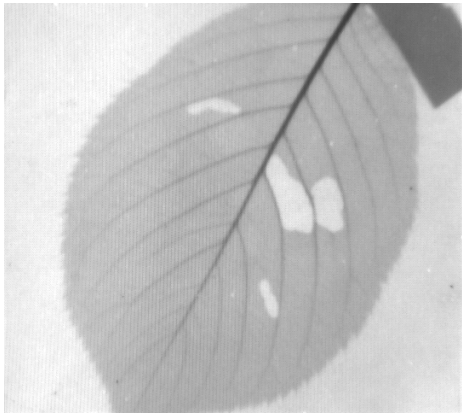
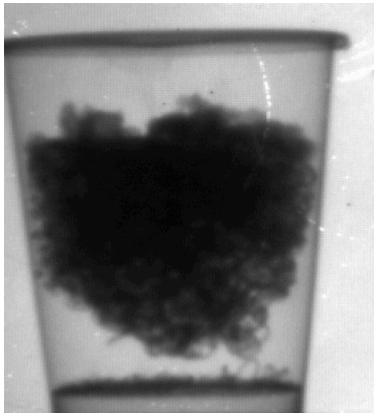
AND TECHNOLOGY (AIST)







Development and application of Scintillating Glass-GEM detector

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Summary of this work

1. Using "Glass GEM" instead of "GEM"

GEM
(Polymyde)

→

Glass GEM
(Glass)

2. Using the scintillation gas

Pr gas
(Ar/CH_4, Ar/CO_2)

→

Scintillation gas
(Ar/CF_4)

3. Changing the readout method

Charge
Counting circuit

→

Scintillation light
Optical camera

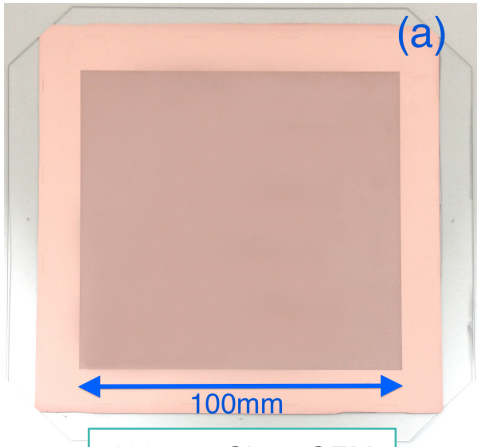
4. Develop a new imaging device

Conventional
FPD, CCD, X-ray I.I.

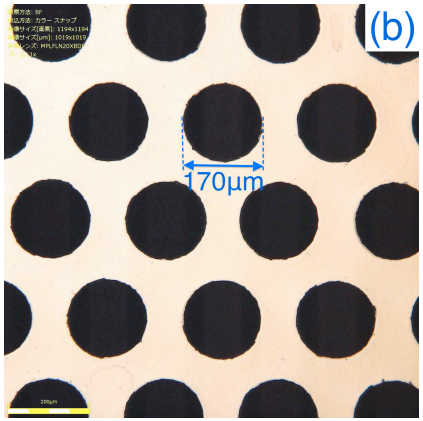
↓

New digital imaging device based on gaseous detector
"Scintillating Glass GEM"

The Glass GEM



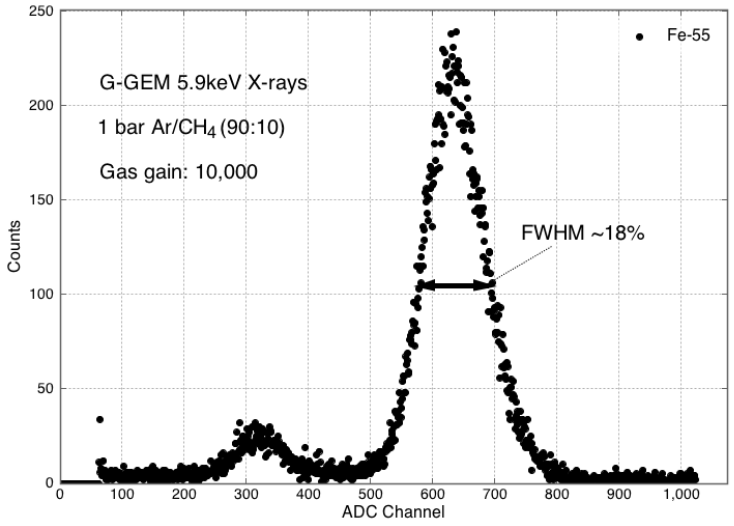
100mm□Glass GEM



Micrograph of Glass GEM

Cross section of the Glass GEM's hole

- We fabricated a Gas Electron Multiplier (GEM)[1] with "glass substrate" (Glass GEM)[2]
- Photo etchable glass process (PEG3 by HOYA Corp.)[3]
- Self support structure (easy to handle)
- No outgas from the substrate
- Direct etching fabricating Process
  - Good uniformity
  - Cylindrical Hole
  - High gain

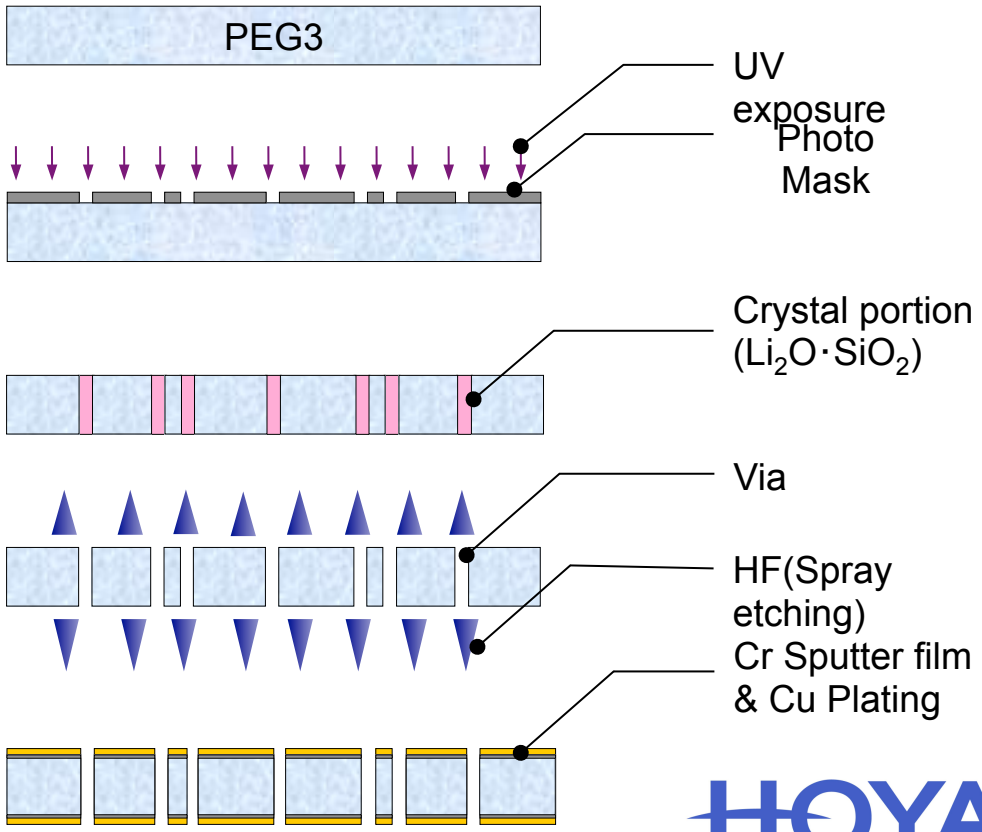


5.9keV Energy spectrum obtained with Glass GEM Energy resolution was 18% (FWHM) with uniform irradiation (gas gain = 1 × 10^4)[3]

[1] F. Sauli, NIM A, vol. 386, no. 2, pp. 531–534, Feb. 1997.
[2] H. Takahashi, T. Fujiwara, et al., NIM A, vol. 724, pp. 1–4, Oct. 2013.
[3] T. Fujiwara, et al., JINST, vol. 9, pp. 11007 - 11007, Nov. 2014

Fabricating Process of Glass GEM (PEG3)[4]

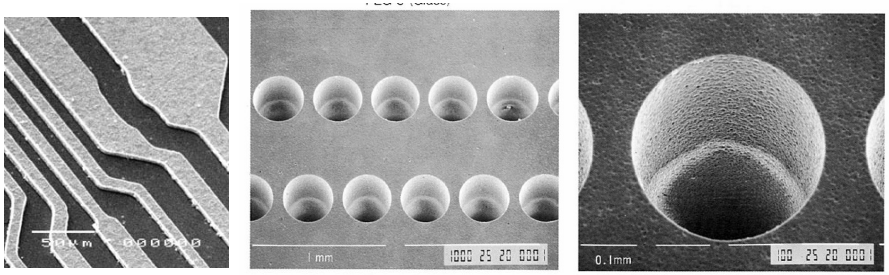
1. Glass Substrate (PEG3)
2. UV exposure (1st_exp)
3. Crystal formation (heat treatment)
4. Via etching (hydrogen fluoride wet etching)
5. Cr sputter & Cu plating



HOYA

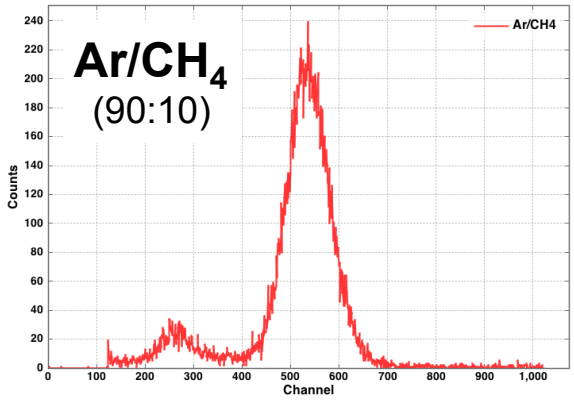
Photo Etchable Glass 3 : PEG3

- Promising technique for precise patterning
- Able to drill high aspect hole
- 680μm deep hole (ex. CERN GEM: 50μm)

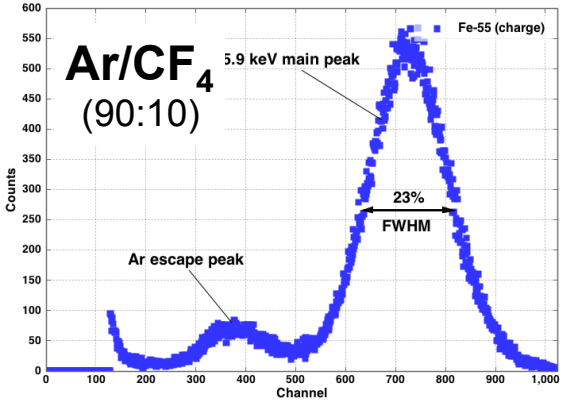


[4] http://www.hoyaoptics.com/gcb/index.htm

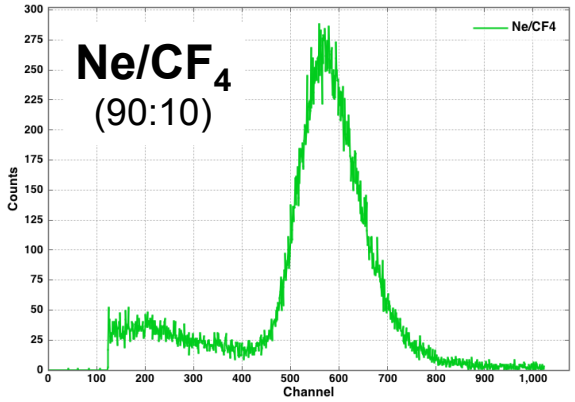
Energy spectrum & gain curve in various gas (^{55}Fe 5.9 keV)[5]



Ar/CH_4 (90:10)

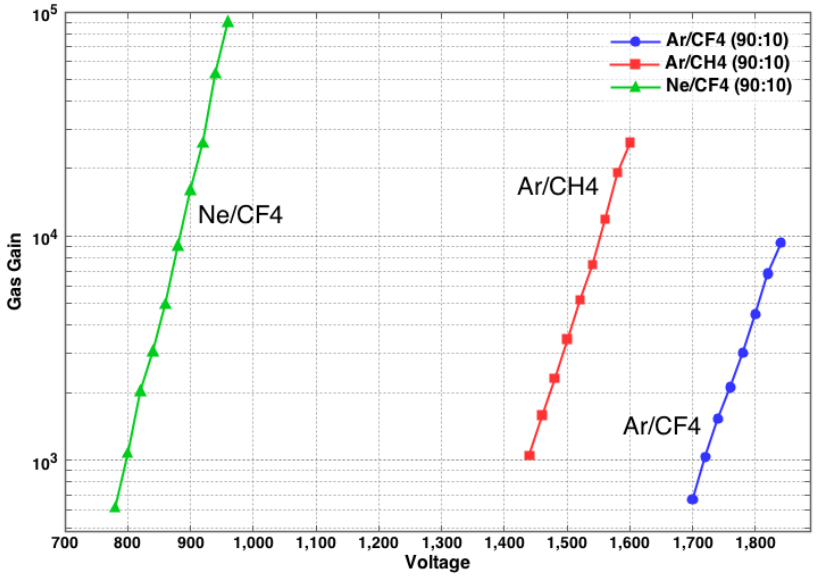


Ar/CF_4 (90:10)



Ne/CF_4 (90:10)

5.9 keV X-ray energy spectrum taken with Glass GEM

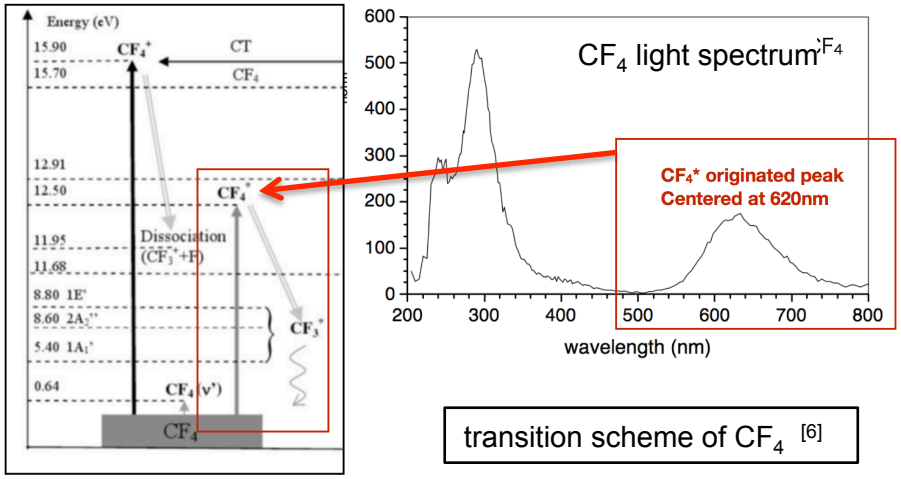


Gain curve of single Glass GEM

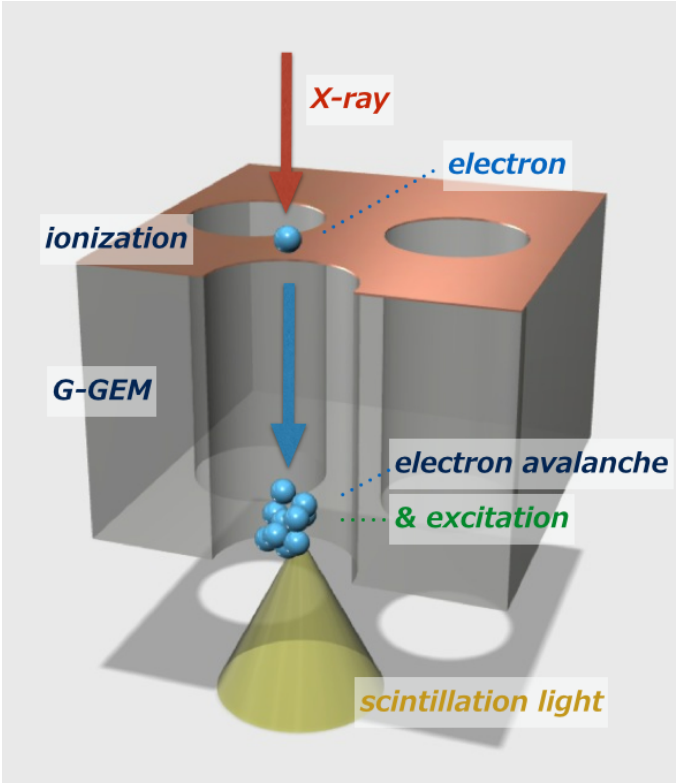
- Succeed in operating Glass GEM in various gas mixtures
- Effective size: 100 * 100mm^2
- **High gain with a single Glass GEM**
  - Gas gain : 3 × 10^4 @Ar/CH_4 (90:10, 1bar)
  - Gas gain : 1 × 10^4 @Ar/CF_4 (90:10, 1bar)
  - Gas gain : 9 × 10^4 @Ne/CF4 (90:10, 1bar)
- Energy resolution: 18% to 23%

[5] T. Fujiwara, et al., JINST, vol. 9, pp. 11007 - 11007, Nov. 2014

Scintillation gas with Glass GEM



transition scheme of CF_4 [6]

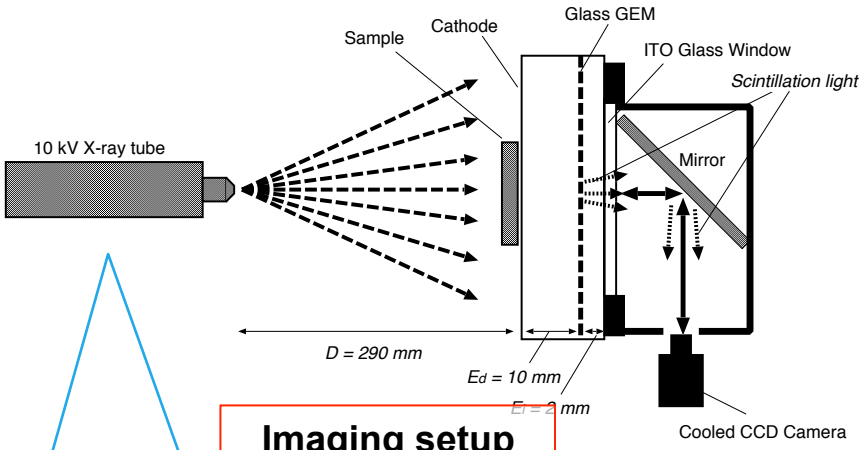


- CF_4 molecules are excited with electron avalanche
- During the process $CF_4^* \rightarrow CF_3^*$
- Scintillation light is emitted
- emits UV and 620nm peak centered visible photons

- **CF_4 is known as a good scintillation gas** *[6] and more (Fraga etc.)*
- **Large amount of scintillation photons would be produced during Glass GEM's high gain avalanche process**
- **Develop a radiation imager with scintillation gas × Glass GEM**
- **Use optical readout instead of charge**

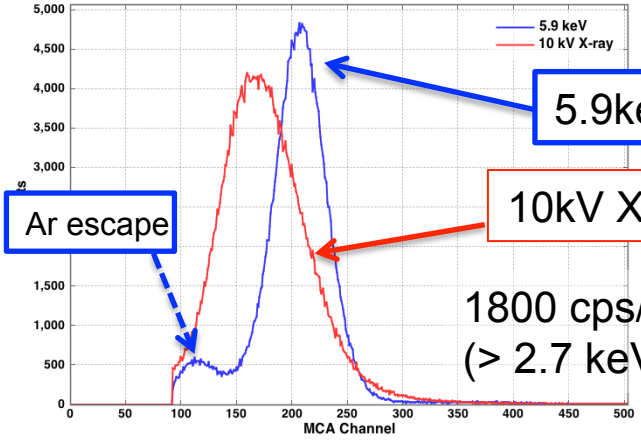
[6] E. Seravalli, Delft University Press (2008)

Imaging setup & result



Imaging setup

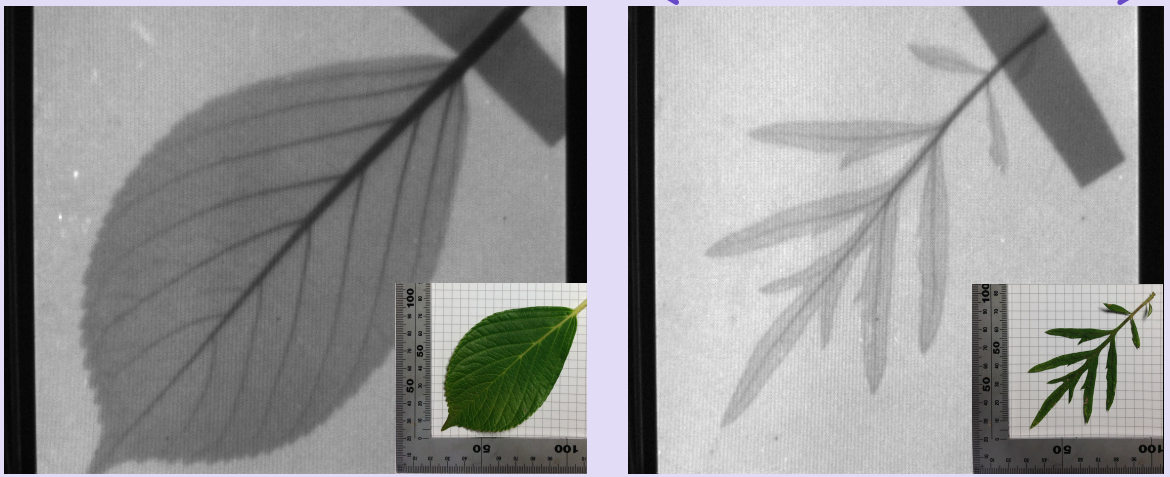
X-ray generator's energy spectrum



[9]

X-ray tube

Amptek Co. Mini-X
(Max. 4W)



Obtained image of leaves (2 sec integration time)[10]

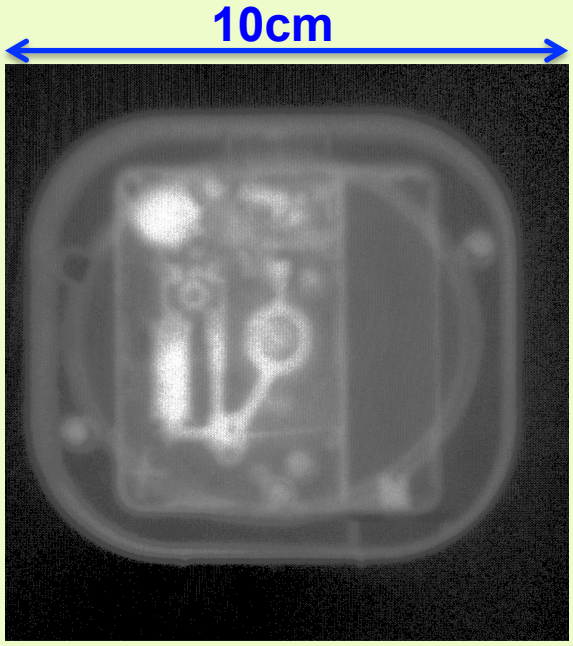
Excellent spatial resolution ≈500μm
Quick imaging of low Z material with low energy X-rays (≈7 keV)

[9] www.amptek.com
[10] T. Fujiwara, et al., Review on Scientific Instruments (Submit

Application

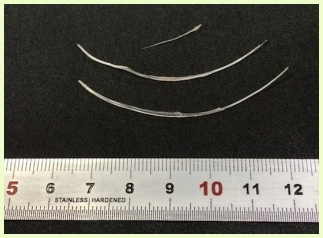
Non-destructive inspection

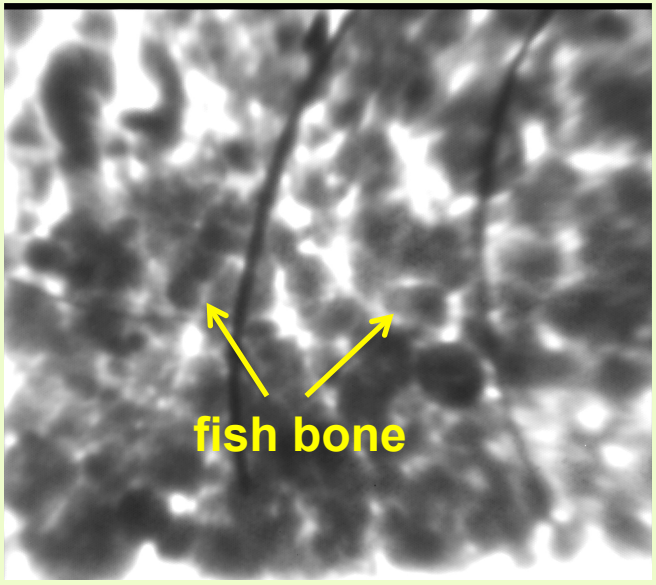
clock@30kV



X-ray transmission image of a clock

Food inspection

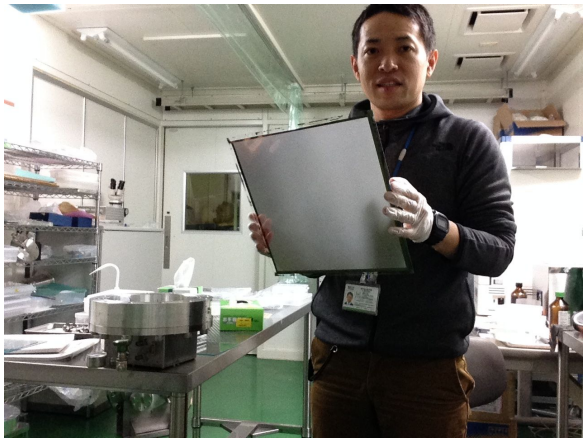




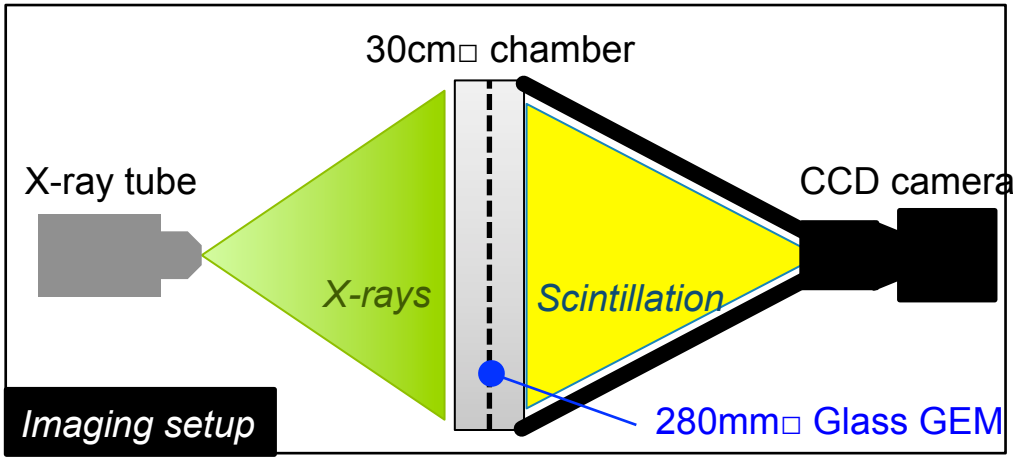
Inspecting fish bones

Large area: 280mm□ Glass GEM

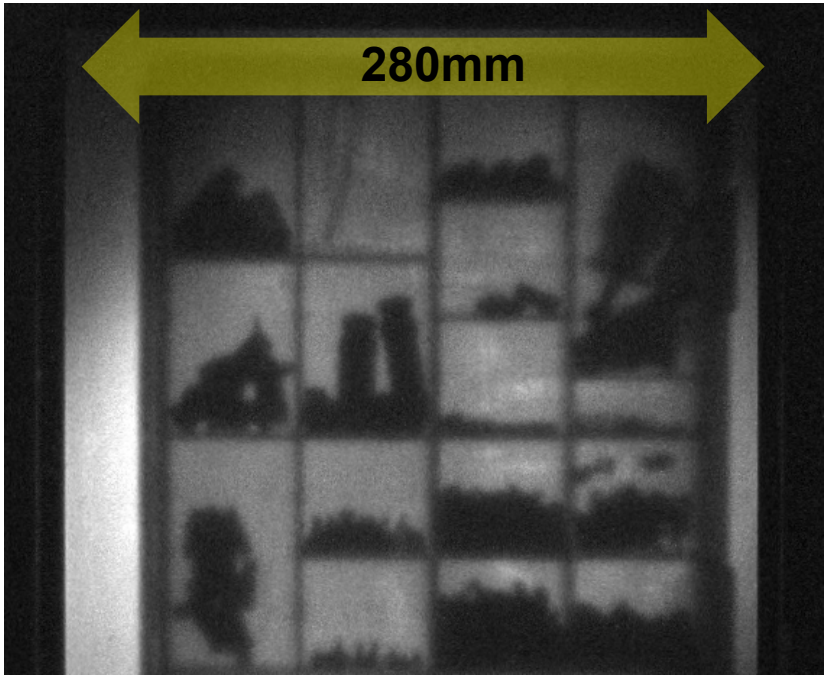
preliminary



300mm□ Glass GEM (1,154,423 holes)



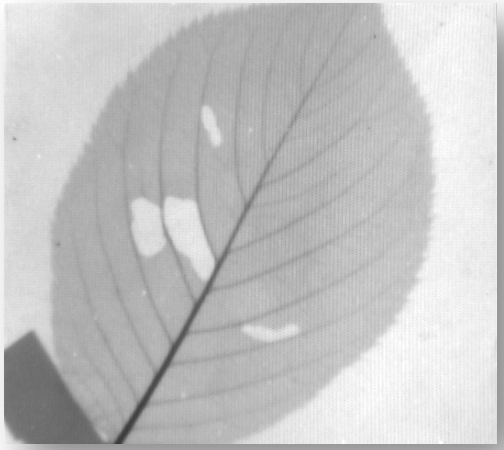
Toolbox



X-ray transmission image of a toolbox

Summary

- 100mm□ digital X-ray imager has been successfully developed with Glass GEM
- High gain and charge-up free enables rapid X-ray imaging
- Optical camera is a powerful readout method
- 500,000 photons (per 5.9 keV) were produced with Glass GEM (gas gain: 9,000)
- X-ray imaging and X-ray CT are performed with ***"Scintillating Glass GEM"***
- 280mm□ Glass GEM imager is now being developed
- The method can also be used for detecting protons, carbon ion beam, and neutrons



Thank you for your kind attention.