BNL

2021.09.07 RBRC MEETING

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Development of the inspection fixture of the line & space pattern for the INTT bus extender inner signal layer ~Hardware~

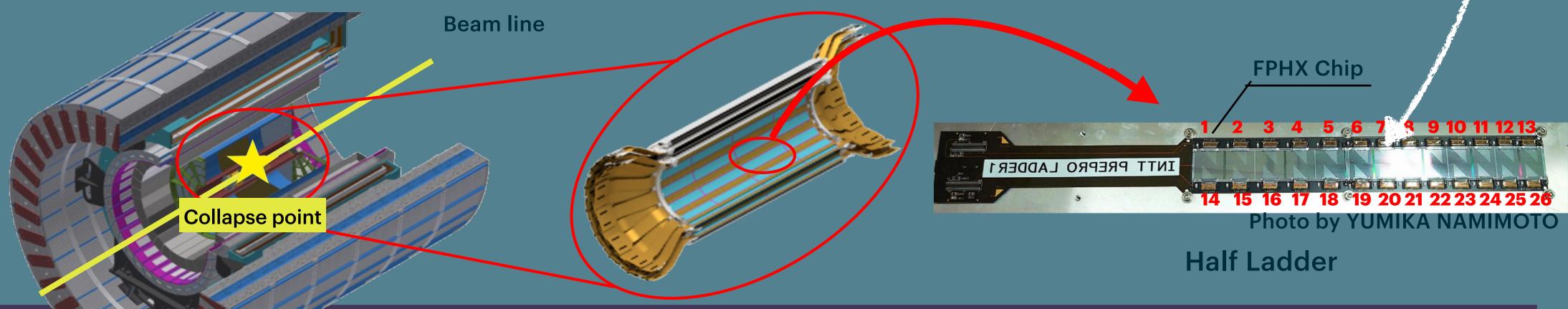
**Rikkyo Univ.** Nakamura Yusuke



**RIKEN** 

INTRODUCTION Intermediate Tracker(INTT)

- sPHENIX experiment will start 2023 to study Quark Gluon Plasma(QGP) at RHIC(Relativistic Heavy Ion Collider)



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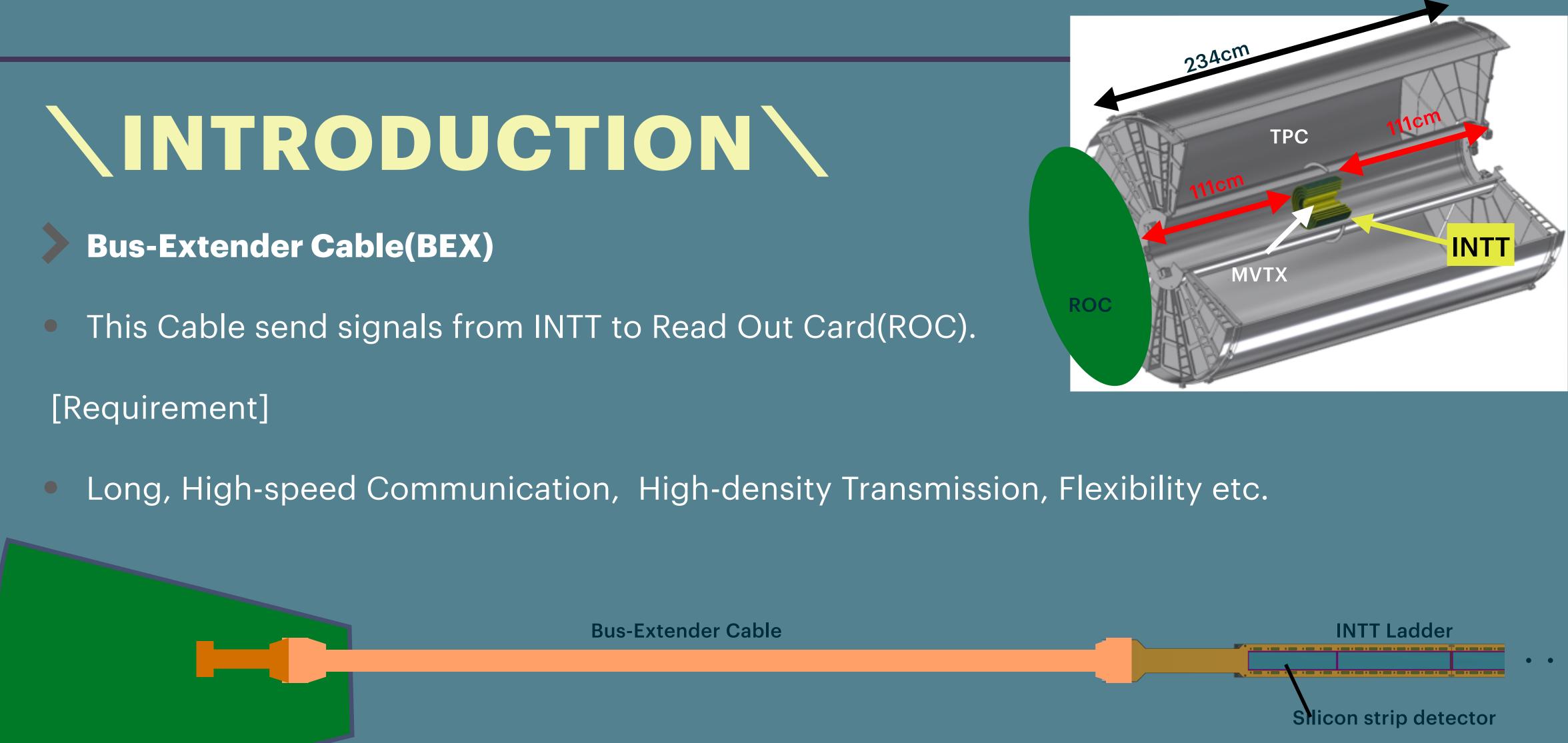
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Silicon strip detector

Silicon detection in one of the particle track detectors : INTT(Intermediate Tracker)

The silicon ladder consists of two silicon strip sensors and 26 FPHX readout chips.





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**Read Out Card** 



# inal Design Review of the INTT Barrels Assembly Tuesday May 25, 2021, 9:00 AM → 6:00 PM US/Eastern



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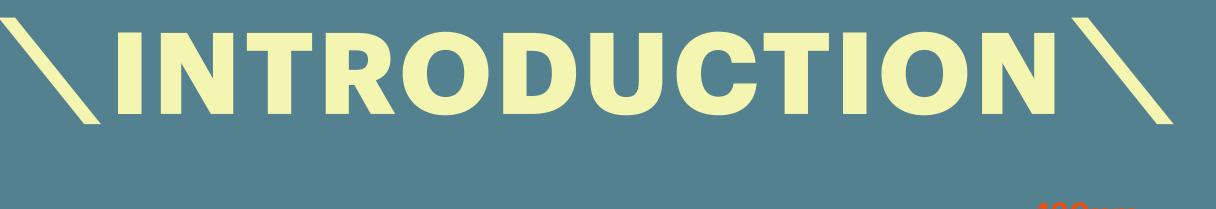
# **BEX Outline**

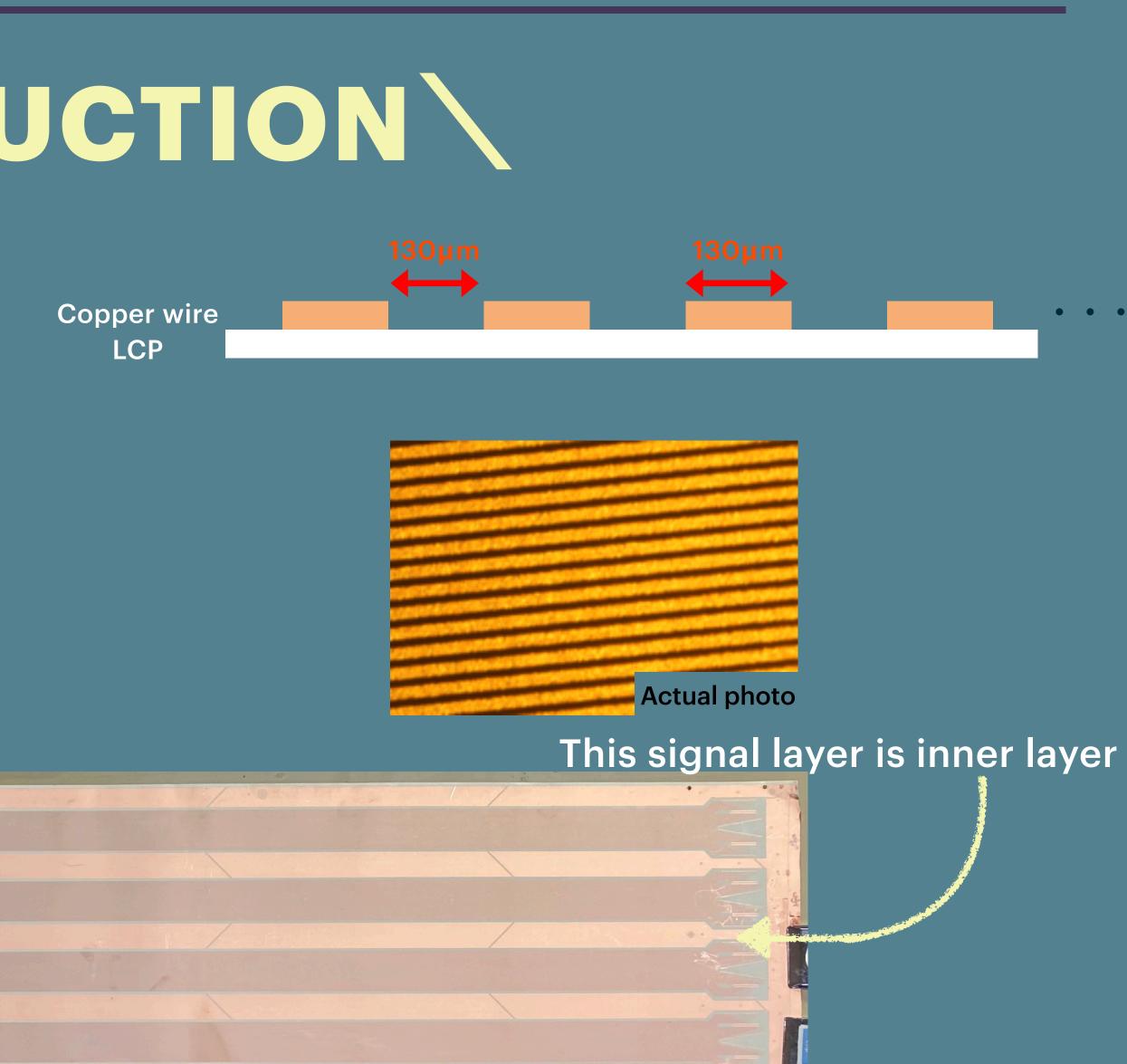
- Length: 111cm, width: 3.5cm
- Number of signal lines : 124 lines
- Signal line spacing : 130µm
- 4 BEXs are printed on each sheet.



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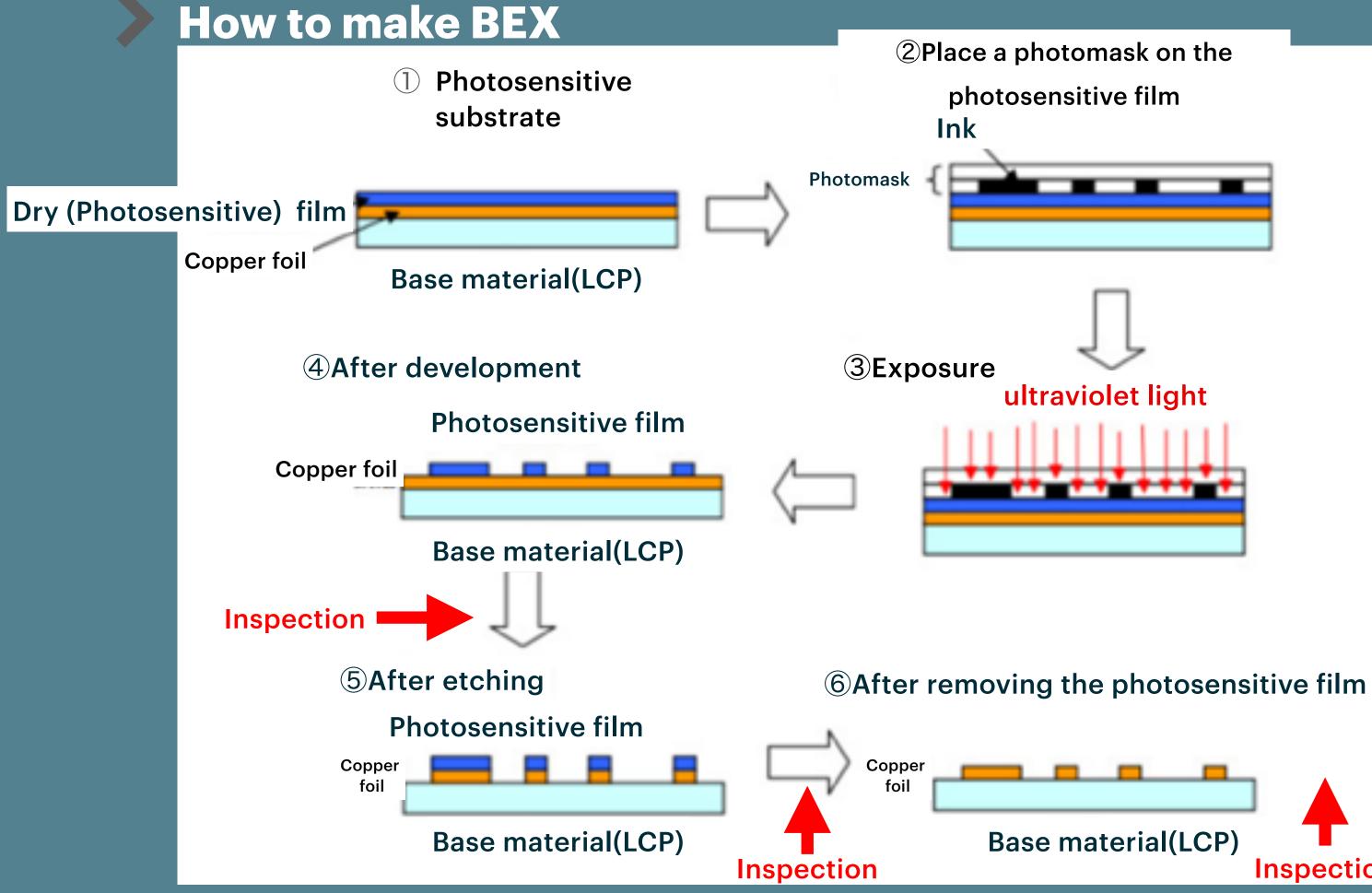
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111cm

# **INTRODUCTION**



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## **Rikkyo Univ. Y.Nakamura**

-A yield often occurs in patterning the inner signal layer. Any abnormalities in the pattern should be detected as early stage as possible to improve the yield rate.

-A continuity test can be executed only after Step 6.

-If a defect is found in the pre-etching process, The dry film can be reattached.

Additional inspection is performed Inspection between processes using a dedicated fixture.





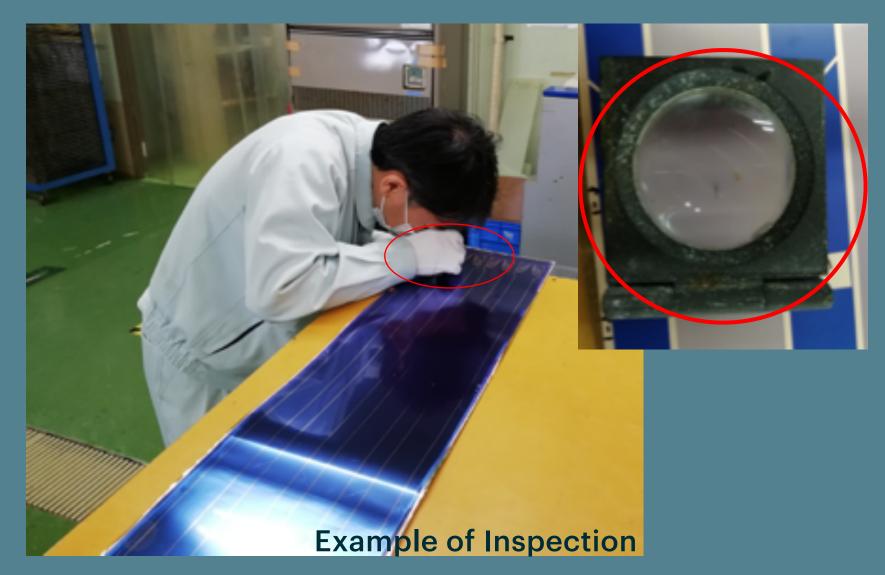






# MOTIVATION

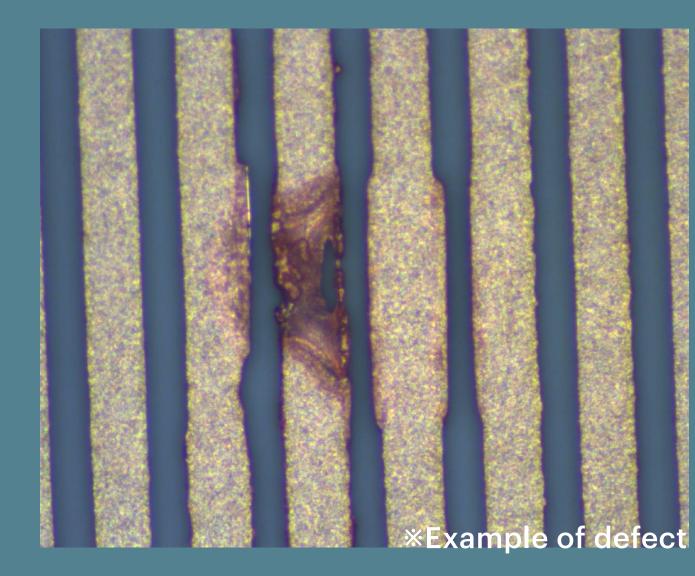
# **Conventional inspection method** Until now, companies have visually inspected 128 lines ×111 cm signal lines using a magnify lens



 $\rightarrow$  Due to the huge burden, the inspection process has to be somewhat reduced by the automation.

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**Mass production is planned to be** <u>140 pieces.</u> If the yield rate is 50%, 35sheets. If the yield rate is 100%, 70sheets.



# **ANALYSIS METHOD**

## Initial analysis method

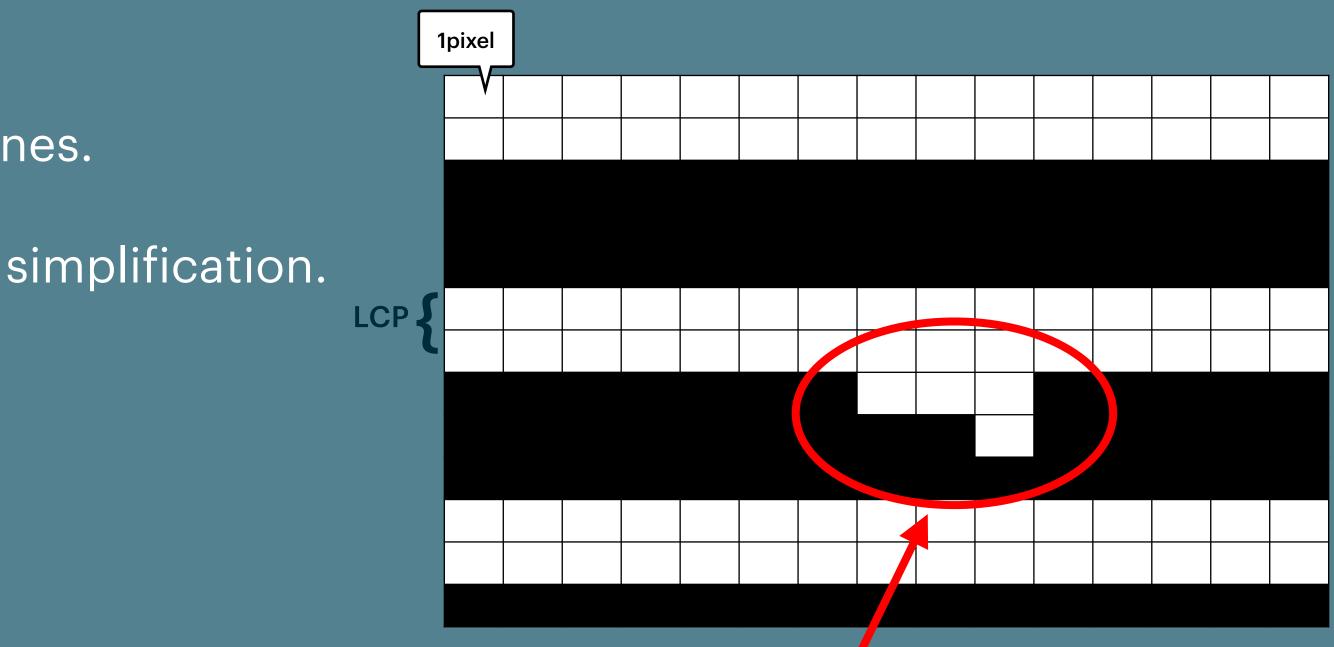
- 1. Take a high resolution photo of signal lines.
- 2. Convert image to black and white for a simplification.

White : LCP
Black : Copper wire

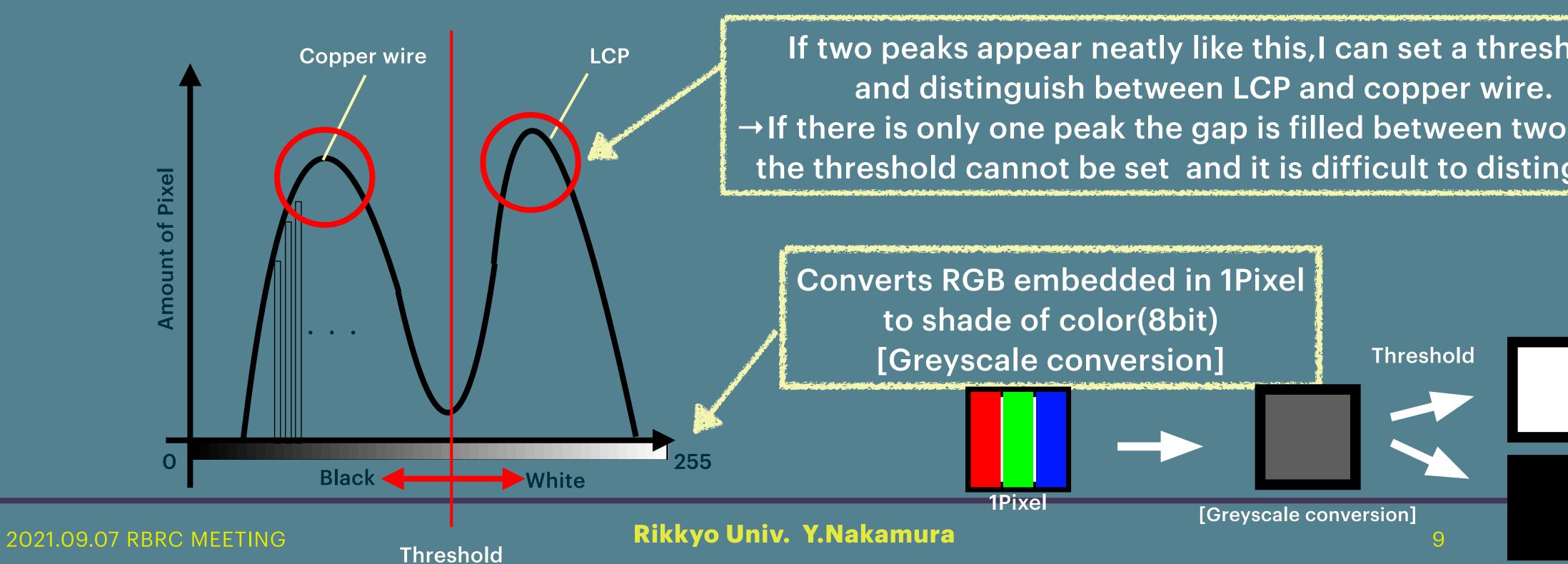
→Preferably, increase the number of pixels assigned to the signal line (Copper wire)

 $\rightarrow$ The larger the number of pixels, the better the precision to find defects.

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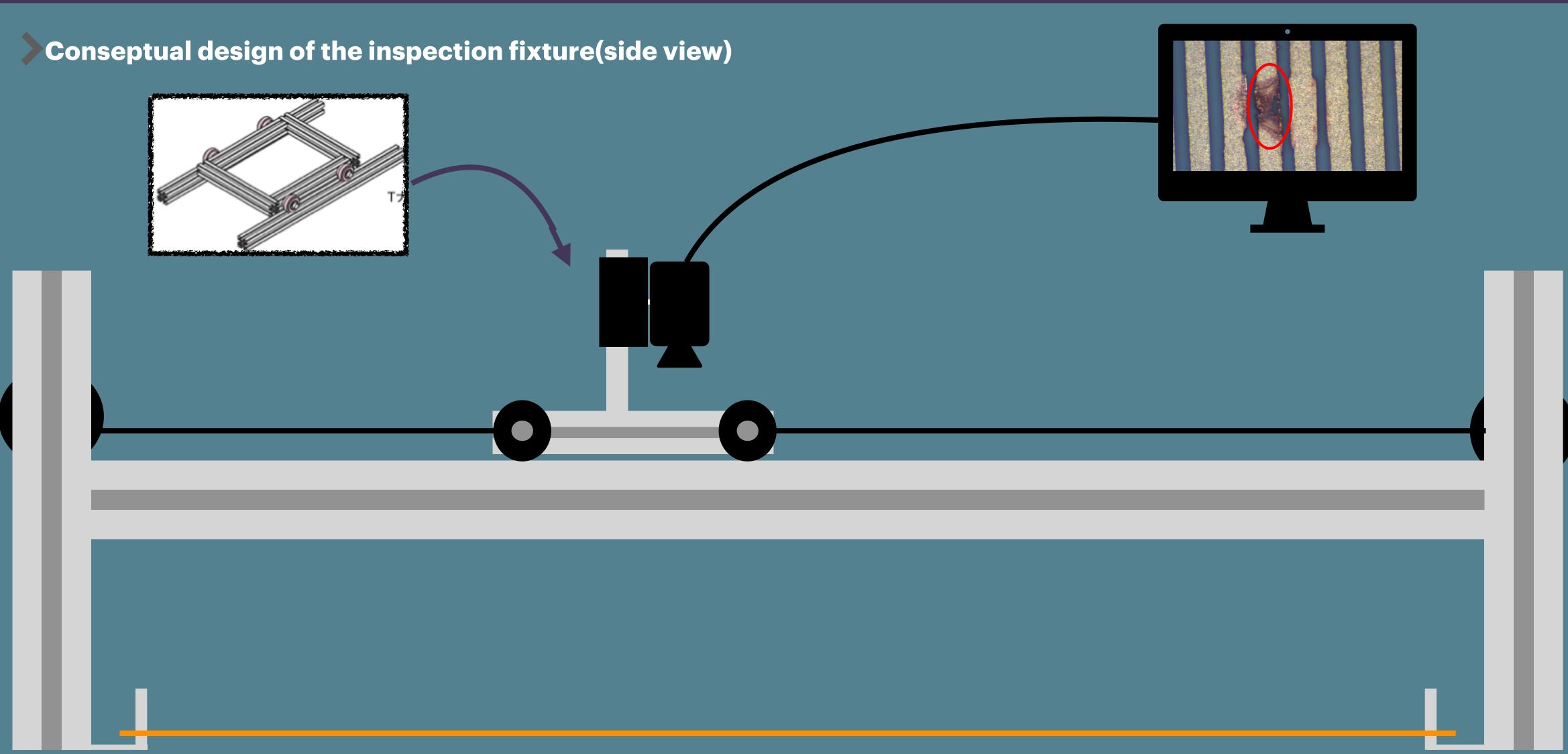
The dimensions of the line (Copper) and space (LCP) are 130 and 130um, respectively.  $\rightarrow$  Due to the difference in the color between the copper and LCP, \*ideally\* two distinctive peaks are expected to appear in color histogram(s).



# **ANALYSIS METHOD**

If two peaks appear neatly like this, I can set a threshold  $\rightarrow$  If there is only one peak the gap is filled between two peaks, the threshold cannot be set and it is difficult to distinguish.





**BEX** sheet

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# **CURRENT SETUP**



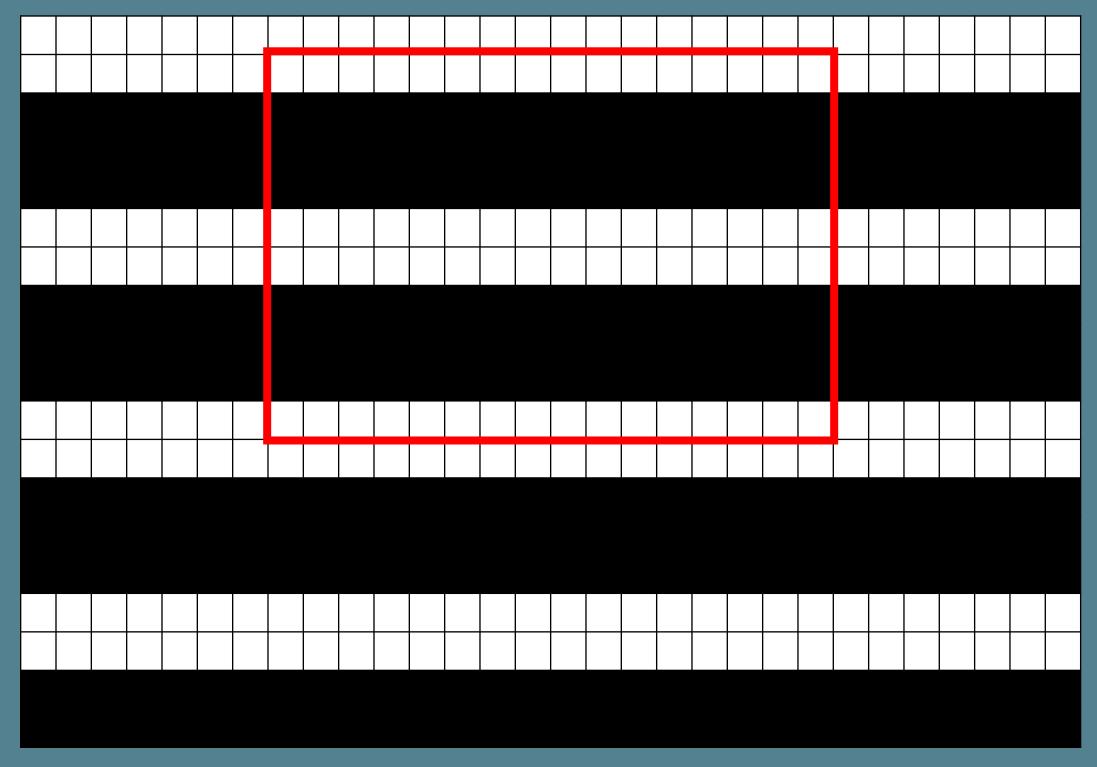
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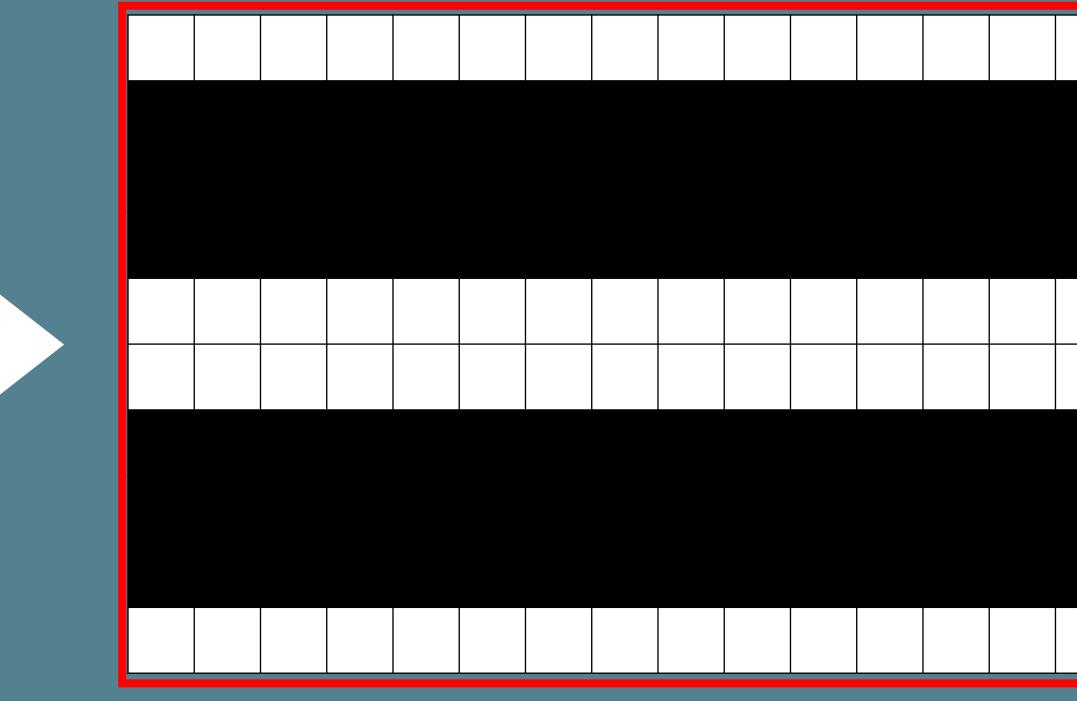
# **\DIGITAL VS OPTICAL ZOOM \**

## **Digital zoom**



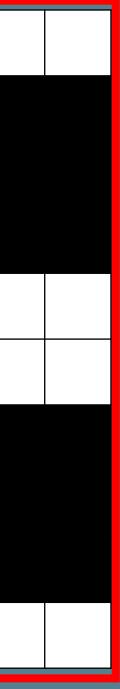
30×19 = 570pixels

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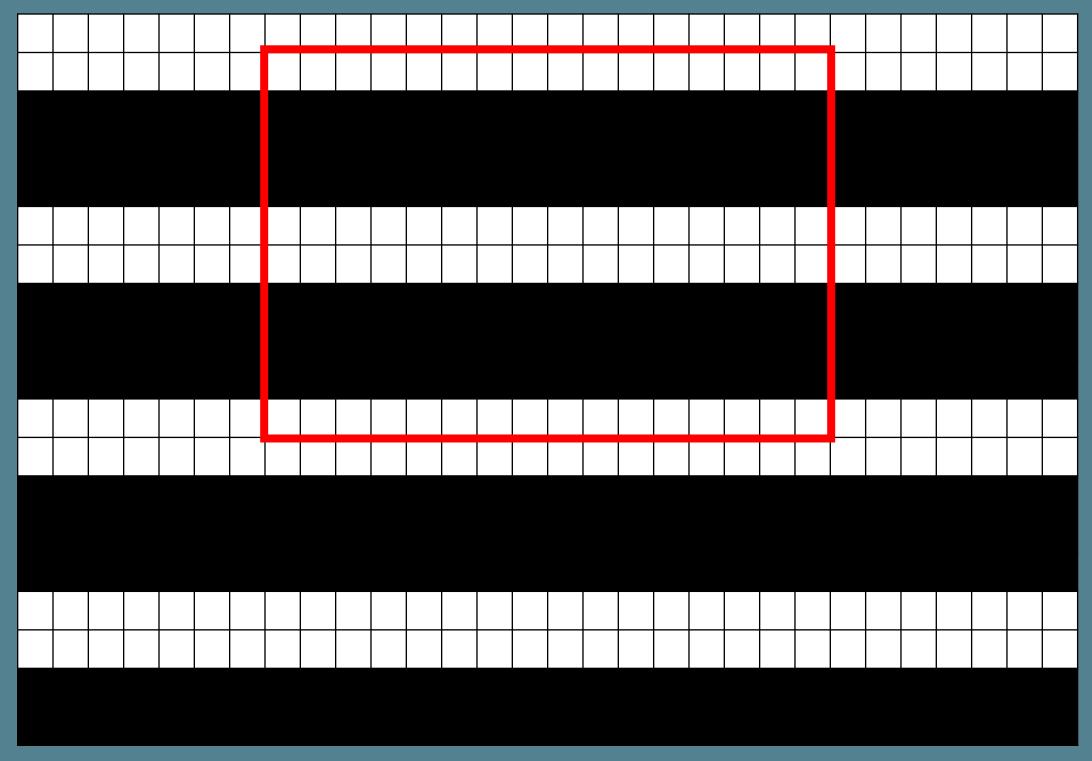
## 16×10 = 160pixels

The number of Pixels will decrease.



# **\DIGITAL VS OPTICAL ZOOM \**

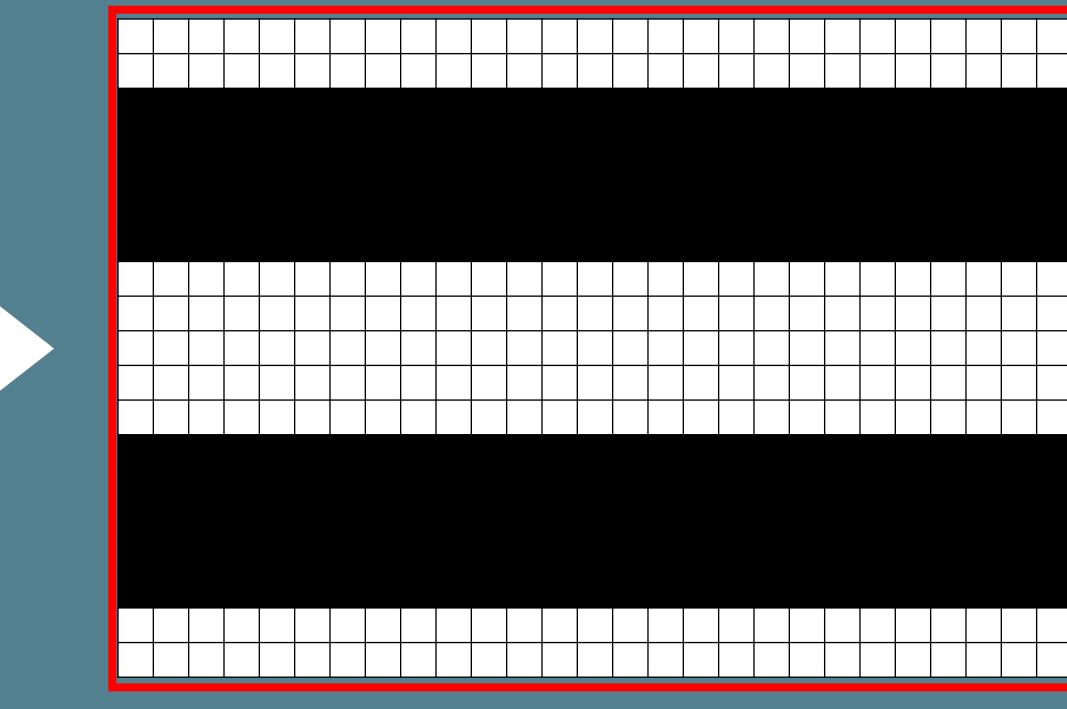
## **Optical zoom**



30×19 = 570pixels

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## 30×19 = 570pixels

Number of pixels doesn't change



# **CAMERA SELECTION**

## iPhone



# **(Spec)**

- Number of pixels : 12 million Pixels
- Zoom
- Real time display output : Possible

### Merit

- Wireless communication is possible.
- Easy focus adjustment.
- Use to it.

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## **Rikkyo Univ. Y.Nakamura**

: Digital

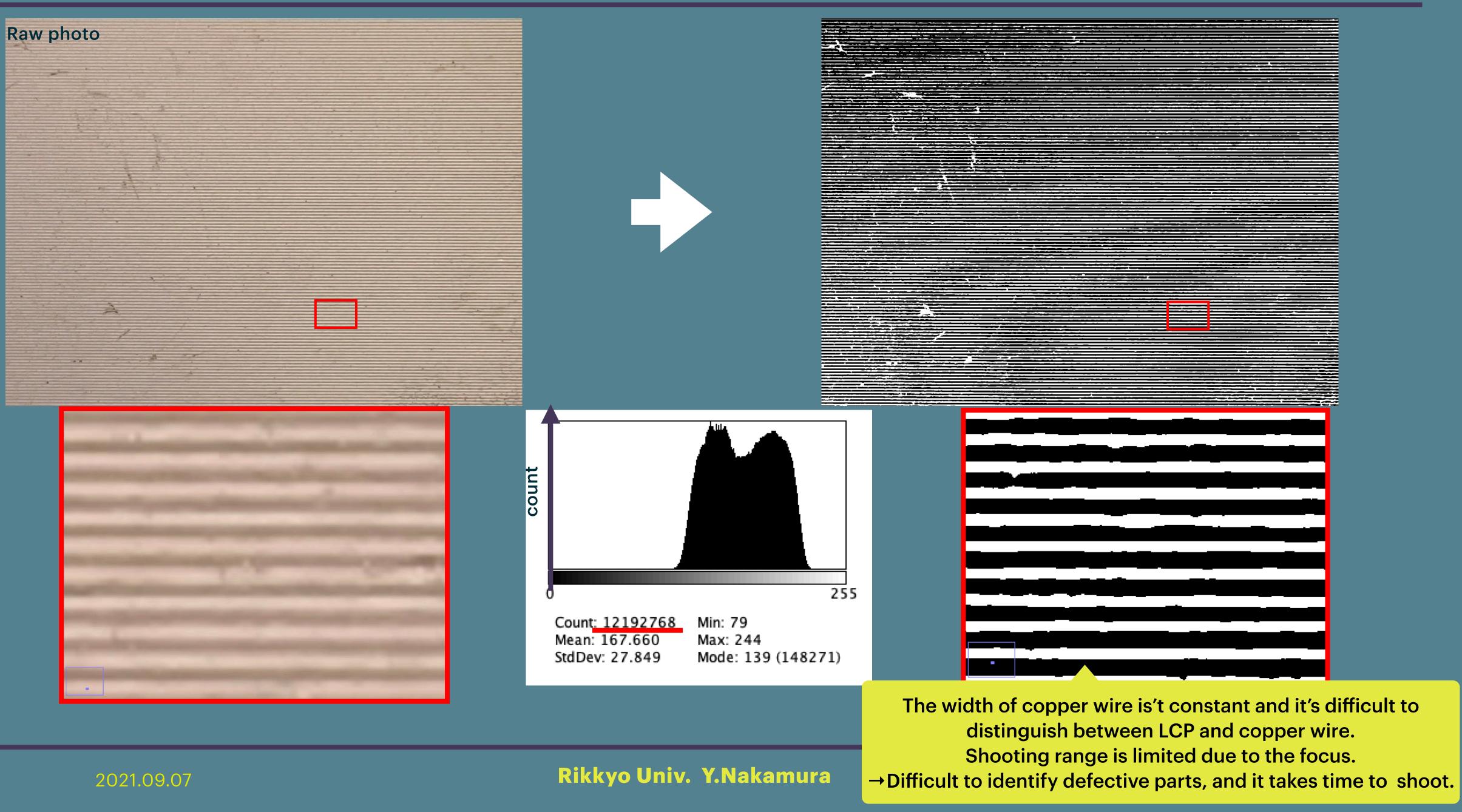


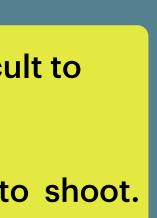
### Demerit

- The number of pixels drops due to digital zoom.
- Comes with other unnecessary features



## Photographs taken with a iPhone





# **CAMERA SELECTION**

## single-lens reflex camera



Canon kiss Digital X

- Number of pixels : 10 million Pixels
- Zoom
- Real time display output : Impossible



- etc.)
- Thanks to the optical close up lens, the target photo can be clearly taken without dropping the resolution.

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# **(Spec)**

: Optical

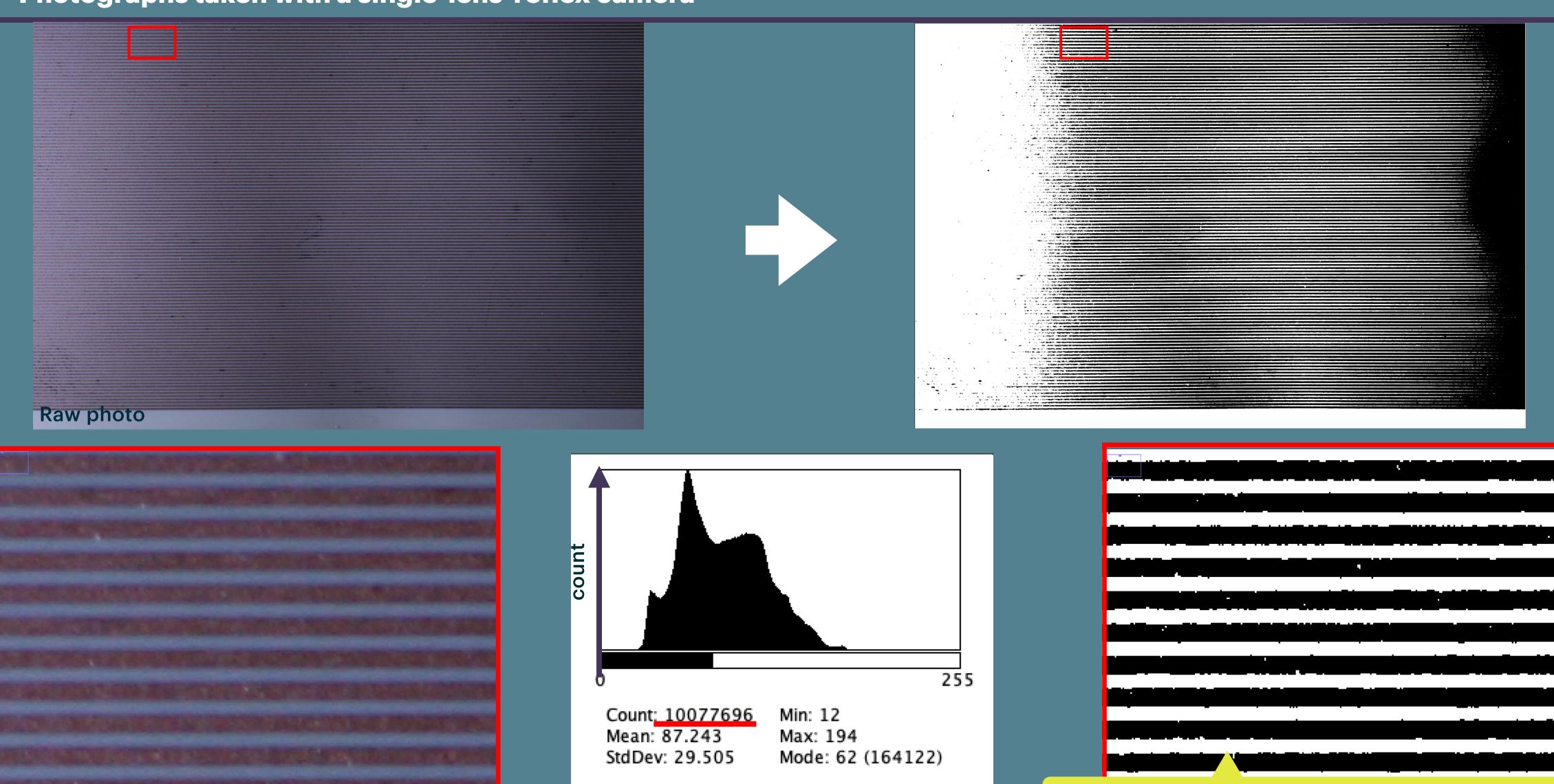


# Fine settings are possible. (ISO sensitivity, shutter speed,

## Demerit

- Support structure becomes massive
- Difficult to adjust focus.
- Real time monitor output and video recording are not possible.

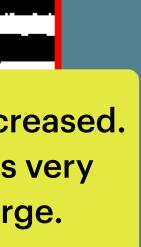
## Photographs taken with a single-lens reflex camera



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Fluctuation in the width of copper wire have decreased. I was able to expand shooting range, but it was very difficult to adjust focus and the setup was large.





# **CAMERA SELECTION**

## Micro scope



- Zoom
- Merit
- Close-Up photography is possible
- Easy focus adjustment.

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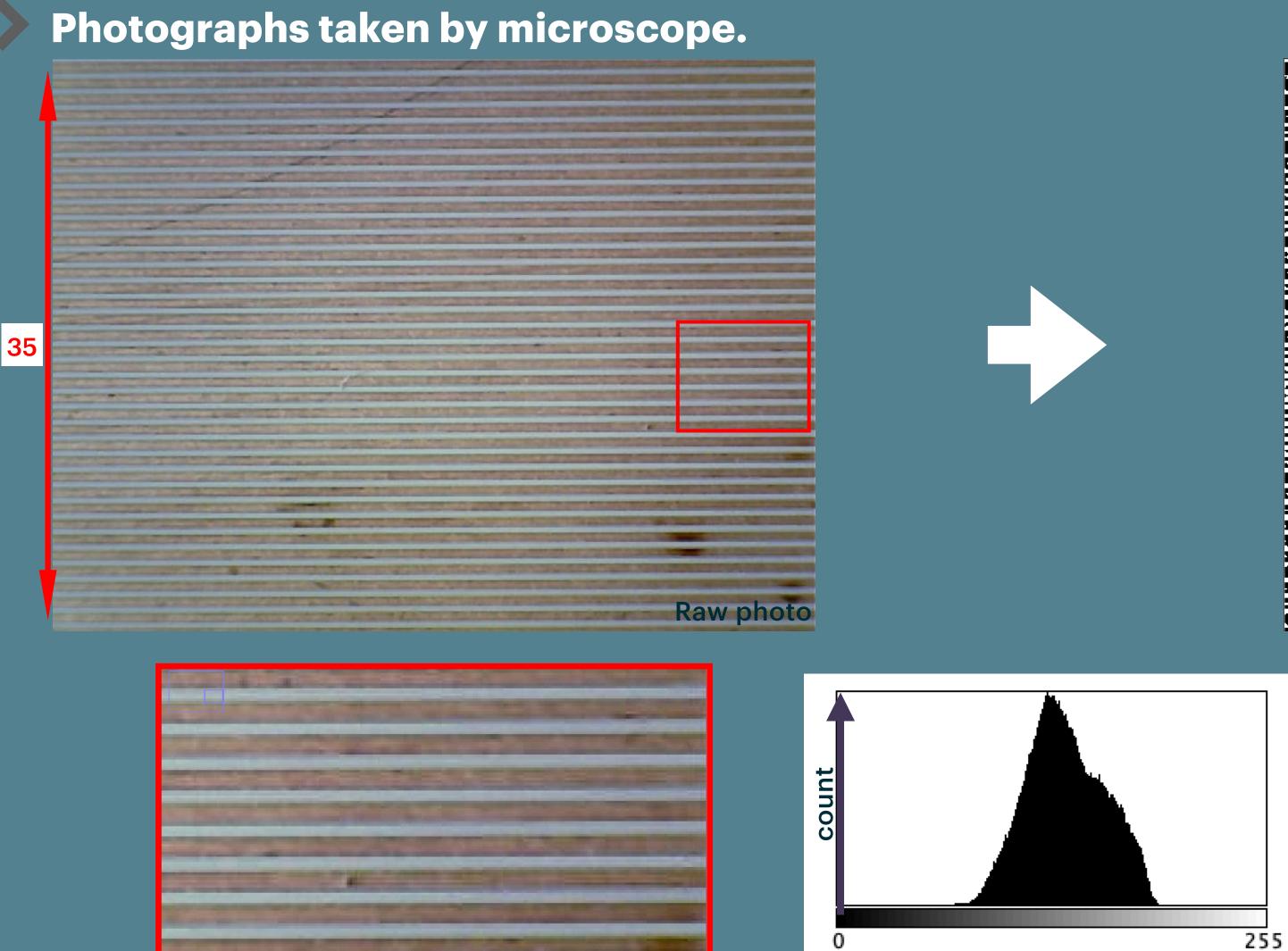
## **Rikkyo Univ. Y.Nakamura**

**(Spec)** • Number of pixels : 300,000 Pixels : Digital • Real time display output : Possible

Demerit 

- The number of pixels drops due to digital zoom.
  - It takes time to shoot because the shooting range is narrow.







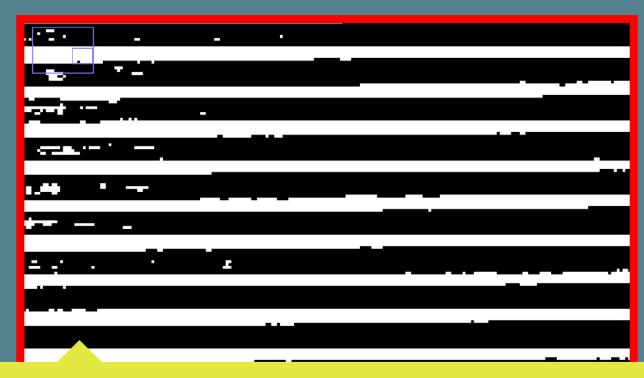
Count: 307200 Mean: 135.748 StdDev: 23.482

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### Rikkyo Univ. Y.Nakamura

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Min: 8 Max: 198 Mode: 125 (5485)



The width of the copper wire isn't constant, and the total number of pixels is also small. So the pixels distributed to the copper wire part become small. → Difficult to identify defective part



# **CAMERA SELECTION**

## CS2000-C



### https://www.shodensha-inc.co.jp/ja/ cs2000-b/



- Zoom



- Small size and easy to setting.
- The number of pixels is the highest.
- Simultaneous monitor output is possible.

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**(Spec)** • Number of pixels : 20 million Pixels : Optical

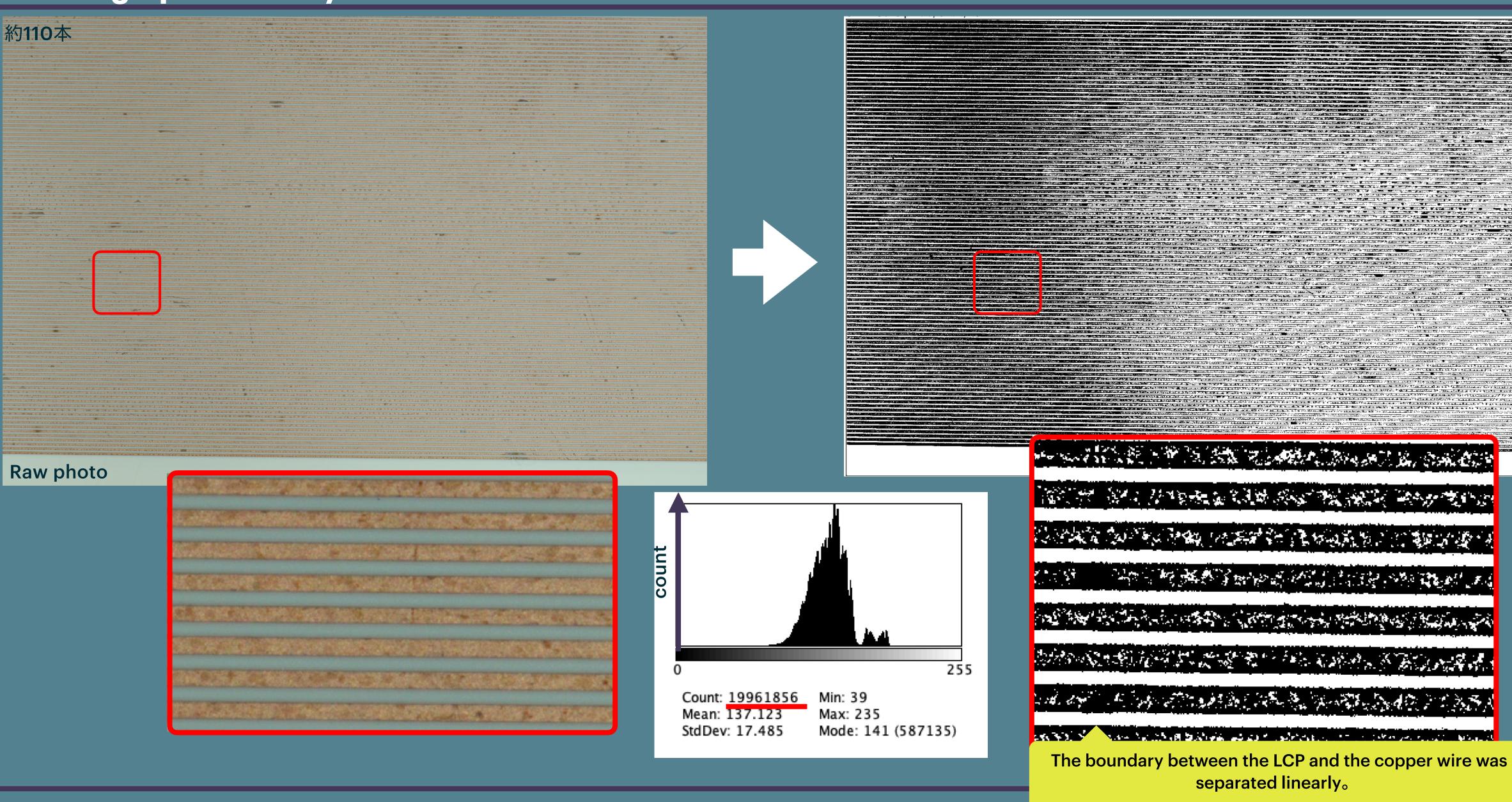
• Real time display output : Possible

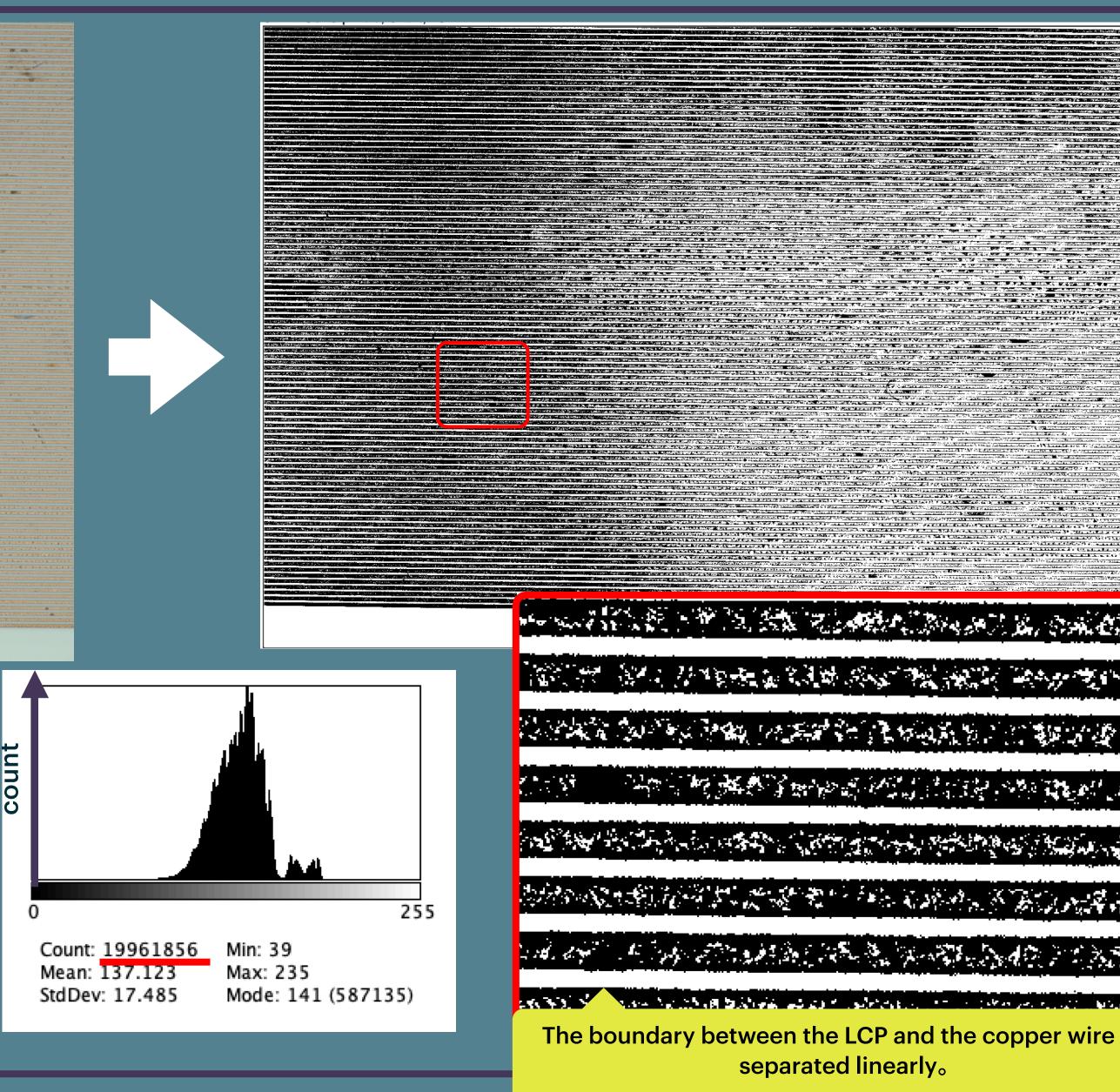
Demerit 

Frame rate is a little slow due to the large amount of pixels.



## Photographs taken by CS2000-C.





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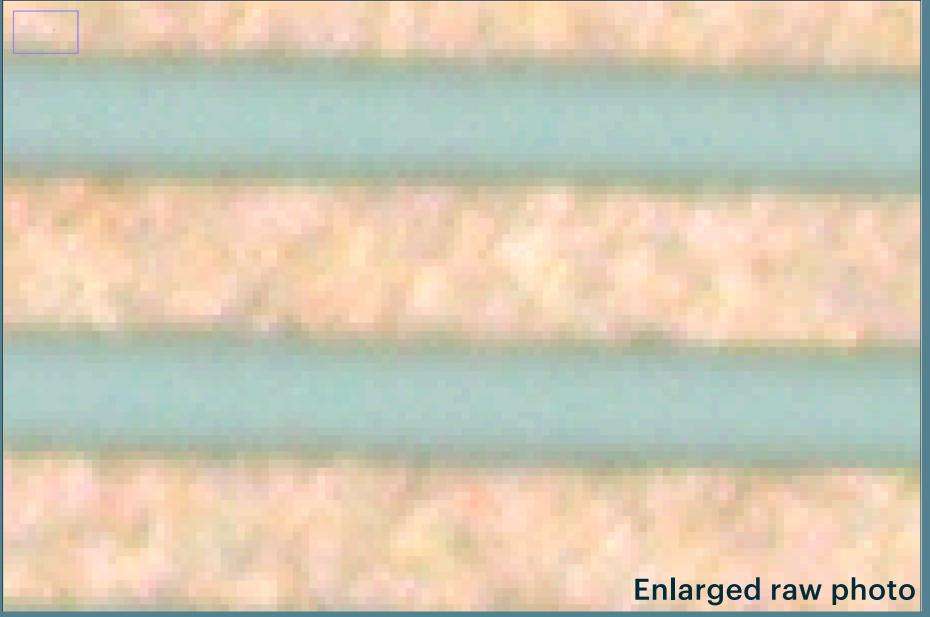
**Rikkyo Univ. Y.Nakamura** 

However, white spots are noticeable inside the copper wire. →Next slide





## This color unevenness of signal line isn't related to lighting, but due to the tiny unevenness on the surface of the copper wire that occur during etching.



→ By shooting with a camera with large number of pixels, such small unevenness of light was reflected in the B-W photograph  $\rightarrow$  Focus on HSB space (Imai-San)

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# SUPPLEMENT

This small unevenness appers in black and white for each part.



## **Fluorescent light**

- The power frequency in Tokyo is 60Hz. Oscillate between invisible light and darkness.
- When shooting under the fluorescent light, a flicker phenomenon occurs due to difference between the frame rate and the frequency of the fluorescent light.  $\rightarrow$  Affect shooting.



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Flicker phenomenon



# LIGHTING

## LED

① Since the LED is always on, the flicker phenomenon doesn't occur

(Static lighting)

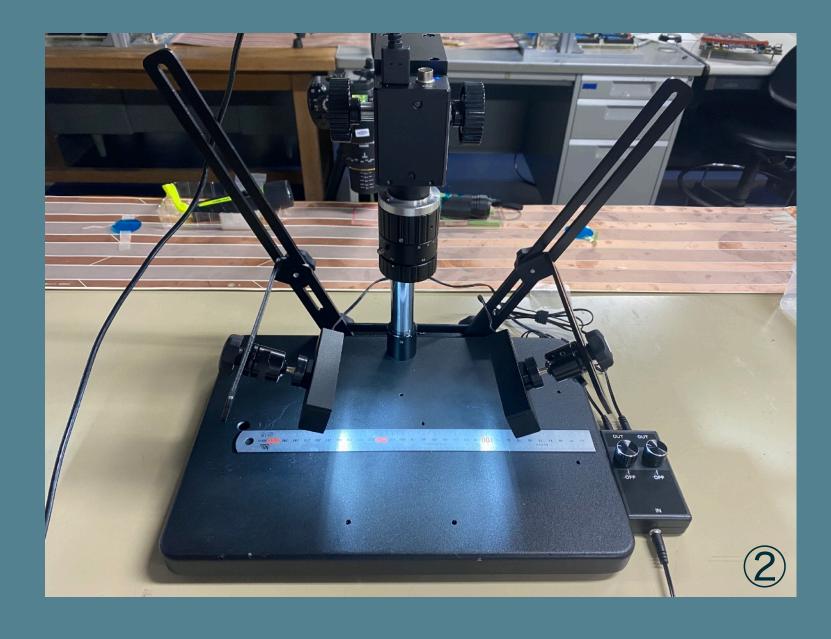
2 By shining light on the object from both sides, unevenness of light is suppressed.



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# Clearer shooting is possible







Worse

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Camera : CS2000-C Light : LED (Reduce light unevenness By placing two light source)

Micro scope



[Hardware near term goal]

Real time output to a large monitor with CS2000-C and visually check for defects.

(Time scale : Less than a month)

[From now on]

**Camera selection** 

**Lighting** 

How to fix the BEX sheet

**Camera support structure** 

**Motor drive camera position** 

fixture

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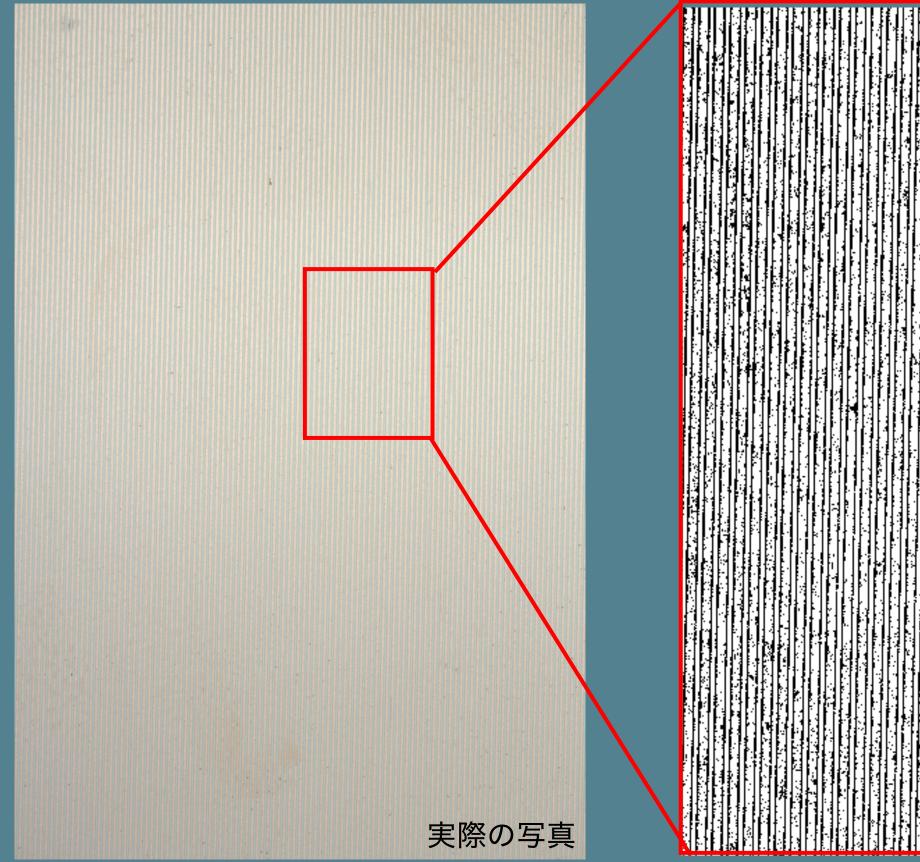
# NEXT STEP

**BUCKUP** 

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## **CS2000-C**実際に撮影した写真



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# 、カメラの選定へ

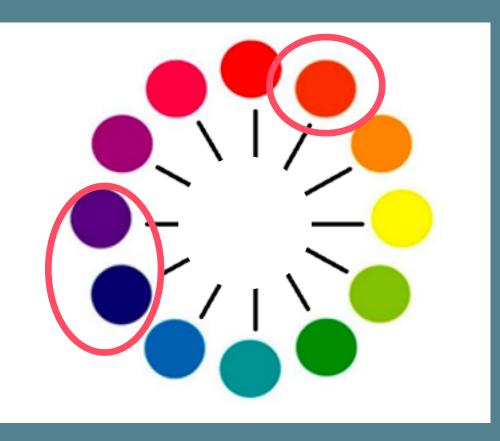
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## 吸収光

- 銅線とLCPの明暗をはっきりとさせるために吸収光を用いた撮影を行う。
- 今回以下の3色のセロハンをライトに取り付けて、観測を行った。



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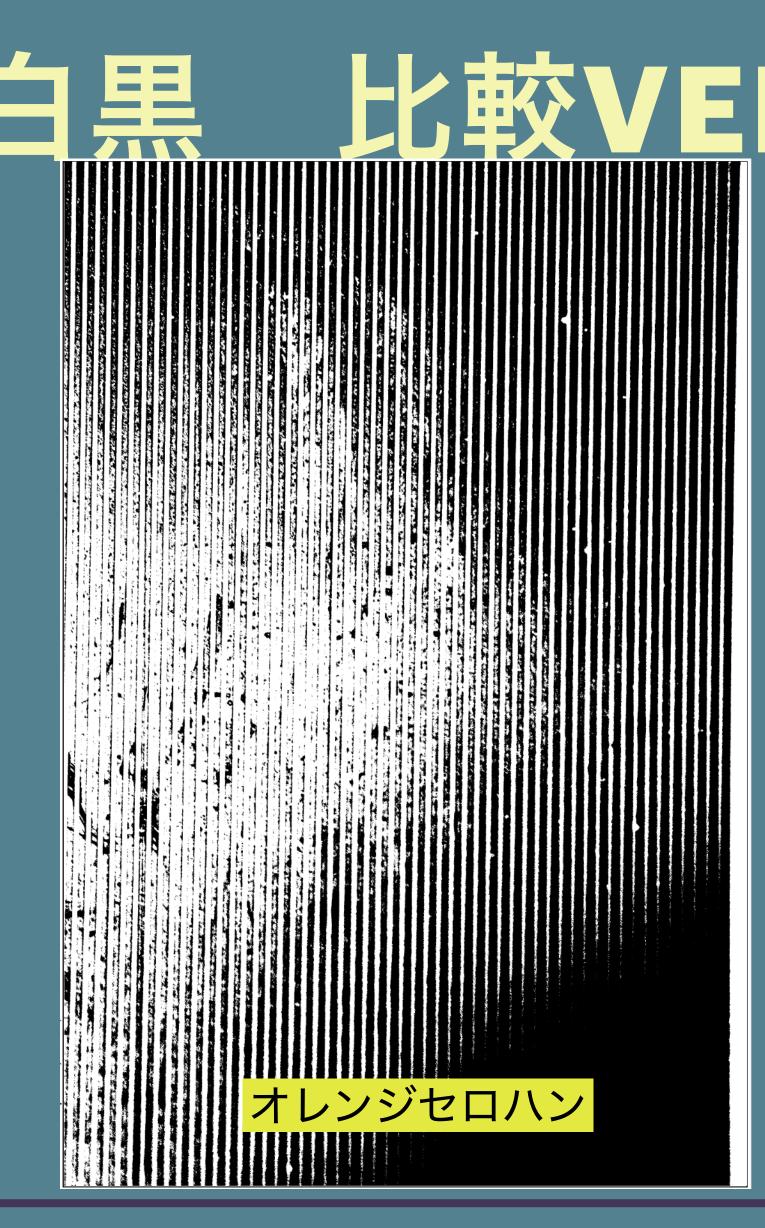
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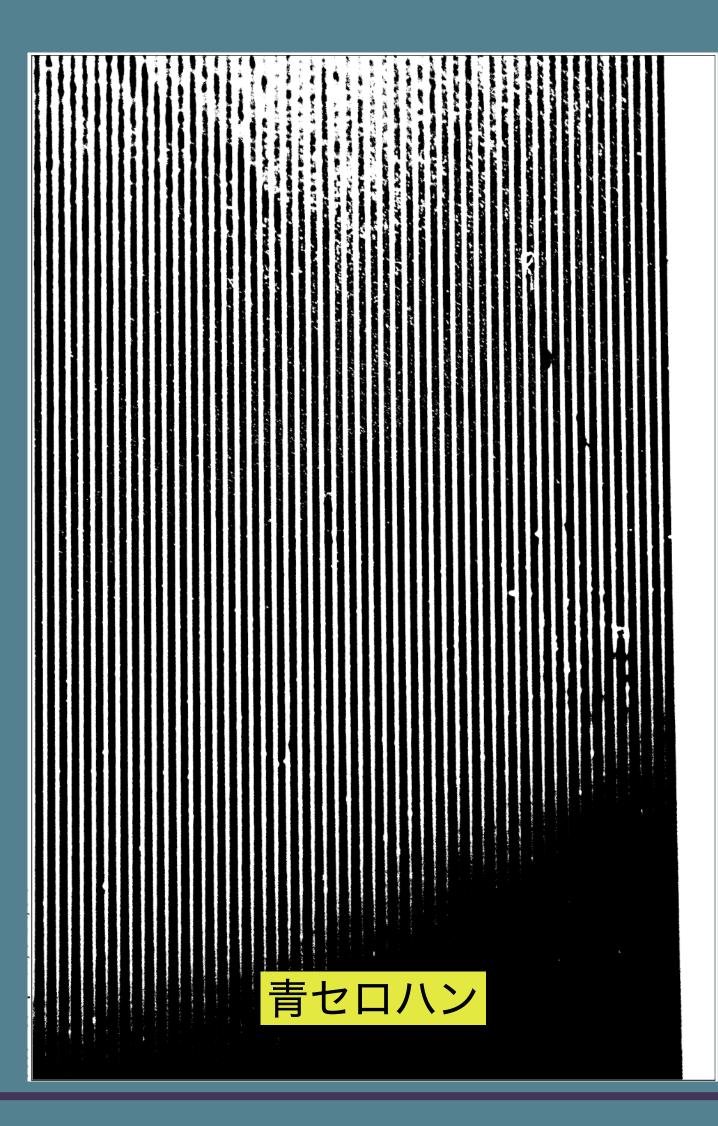
銅線の色は暖色系(λ:長め)なので、吸収光は青~紫と言った寒色系(λ:短い)が考えられる。





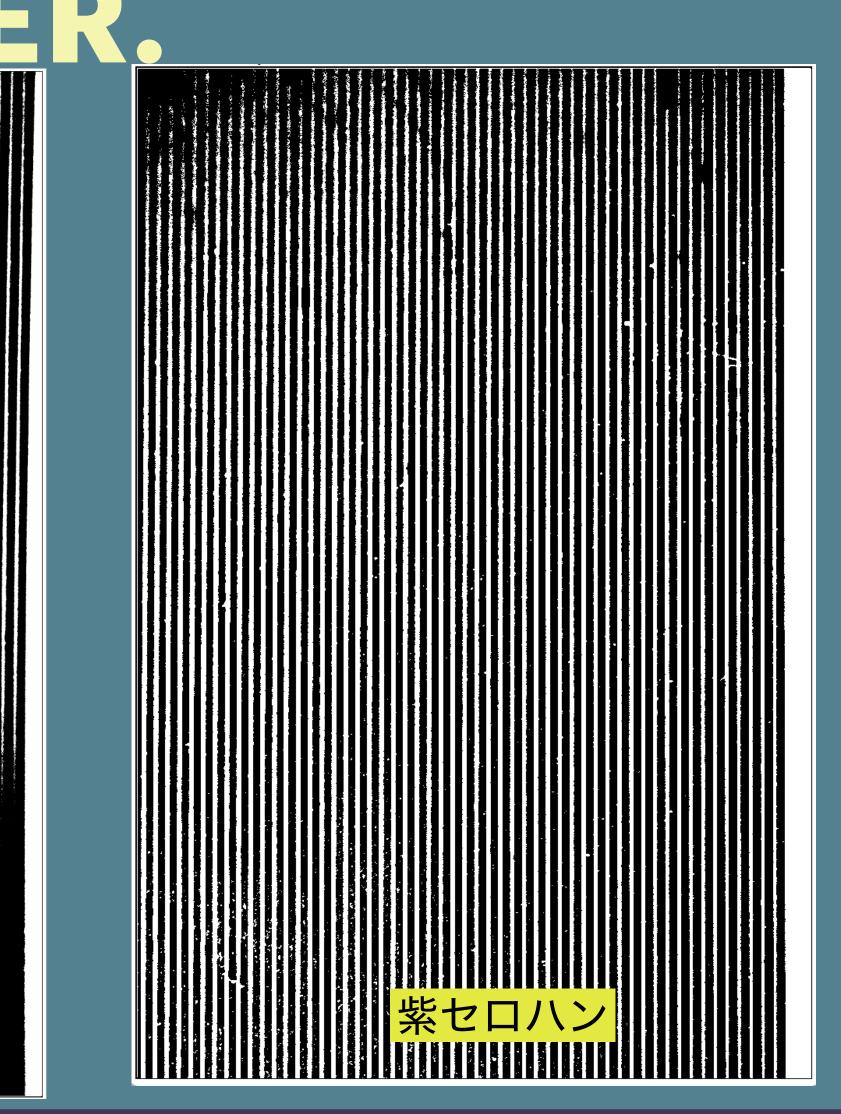
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### 2021.08.13



## ←影の部分が真っ黒になっているため これが小さなピークとなって現れる。