JX Nippon Mining & Metals Corporation Company Introduction

October, 2018

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JXTG Holdings

Aiming to develop into one of the most prominent and comprehensive energy, resources and materials company groups in Asia

Listed subsidiaries
NIPPO/Toho Titanium

JXTG Nippon Oil & Energy

A leap forward to become a standout market leader

Market Share of domestic sales of petroleum products

50%

FY2016 actual: No. 1 in Japan

Established presence in the global market

Paraxylene ※1

No. 1 in world **3.62** million tons/year

Propylene

No. 1 in Asia **1.7** million tons/year

JX Nippon Oil & Gas Exploration

Crude oil and natural gas production (a project company basis)

128 thousand barrels/day

Crude oil equivalent (FY2016 actual)

JX Nippon Mining & Metals

Equity entitled copper mine production

200 thousand tons/year

contained in copper concentrate (FY2016 actual)

Refined copper production capacity

920 thousand tons/year

on equity stake basis as of March 2017 ※2

Electronic Materials

Products with world No.1 market shares

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JX Nippon Mining & Metals Corporation (JX-NMM)

Company Name	JX Nippon Mining & Metals Corporation
Head Office	Otemachi, Chiyoda-ku, Tokyo, Japan (in front of Imperial Palace)
Establishment	Y1905 as mining company in Hitachi
Capital	¥20,000 Million
Stock Holder	100% JXTG Holdings,Inc.
Employees	2,600 employees (as of 2017.1. 1)

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JX- NMM Consolidated Financial Result

Sales Revenue

100M JPY

12000
9000
6000
3000
0

9,649 10,391 11,560 10,497 10,031

2012 2013 2014 2015 **2016**

CAGR 8% 9% 3% 1%

Income

100M JPY

600
400
200
0

440 474 566 133 250

2012 2013 2014 2015* **2016**

* Impairment for “Developing Resources” : ≒M$ 825

<Segments>

600
400
200
0
566
474 440 133 250
25 63 111 266 -10 -15
32 56 90 125 225 -54
15 67 166 168 181 -31
30 50 219 133 -242 -57
57 36 49 183 206 -281

2012 2013 2014 2015 **2016**

Developing Resources
Smelting
Elecronic Materials
Recycling
Titanium
Inventory Related

Elecronic Materials 2017 Financial FCST

250*

* JX-NMM will adopt IFRS since 2017.

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Organization Chart of JX-NMM

- Board of Directors
  - Chairman
- President & Representative Director
  - Executive Meeting
    - CSR Committee
    - Internal Control Council
    - Risk Management Council
    - Human Resource Council
    - Technology Council
  - Technology Group
  - Metals Group
  - Recycling & Environmental Services Group
  - Electronic Materials Group
    - Administration Dept.
    - Planning Dept.
    - Technology Dept.
    - Functional Materials Division
      - Copper Foil Dept.
      - Rolled & Fabricated Products Dept.
      - Market Development Dept.
      - Hitachi Works
      - Kurami Works
    - Thin Film Materials Division
      - Sputtering Target Dept.
      - Compound Semiconductor Dept.
      - Surface Treatment Dept. ⇒ UBM
      - Isohara Works
- Auditor
  - Secretariat to Auditors

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JX Nippon Mining & Metals - Business Streams

Metals

Resource Development

Development and Mining of non-ferrous metal resources

Smelting and Refining

Smelting and refining of non-ferrous metals; copper, gold, and silver

Recycling and Environmental services

Recycling of non-ferrous metal materials and treatment of industrial waste for re-use

Smelting and Refining

Smelting and refining of non-ferrous metals; copper, gold, and silver

Electronic Materials

Metal Manufacturing

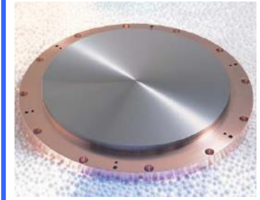
Precision Rolling

Precision-rolling of copper, copper-alloy, and special steel products

Precision Fabrication

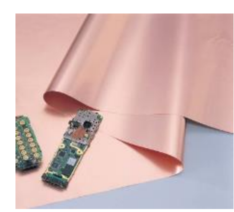
Precision fabricated products such as gold-plated products and press products

Thin Film Materials



Thin film materials such as sputtering targets, and compound semiconductor materials

Copper Foil



Electro-deposited copper foil, treated rolled copper foil

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JX Metal Business Electronic Materials Share

Metals Business

Electronic Materials

Main products	Global market share	Primary applications	End-use applications				
			PCs	Mobile phones / Smart phones	Digital, Avs	Telecom infra/ Data canter	Auto mobiles
Semiconductor targets	60% No.1	CPUs, memory chips, etc.	◎	◎	◎	◎	○
ITO targets for FPDs *	30% No.1	Transparent electrodes	◎	◎	◎		○
HD media targets	60% No.1	HDD (Hard disk drives), etc.	◎		○	◎	
In-P compound semiconductors	50% No.1	Optical comunication devices, High-speed IC			○	◎	○
Treated rolled copper foil	80% No.1	Flexible printed circuit boards	○	◎	◎		○
Phosphor bronze	65% No.1	Connectors, Springs for electronic materials	○	◎	○		○
Corson alloy (C7025)	60% No.1	Connectors, Lead frames	○	◎	○	○	○
Titanium copper alloy	70% No.1	High-class connectors, etc.	○	◎	○		○

* Flat Panel Displays

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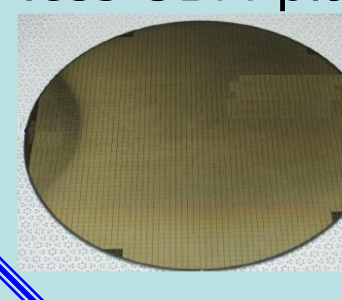
Products of Surface Treatment Department

※Product written in blue letters is under developing

Products :
Materials for Semiconductor wiring & interconnection /Subcontracting service for E-less UBM plating layer

E-less UBM plating



Applied for Semiconductor packaging

Low-α Sn

Low-α Sn materials for solder, plating solution and so on

CuP anode

Anode materials for Cu plating of wafers

Cu paste

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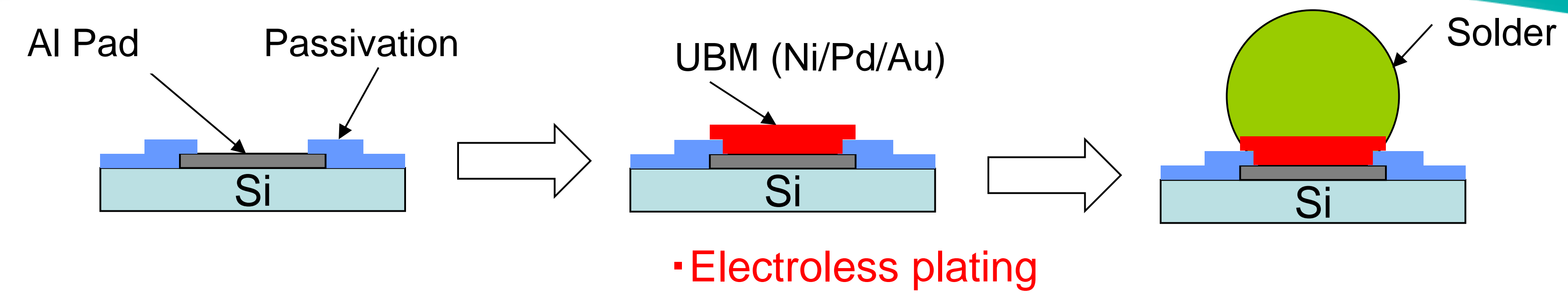
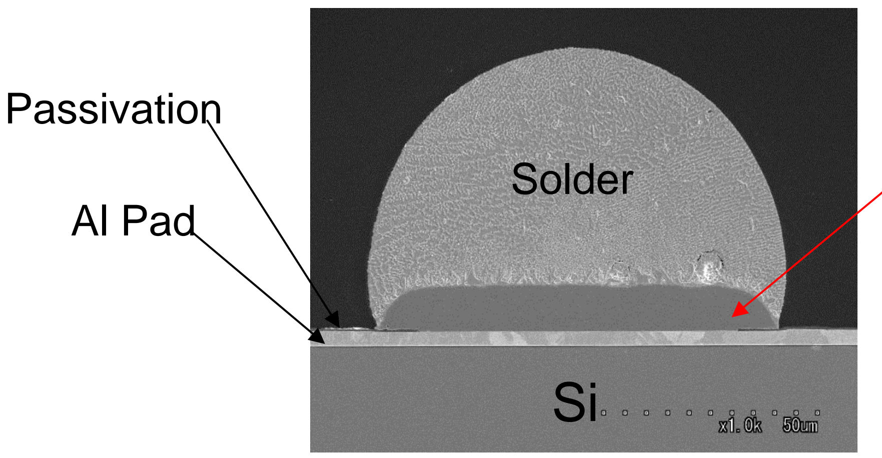
What is UBM-Solder Bumping?

Under
Bump
Metallization



・Electroless plating



UBM (Ni/Pd/Au)

Ni: Barrier layer of solder diffusion

Pd: Barrier layer of Ni diffusion

Au: Widen process window for bonding
Solder Wettability

Fig. Cross section of Bumping on Pad

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Advantages of E-less UBM

Comparison between Electroless and Electrolytic plating

Advantages

✓ Low Cost: High selectivity (Plating on the selected portion)
Selective plating with short process
--- No Mask (high flexibility for changing chip design)
No Metal Sputtering needed

✓High Throughput: Batch Processing of Multiple Wafers
No wafer size requirement, No photo-process

✓Fine pattern: No electrode needed

Drawbacks

✓ High sensitivity: Susceptible to electrical potential difference between pads, surface contaminations and Si exposed portion (scribe line)

✓ Resist/Passivation attack: Resist and passivation are attacked by plating solution in some cases.

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UBM Production Site

Japan

Co., Ltd.

JX Nippon Tomakomai Chemical Co., Ltd.

Kurami Works, Kawasaki Plant

Kawasaki Office, JX Nippon Coil Center Co., Ltd.

Esashi Works,

Sanyu Electronics Industry Co., Ltd.

Isohara(磯原) site

JX Nippon Kurobe Galva Co., Ltd.

JX Nippon Mikkaichi Recycle Co., Ltd.

Tsuruga Plant

JX Nippon Tsuruga Recycle Co., Ltd.

Tamano Smelter, Hibi Kyodo Smelting Co., Ltd.

Isohara Works

Isohara Fabricating Works

Suzuki Manufacturing Co., Ltd.

Kurami Works

Kurami Office, JX Nippon Coil Center Co., Ltd.

Takatsuki Works, JX Metals Trading Co., Ltd.

Kasuga Mines Co., Ltd.

Saganoseki Smelter & Refinery, Pan Pacific Copper Co., Ltd.

Saganoseki Plant, Japan Copper Casting Co., Ltd.

Taiwan

LS-Nikko Copper Co., Ltd.

JX Nippn Mining & Metals Korea Co., Ltd.

Poongsan-Nikko Tin Plating Corp.

Nikko Metals Suzhou Co., Ltd.

Nikko Fuji Precision (Wuxi) Co., Ltd.

Changzhou Jinyuan Copper Co., Ltd.

Pan Pacific Copper Shanghai Co., Ltd.

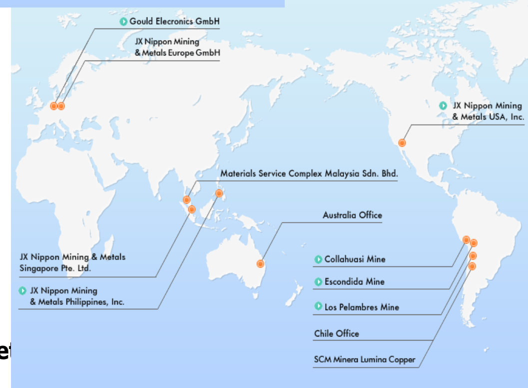
Nikko Metals Shanghai Co., Ltd.

Nikko Metals Trading & Services (Shanghai) Co., Ltd.

Longtan(龍潭) site

Nikko Metals Taiwan Co., Ltd.

Nikko Metals Hong Kong Co., Ltd.



2 production sites related to UBM

Japan Isohara(磯原) site
--- Mass production, Trial production, Sample analysis

Full-Automatic Plating Line #1

Full-Automatic Plating Line #2

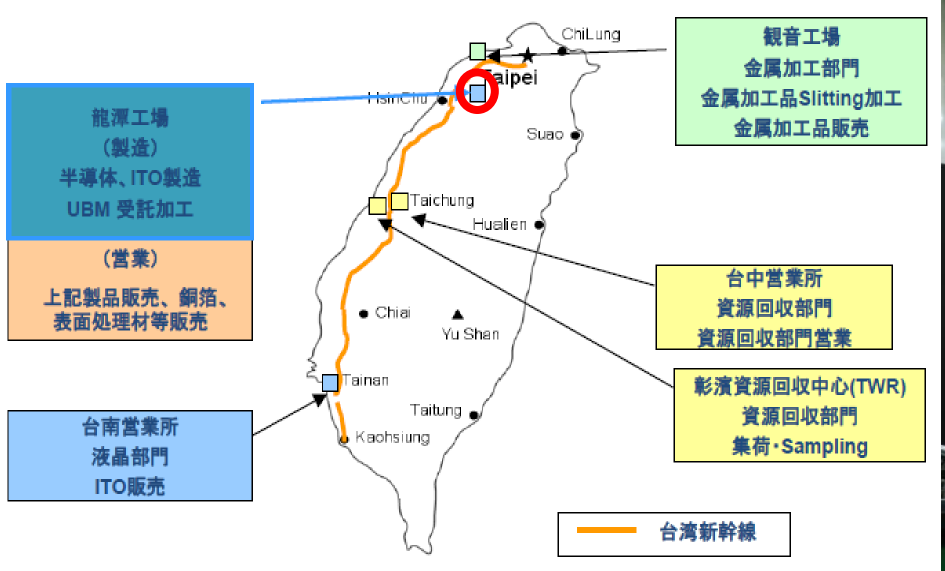
2007.6 Production Line#1 and #2 installed
2008.1 Operation started

2010.12 Production Line#3 installed
2011.5 Operation started

Full-Automatic Plating Line #3

Taiwan Longtan(龍潭) site --- Mass production

Dec. 2014 Installed
Feb. 2015 Operation started



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Capacity

Location	Taiwan	Japan
Plating Line	1 line	3 line (2 of 3line are occupied)
Equipment capacity (pcs/month)	30,000	39,000
Current capacity (pcs/month)	20,000	15,000

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JX's Electroless-plating UBM service

Arrival of wafer → Inspection → E-less Plating (UBM Formation) → Inspection → Shipping

Inspection:
- •Appearance (Naked eyes)
  crack, scratch,
  foreign particle,
  discoloration

Inspection:
- •Thickness (XRF)
  Ni/Pd/Au, Ni/Au
- •Appearance
  (Naked eyes, Optical Micro Scope)
  crack, scratch,
  foreign particle,
  discoloration

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Basic process of E-less plating for UBM -- Ni/Pd/Au process

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Features of JX's E-less Ni/(Pd)/Au UBM

Table Typical features of the process

Ni (material)	Ni- P (P: 5~10wt%)
Ni thickness	1.5~5.0μm should consider pad spacing
Pd thickness (center value)	0.05~0.2μm
Au thickness (center value)	0.02~0.2μm (Ni/Pd/Au: max.0.05um, Ni/Au: max.0.2um)
Thickness uniformity	Less than ±10% in 200mm wafer
Shear strength	100MPa (typical data)
Al etching	0.1μm (for AlCu, AlSiCu) 0.5μm (for AlSi)

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JX's Electroless plating for UBM

Property	Specification (Mass production in Longtan)	Specification (Trial production in JPN site)
Wafer	Si	Si, GaAs, SiC, GaN
Bond pad metal	Al, AlSi, AlSiCu, AlCu	AlCu, AlSiCu, AlSi, Al, Au, Cu
Bond pad thickness	≧1μm	min. 0.4μm
Passivation	SiN, SiO_2, polyimide	← See left
Residues on bondpads (inorganic, organic)	Not acceptable	← See left
Wafer size	≦ 300mm (12”)	← See left
Wafer thickness	≧200μm	80μm (6”) , 130μmt (8”)
Bond pad geometry	Square, rectangular, round, octagonal and any others	← See left
Passivation opening	≧60μm	min. 4μm
Bond pad spacing	≧ 20μm (depends on Ni thickness)	min. 7μm (depends on Ni thickness)
Wafer fabrication process	CMOS, power device, MEMS and any others	← See left
Ink dots	Not acceptable	← See left
Probe marks	Acceptable	← See left
Scribe lines	SiO_2, SiN (must be passivated)	← See left

Inspection equipment (Taiwan & Japan)

Measurement of plated film thickness

Wafer micro visual inspection

Fluorescent X-ray(XRF) Analyzer

Wafer Microscope

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Characteristic evaluation equipment(Japan site only)

Reflow Oven

Wire bonder

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Characteristic evaluation equipment(Japan site only)

Bondtester
Evaluation for reliability of
Solder joint & Wire bonding

Solder checker
Evaluation for Solderability
(Solder wettability)

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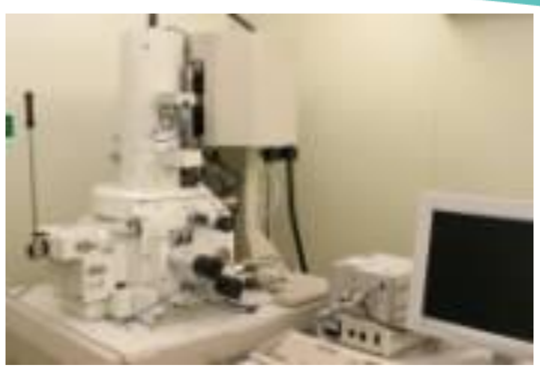
Analytical equipment(Japan site only)

Instruments for Surface morphology

Noncontact 3D Measuring Equipment

(Surface profile)



FE-SEM

(High mag. Observation)

FIB-SIM

(X-section)

SPM

(Surface profile)

STEM (in Hitachi)

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Analytical equipment(Japan site only)

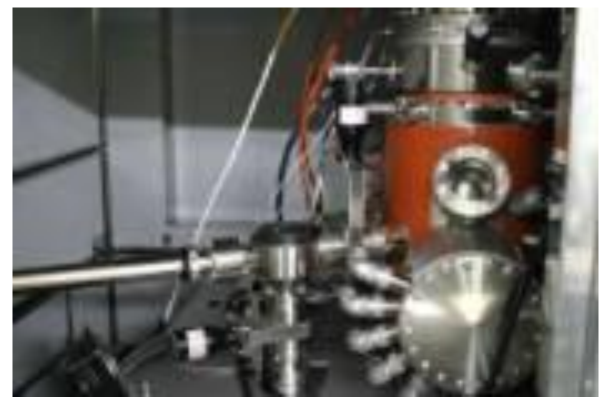
Instruments for Functional group analysis

FT-Raman

FT-IR

Instruments for Elemental analysis

FE-EPMA



FE-AES

XPS
(in Hitachi)

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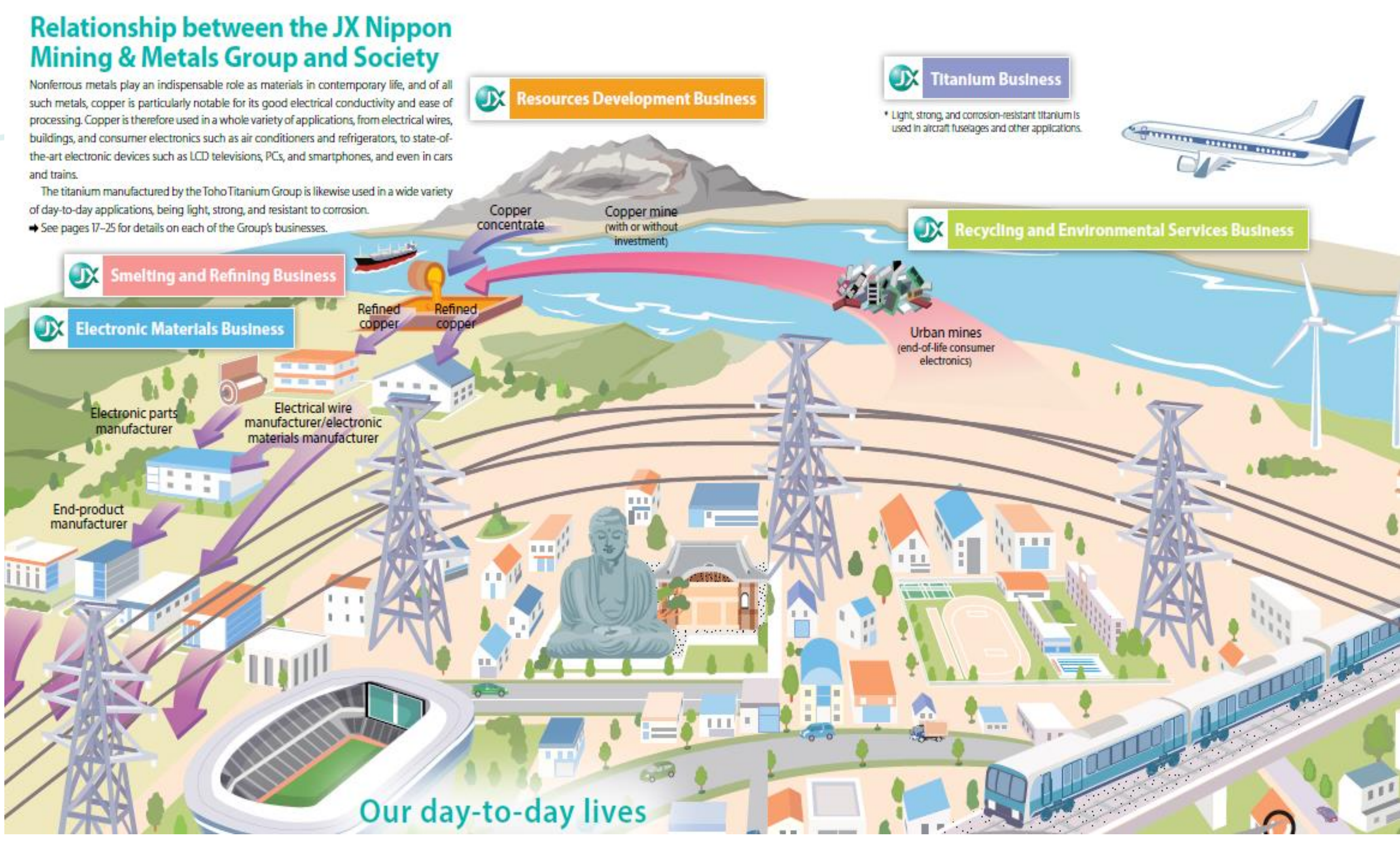

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Appendix

Example of Defect Mode

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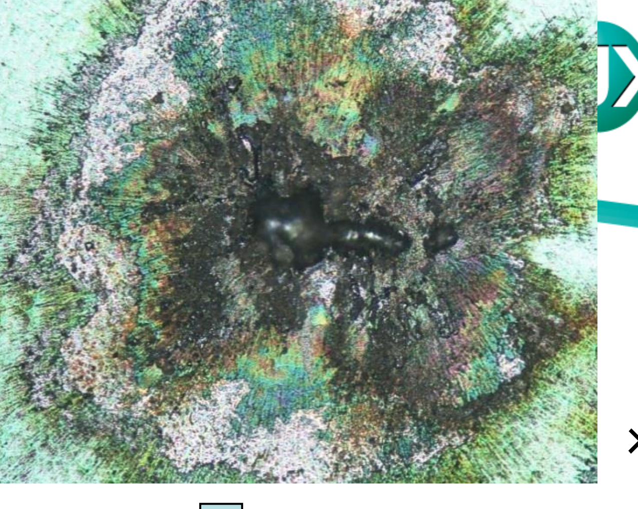
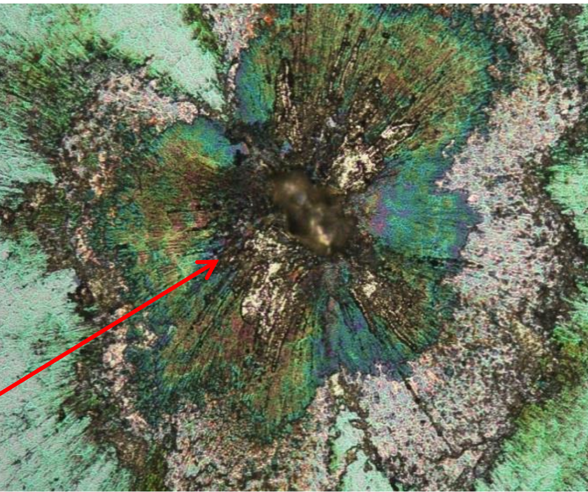
Example of unsuitable wafer for Electroless plating (1) Si exposed portion (Abnormal plating)



×200

Plating



Au deposition

×200

There were some tiny dimples at the back-side.
After the plating process, abnormal Au plating was observed on the dimples.

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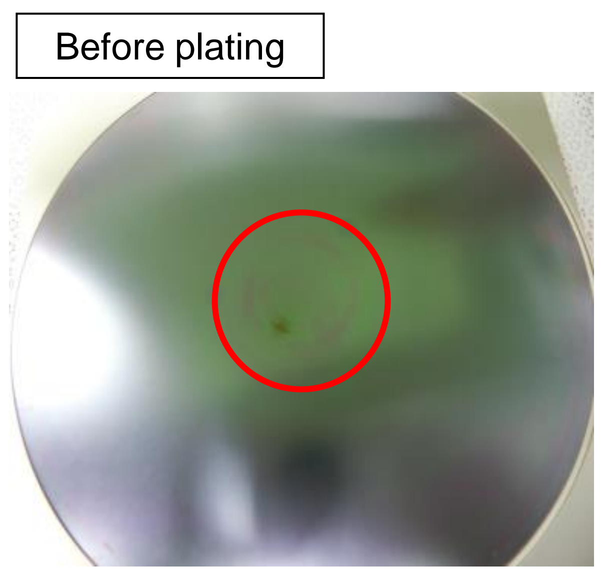
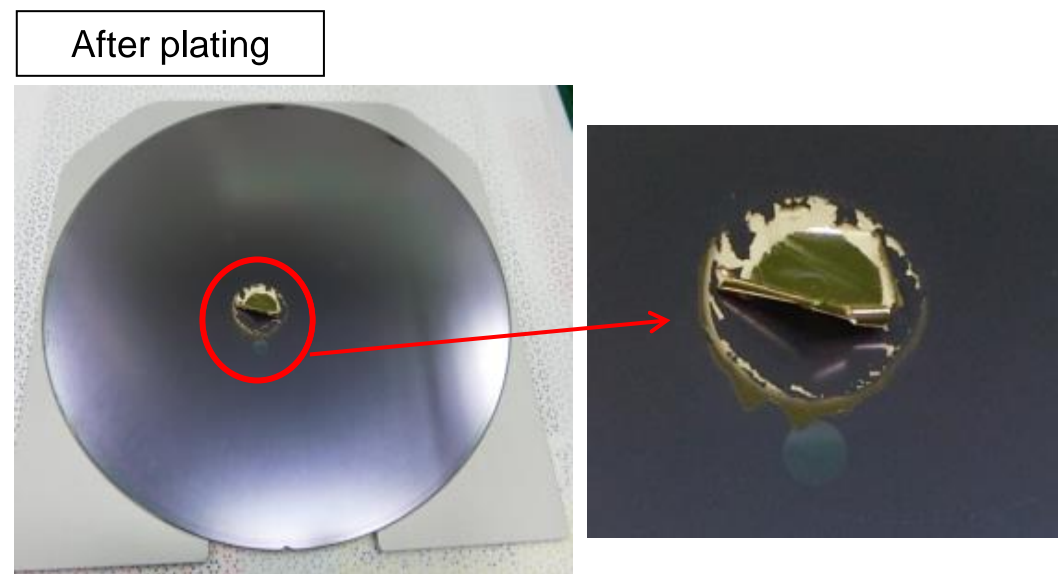
Example of unsuitable wafer for Electroless plating (2)

Surface contaminations on wafer (Abnormal plating)

Before plating



After plating



Abnormal Au plating and peeling of plating film were observed at backside.

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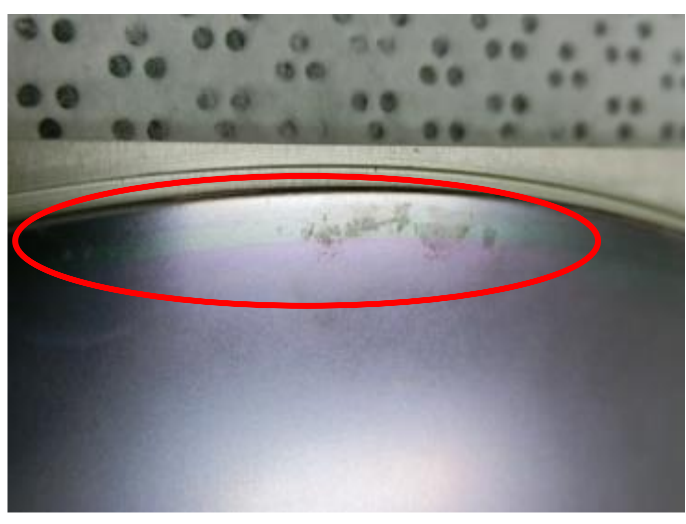
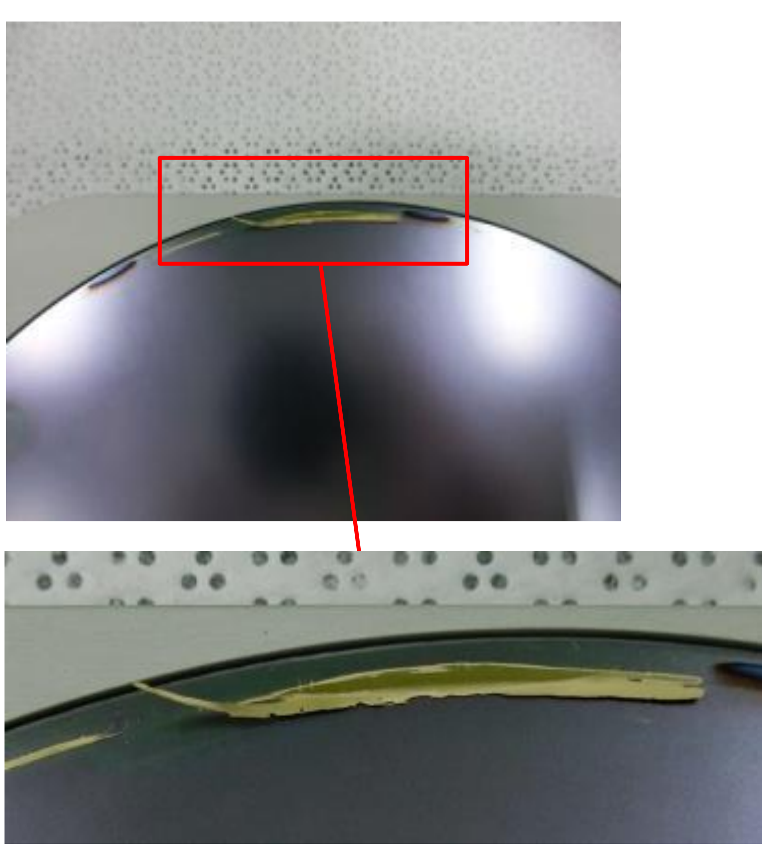
Example of unsuitable wafer for Electroless plating (3)

Surface contaminations on wafer (Abnormal plating)

Before plating



After plating



Abnormal Au plating and peeling of plating film were observed at backside.

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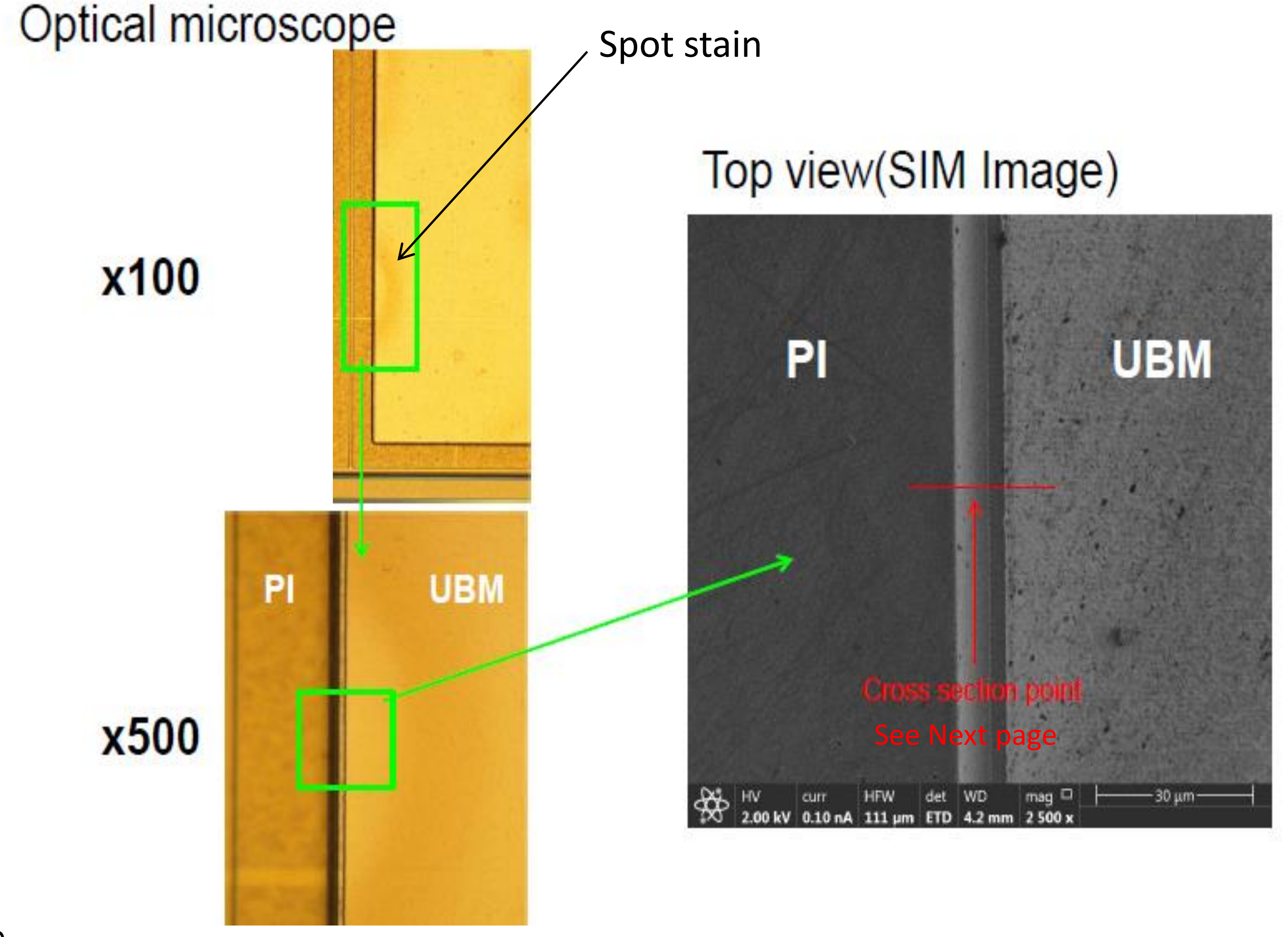
Example of unsuitable wafer for Electroless plating (4)

Insufficient adhesion of PI (Spot stain)



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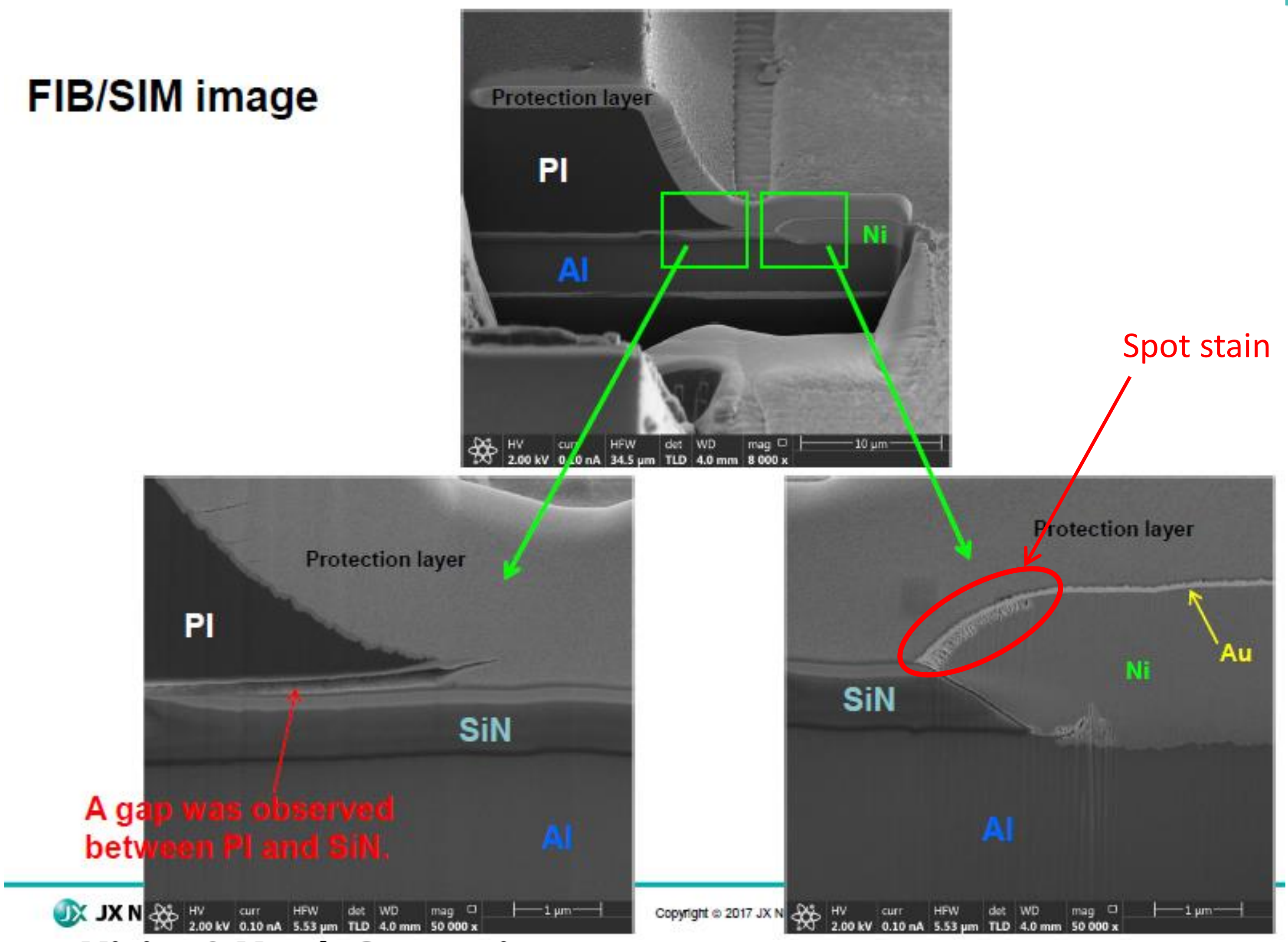
Example of unsuitable wafer for Electroless plating (4)

Insufficient adhesion of PI (Spot stain)



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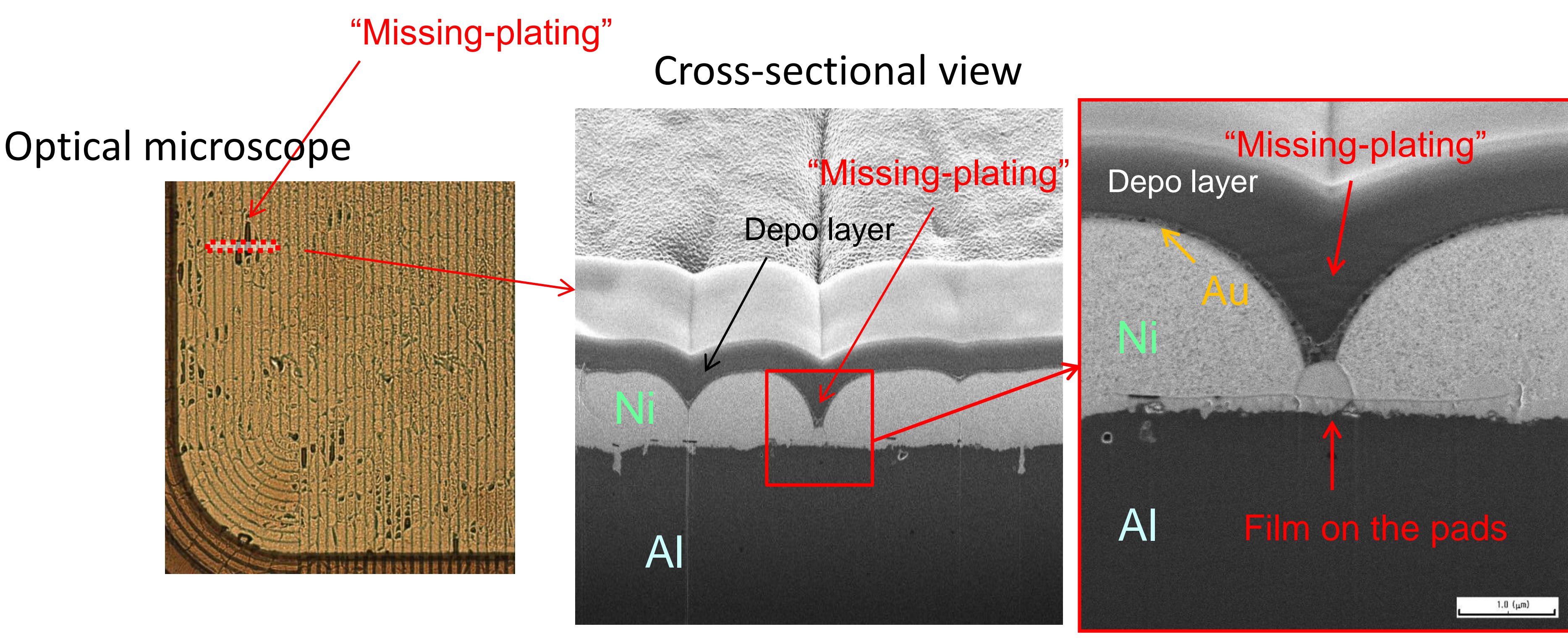
Example of unsuitable wafer for Electroless plating (5)

Surface contaminations on Pad (Missing plating)



Something like film was observed on the Al-Cu pad at "missing-plating" point.

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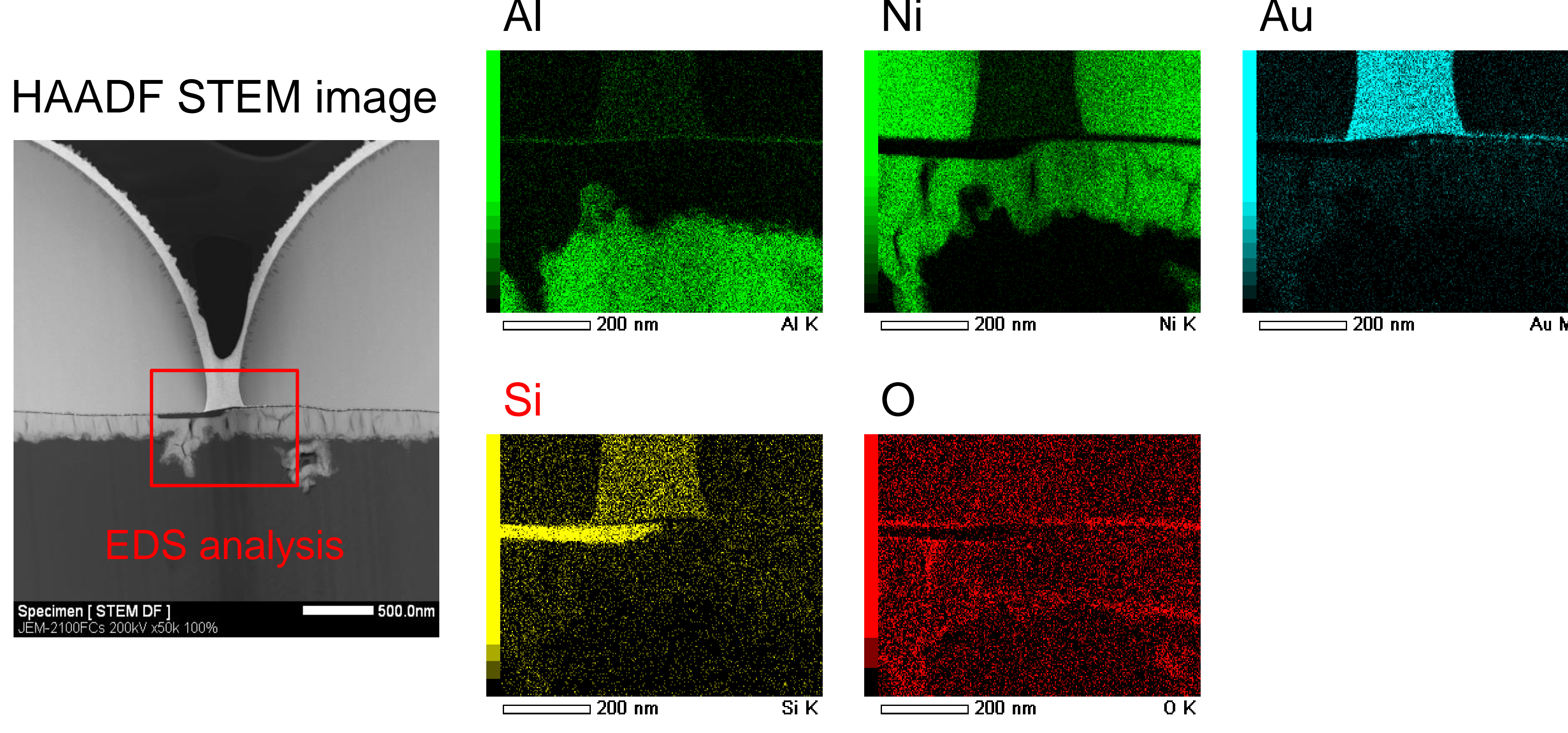
Example of unsuitable wafer for Electroless plating (3)

Surface contaminations on Pad (Missing plating)



At "missing-plating" point, thin residue was observed on the Al-Cu pad.
By EDS elemental analysis, Si was detected as component of the residue.

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