KOTO

Compact Makes Impact

Cu direct plating technology on quartz glass for RF application

T. Onishi, M. Takayama
Koto Electric Co., Ltd. / Japan

GWC
Glass Wet Cu Plating

May 1st, 2025

Today's Agenda

- About KOTO
- Back Ground
- GWC (Glass Wet Cu Plating) Introduction
    - Process Flow
    - Feature / Key Process
    - Adhesion Mechanism
    - High Aspect Ratio (AR)
    - Reliability
    - Application
- Conclusion

T. Onishi

Onishi is managing director of process engineering consulting company Grand Joint Technology Ltd (G.J.Tech) 28Y in HK.

Older chemical background semiconductor packaging Japanese engineer 45 years in electronics assembly packaging field life with failure analysis + packaging process improvement

senior the Japan Institute of Electronics Packaging (JIEP) member and a director of Nagano Jisso Forum Japan.

More than 10 years of Glass PKG research with Koto & NJF

32Y in HK

宇宙航空、軍用電子部品研究会 『CMSE2023』@LAX

～ロサンゼルス空港ホテルで開催された、特殊電子部品専門研究会～

Grand Joint Technology Ltd
大西　哲也（T. Onishi）

写真4　各セッションでも続く討議

写真5 『CMSE2023』の展示の様子

Glass PKG session @ ICEP2024

Keynote Lecture III: Glass packaging for Emerging Applications in Advanced Communications and AI
Madhavan Swaminathan, The Pennsylvania State University

FA1: Glass PKG-1

Chairs: J. Mizuno, National Cheng Kung University, T. Onishi, Grand Joint Technology

FA1-1 <Session Invited> Markets, Opportunities, and Challenges with Glass Package Applications: Today +10
E Jan Vardaman, TechSearch International, / USA

FA1-2 <Session Invited> Glass Material and TGV Formation Technologies
Yoichiro Sato, AGC / Japan

FA1-3 <Session Invited> The Role of Structured Glass Substrates for Heterogeneous Integration of Electronics
Martin Letz, Schott / Germany

FA1-4 <Session Invited> High Volume Glass Microhole Formation by LIDE
Hiroyuki Kamidate, LPKF Laser & Electronics / Japan, Richard Noack, LPKF Laser & Electronics / Germany

FA2: Glass PKG-2

Chairs: Y. Sato, AGC, J. Vardaman, TechSearch International

FA2-1 <Session Invited> Challenge of Metallization on Glass Core and Through-Glass Vias
Tomoki Shinohara, Toshio Honda, Toshiya Fujiwara, Atotech Japan / Japan

FA2-2 Development of the Integrated Passive Device for Sub6 Band Using 100 μm Thickness Glass Substrate
Tomoyuki Ishii, Masashi Sawadaishi, Noriko Kano, Masao Ishibashi, Takashi Kizu, TOPPAN Holdings / Japan

FA2-3 Physical and Thermal Characteristics of the Advanced Package with Glass Core Substrate
S. Mitarai, K. Adachi, T. Igarashi, K. Seki, N. Kakoiyama, Y. Tanaka, S. Oka, M. Nakazawa, H. Iwamoto, Sony Semiconductor Solutions / Japan

FA2-4 <Session Invited> Glass Package Trends & Core Technologies
Tetsuya Onishi, Grand Joint Technology / Hong Kong

FA4: Professor S. Denda Memorial Session

Chairs: F. Miyashiro, YJC, K. Hashimoto, C-NET

FA4-1 <Session Invited> (10min.)
Reminiscence of Dr. Seiichi Denda- "Japanese Session" in ISHM/IMAPS Conference
Fumio Miyashiro, Yokohama Jisso Consortium / Japan

FA4-2 <Session Invited> (30min.)
TSV and Bosch Process / The Bosch Process, Enabling the Practical Application and Mass Production of TSV
Hiroshi Tanaka, Sumitomo Precision Products / Japan

FA4-3 <Session Invited> (30min.)
Toward Glass Core Substrate From Si Interposer for the Future Advanced Packaging
Satoru Kuramochi, Dai Nippon Printing / Japan

FA4-4 <Session Invited> (30min.)
Multilayer Glass Core Substrate Technology with Using Conductive Paste
Taiji Sakai, FICT / Japan

Glass PKG session @ ICEP2025

11:30 **TA2: Glass PKG-1**

TA2-1 <Session Invited>
Glass Packaging Markets and Critical Issues to Solve
E Jan Vardaman, TechSearch International / US

TA2-2
Advanced Fabrication Techniques for Through Glass via (TGV) in Glass Core Substrates for Hetrogeneous Integration of 2.5D/3D Advanced Packaging Applications
Venugopal Govindarajulu[1], Coby Tao[1], Vengal Jalagam[1], Keshav Chandran[1], Katsumi Yoneda[2], Zia Karim[1], [1]Yield Engineering Systems / USA, [2]Yield Engineering Systems / Japan

TA2-3
Driving Efficiency in Advanced Packaging: TGV Tool Concepts and Supply Chain Impacts
Richard Noack, Nils Anspach, Daniel Dunker, Roman Anspach, Rafael Santos, LPKF Laser & Electronics / Germany

TA2-4
Pre-treatment for Adhesion Layer in Panel-Level Sputtering Applying an Improved Linear Ion Source
A. Higashi, A. Ihori, T. Yuze, T. Terasawa, Y. Morikawa, ULVAC / Japan

14:00 **TA3: Glass PKG-2**

TA3-1 <Session Invited>
High AR TGV Direct Wet Cu Metallization on Glass
A. Okitmoto[1], T. Onishi[1,2], K. Inoue[1], M. Takayama[1], [1]Koto Electric / Japan, [2]Grand Joint Technology / Hong Kong

TA3-2
Development of Acid Copper Electroplating Chemicals for Advanced Packaging with TSV and TGV
Nobuaki Nagano, Shota Suzuki, Ryo Aizawa, Yusuke Suga, Tetsuro Eda, JCU / Japan

TA3-3 <Session Invited>
Acid Copper Plating Process for RDL Suitable for Glass Substrate
Atsuya Yamaguchi, Kohei Imahase, Reito Kobayashi, Tetsuro Eda, JCU / Japan

TA3-4 <Session Invited>
Integrated Low Temperature Based Glass Core Substrate Manufacturing Solutions Minimizing SeWaRe Type Failures
Christian Buchner, SCHMID Group / Germany

14:00 **FA3: Glass PKG-3**

FA3-1
Examination of Panel-Level Manufacturing Methods for Glass Core Substrates
Shun Mitarai, Kiwamu Adachi, Takahiro Igarashi, Kosuke Seki, Naoki Kakoiyama, Yuto Tanaka, Shuichi Oka, Masashi Nakazawa, Hayato Iwamoto, Sony Semiconductor Solutions / Japan

FA3-2 <Session Invited>
Challenge for Glass Core Substrate with the Stress Analysis and Reliability
Satoru Kuramochi, Dai Nippon Printing / Japan

FA3-3 <Session Invited>
Multilayer Glass Technology for Advancing Packaging and Substrate Innovation
Akira Tamura, FICT / Japan

FA3-4 <Session Invited>
Glass PKG Technology Trend & Core Items
Tetsuya Onishi, Grand Joint Technology / Hong Kong

P15 Cu Metallized Glass Core Evaluation & Testing Method
T. Onishi[1,2], A. Okitmoto[1], K. Inoue[1], T. Watanabe[1], M. Takayama[1], [1]Koto Electric / Japan, [2]Grand Joint Technology / Hong Kong

1 more poster + 4 presentation
TTL 18 Glass PKG

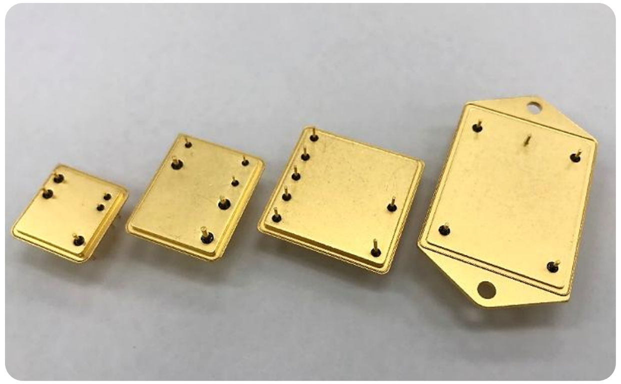
Introduction of KOTO Electric

Lamp Division

Specialty lamps
・Cinema
・TV and stage lighting
・Fishing industry

Hermetic Seals Division

Hermetic seals
・Electronic devices
・Defense
・Aerospace



Device Division

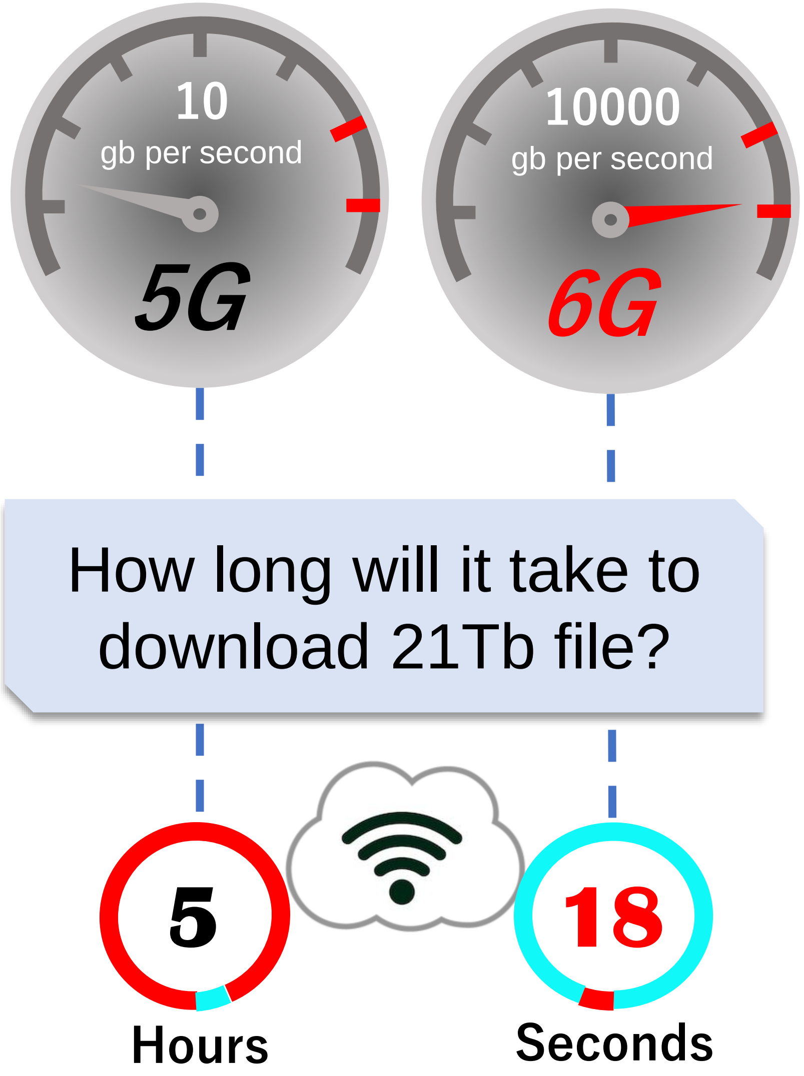
Applying proprietary technology
Developing new business

Plating on glass
▶ Glass sealing and plating technology

Plating on micro-items
▶ Micro-size handling and plating technology

Plating on special resin materials using UV
▶ Lighting and plating

Introduction



Beyond 5G / 6G and the IoT

What Will the IoT Be in the 2030s?

Requirements

- ☆ **High speed data communication**
- ☆ **High speed simulation**
- ☆ **High performance processing**

Systems Packaging Material Platform Options

Characteristic	Ideal Properties	Glass	SC Si	Poly Si	Organic	Metal	Ceramic
		Materials					
Electrical	▪ High resistivity ▪ Low loss and low k	Good	Poor	Fair	Good	Poor	Good
Physical	▪ Smooth surface finish ▪ Large area availability ▪ Ultra thin	Good	Fair	Good	Fair	Fair	Fair
Thermal	▪ High Conductivity	Fair	Good	Good	Poor	Good	Fair
Mechanical	▪ High strength & modulus ▪ Low warpage	Fair	Fair	Fair	Poor	Good	Fair
Chemical	▪ Resistance to process chemicals	Good	Fair	Fair	Fair	Poor	Fair
TPV and RDL Cost	▪ Low cost Via formation and metallization	Fair	Poor	Fair	Fair	Poor	Poor
Reliability	▪ CTE matched to Si and PWB	Good	Good	Good	Fair	Poor	Fair
Cost/mm^2	▪ At 25μm I/O pitch	Good	Poor	Fair	Poor	Poor	Poor

Good Fair Poor

Glass Interposer

- ○ Cost: Lower than Si
- ○ Thermal conductivity: thin one is acceptable
- ○ CTE: as same as Si
- ○ Via: need more / new development
- ○ Pattern line: as same as Si
  * Cu plating is key issue
- ○ High Frequency: Excellent
- ○ Thin glass handling: need special method

Glass PKG Application

Application	Product Type				
E-component	RF device	MEMS	MEMS Switch	Pressure sensor	
Photonics Opt	CIS	Lens	Optical guide	Sensors	LD device
Antenna	5G	mmWave			
Interposer Substrate	5G Ai HPC	FOWLP			
Medical	Micro fluidics	Endoscope	Reactor	Eye	
Touch panel	Touch sensors				
Others	Positioning				

Glass vs Silicon interposer properties

Excellent is Yellow
Fail is Blue

	Silicon	Glass
Thickness (um)	20 ～ 700 (Thinning is necessary)	≧50 (Thinning is not necessary)
Insulation (Ωcm)	$25 \sim 1\times10^{3}$	$\geqq 1\times10^{15}$
Dielectric constant	11.8	3.6 , 5～7
Size (in general)	φ4”～12”	φ4”～12”, Panel
CTE	3～5	1, 3～6, 5～8

Conventional Process and Disadvantages

Conventional Process

- ✓ Dry process
  Sputtering, CVD,
- ✓ Etching + E.L. Plating
- ✓ Printing (Metal paste)
- ✓ Sol-Gel process

Problems

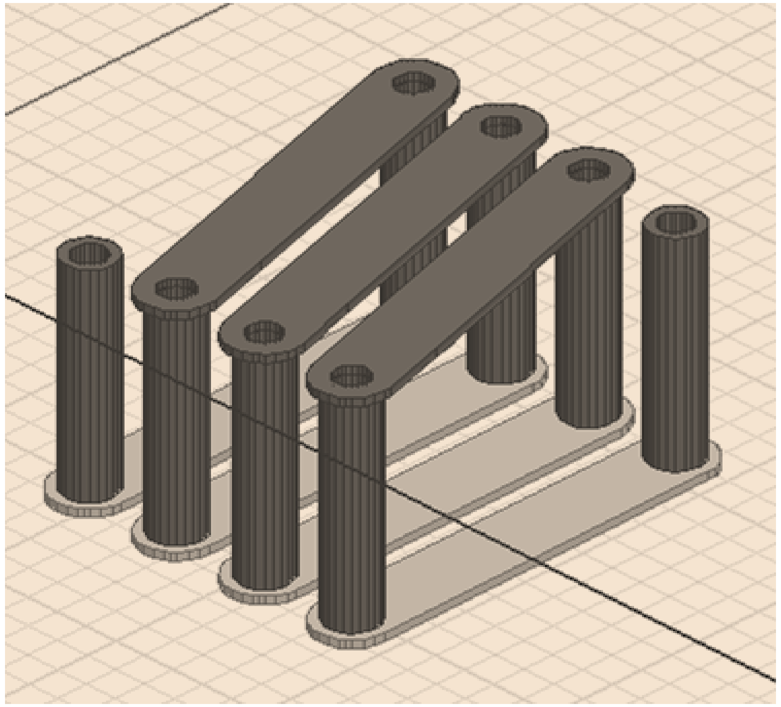
- Difficult to metallize on the 3D structure
- Degrade glass properties
  Heat resistance
  Smooth surface
- High cost process

New glass metal coating techniques required for

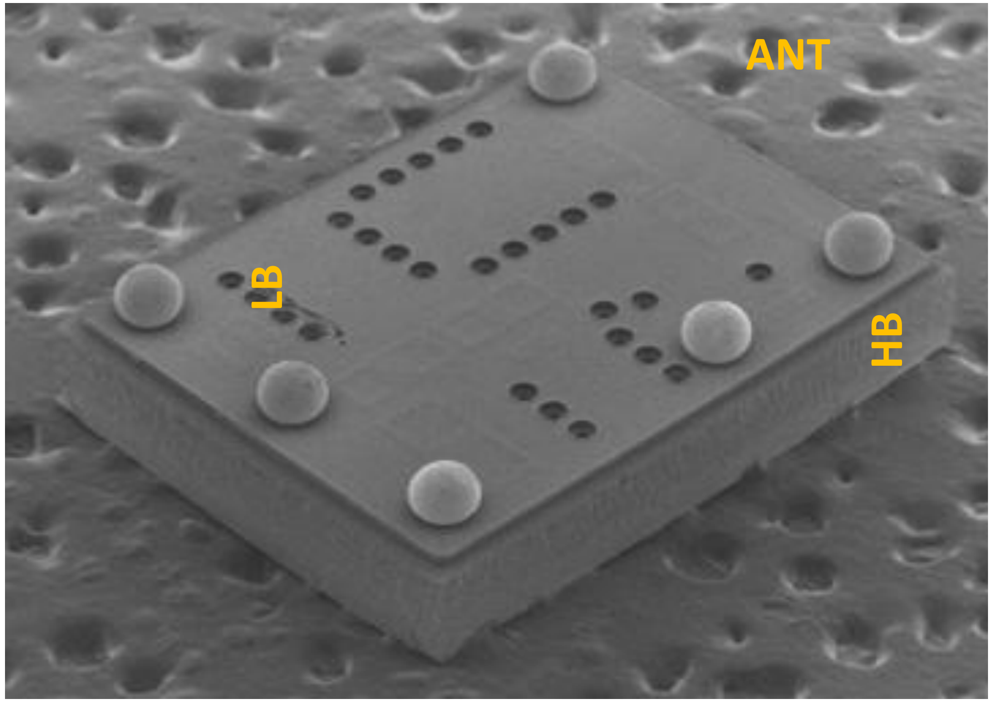
- ➢ **Reducing Process cost**
- ➢ **Easy metallization on 3D structure**
- ➢ **Maintaining glass properties**
- ➢ **Forming good adhesion strength film**

Glass TGV Cu metallization

Glass TGV Application Market



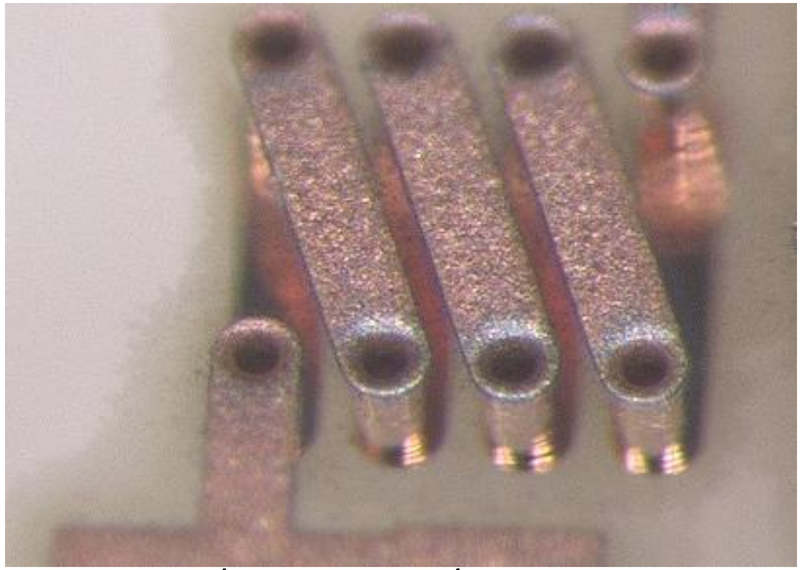
3D rendering of inductor structure



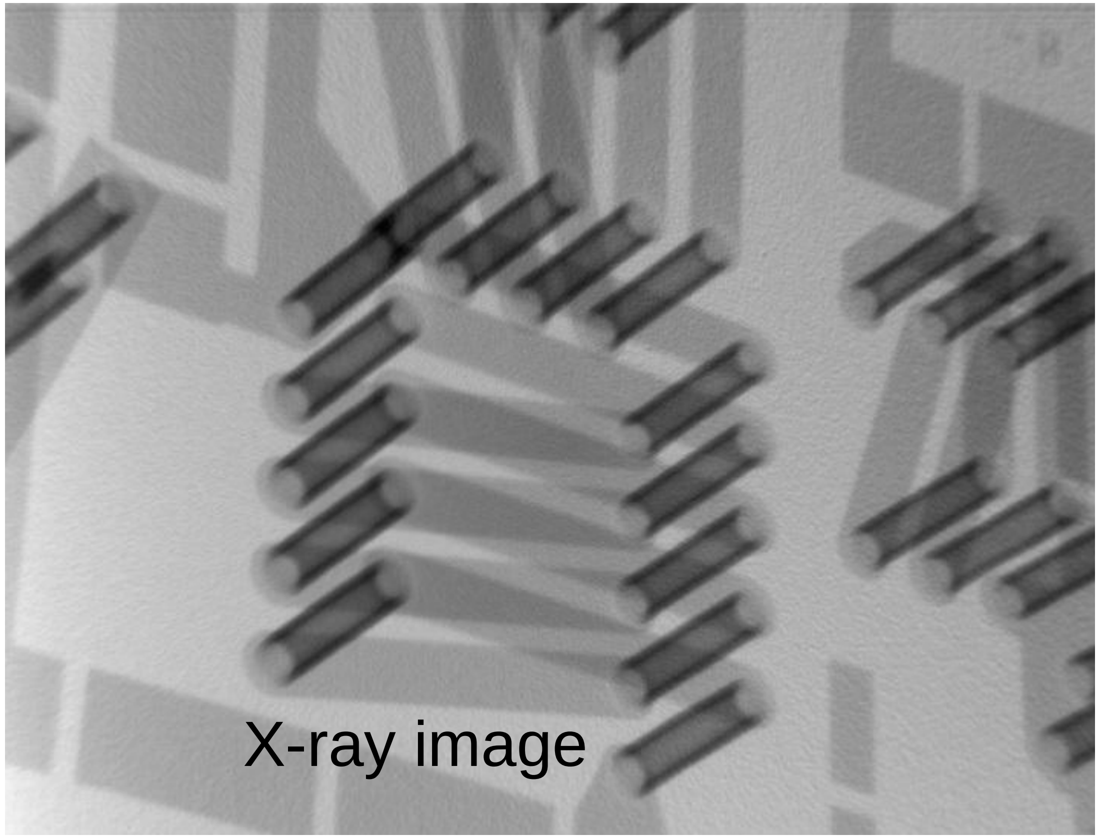
- As the result of well adhered seed copper layer, High Q inductance from 3D Inductor is achieved.

Glass substrate IPD device with TGV

TGV Cu plating on glass for IPD

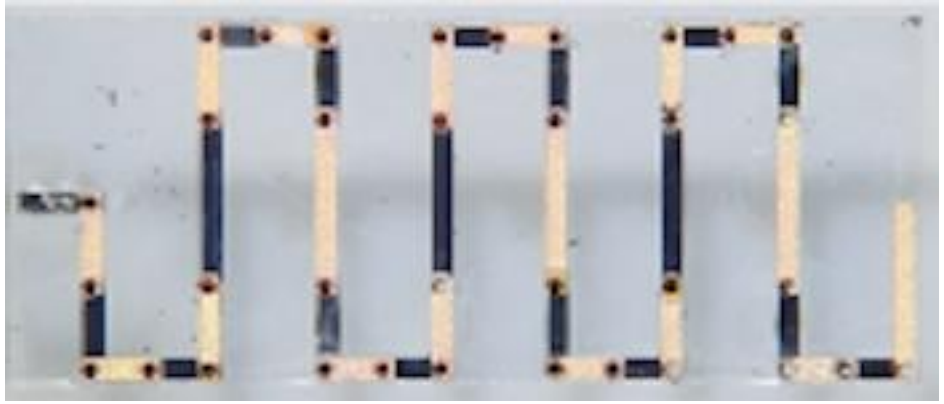


L/S: 100 / 40 um



3D induction coil can get more high Q, because this process can make good adhesive Cu pattern on the glass surface directly.

Glass TGV Application @ Germany



- 10 x 4 qmm antenna made of 700 µm thick borosilicate glass material
- 15 µm thick electroplated copper for liner metallization of vias and redistribution
- dielectric passivation and solder bumps for bonding
- prototype demonstrate the suitability of used glass material for 2.4 GHz ISM band

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Structured-Glass Waveguide Technology for High-Performance Millimetre-Wave Components and Systems

CHAD BARTLETT [1] (Student Member, IEEE), ANTONIO MALAVÉ [2], MARTIN LETZ [3], AND MICHAEL HÖFT [1] (Senior Member, IEEE)

[1] Institute of Electrical and Information Engineering, University of Kiel, 24143 Kiel, Germany
[2] Institute for Materials Science, University of Kiel, 24143 Kiel, Germany
[3] Research and Technology Development Department, Schott, AG 55122 Mainz, Germany

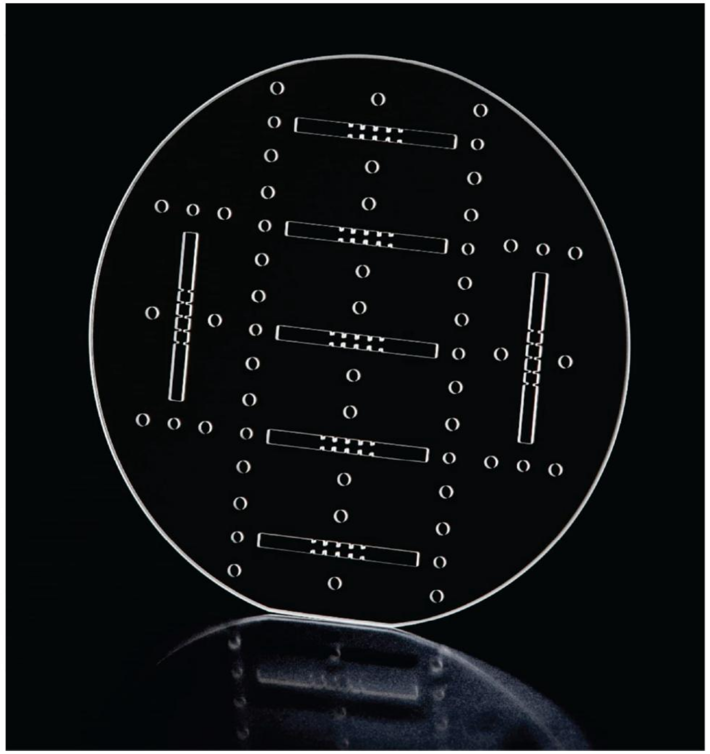

FIGURE 6. A structured-glass wafer sample (100 mm ⌀) with multiple filter structures throughout. (The sample shown is for the middle layer of the filter design shown in Fig. 3).

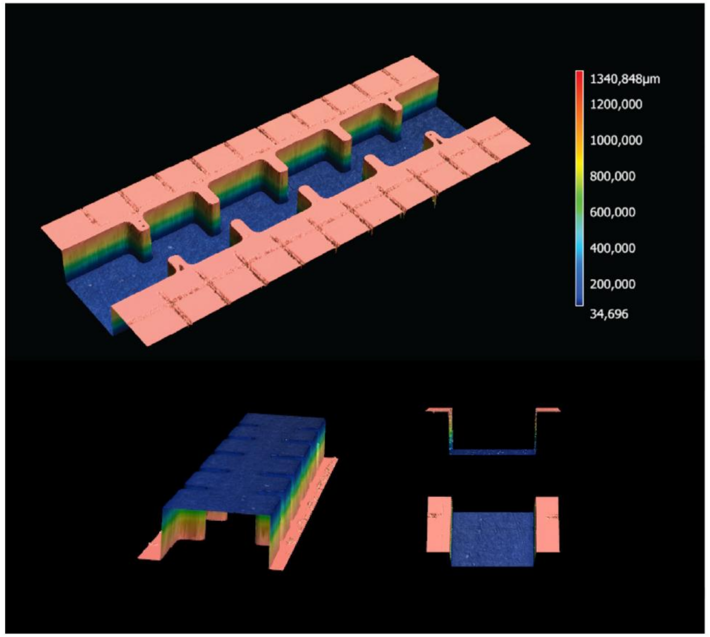

FIGURE 8. 3-D Laser-microscope profiles of the single laser-induced filter shown in Fig. 7. (Grid lines shown on top of the profile are an artifact of the microscope scan). The short waveguide sections (lower right) highlight the vertical sidewall profile at the input section of the filter.

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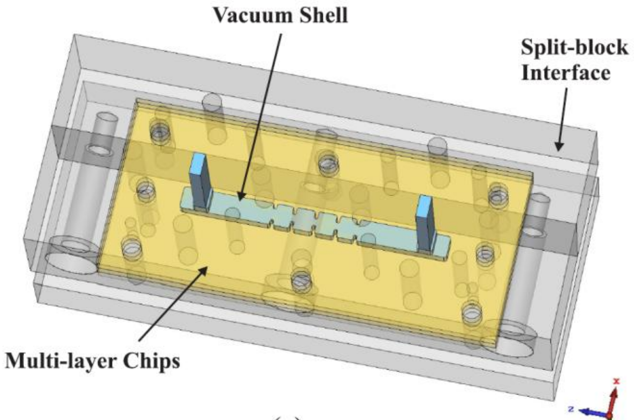
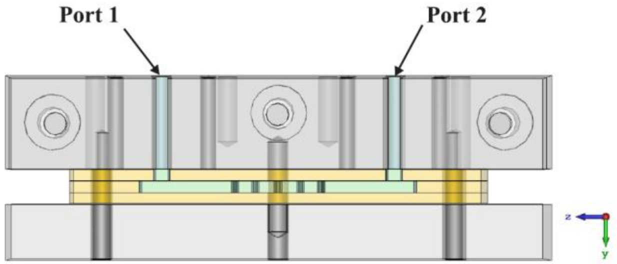


(a)



(b)

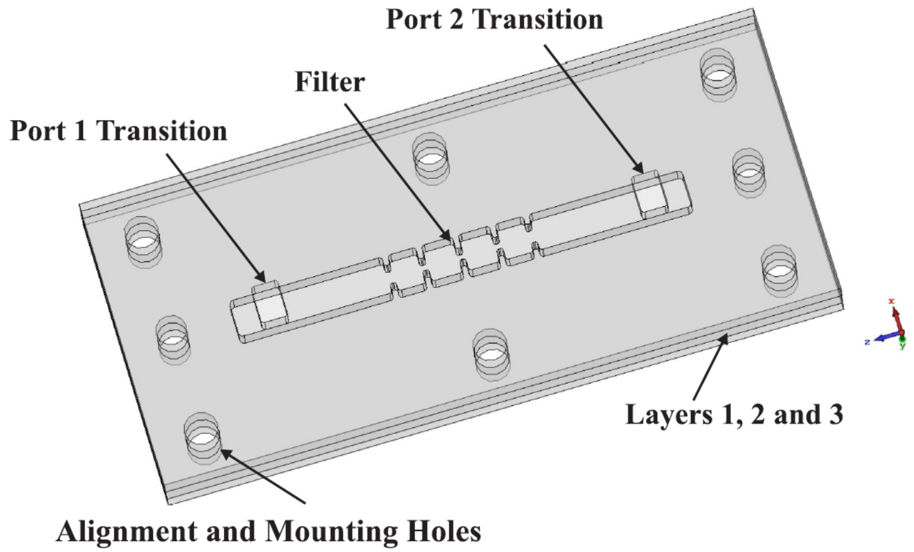
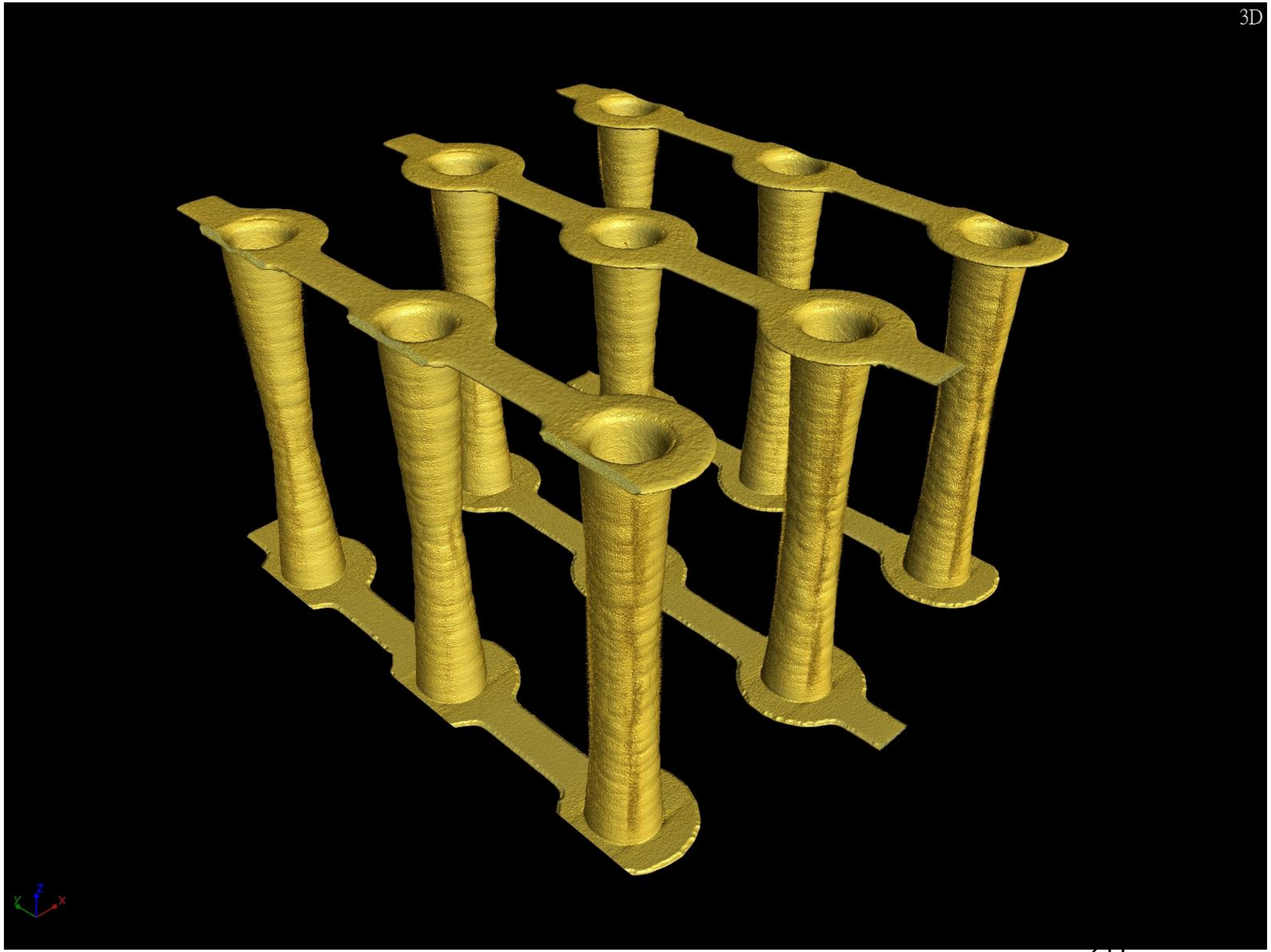
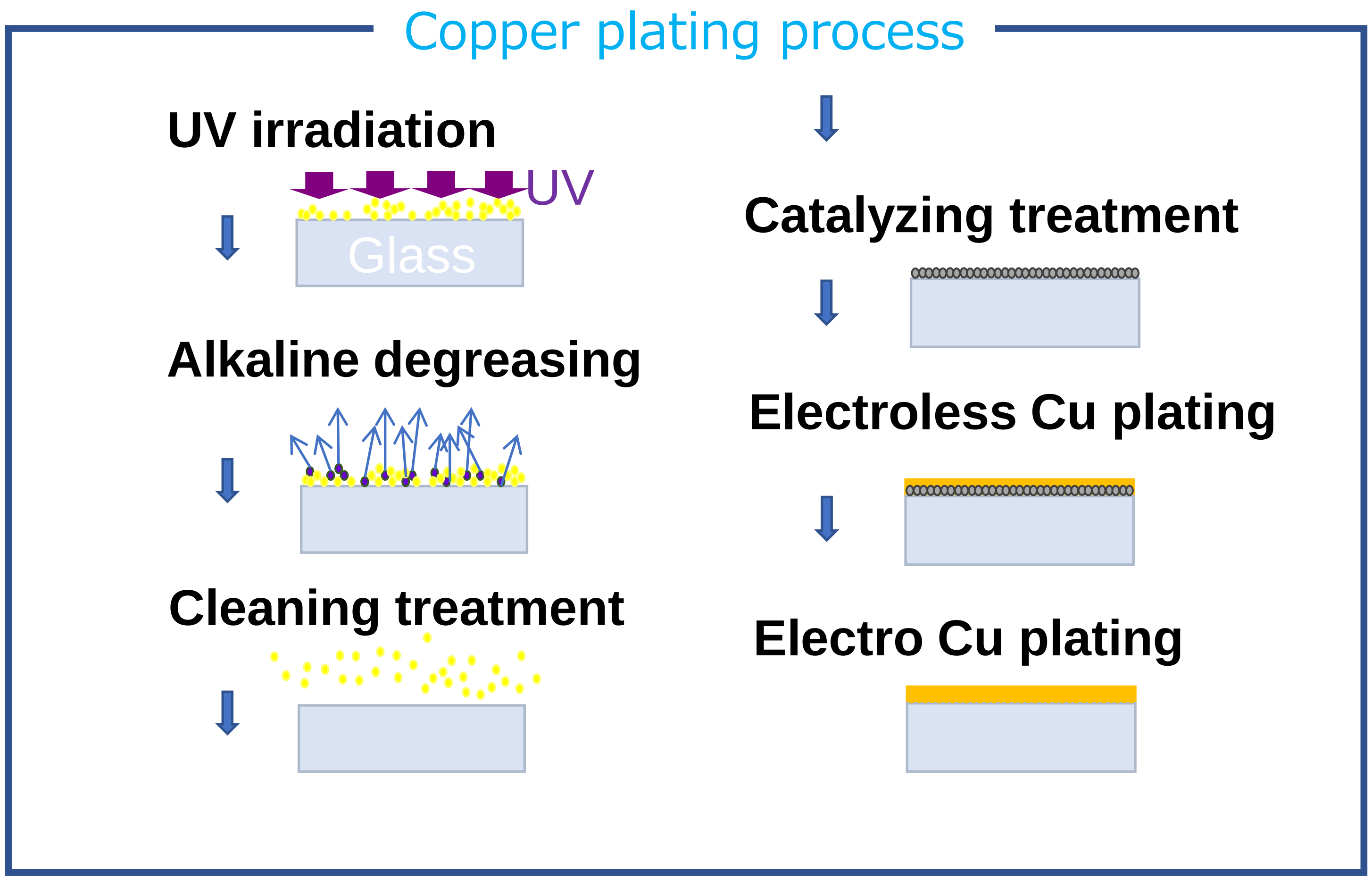


FIGURE 3. CAD layers of the proposed filter structure with the E-plane transitions ports; three wafer chips with similar heights are stacked to assemble the full component package.

Glass PKG FA



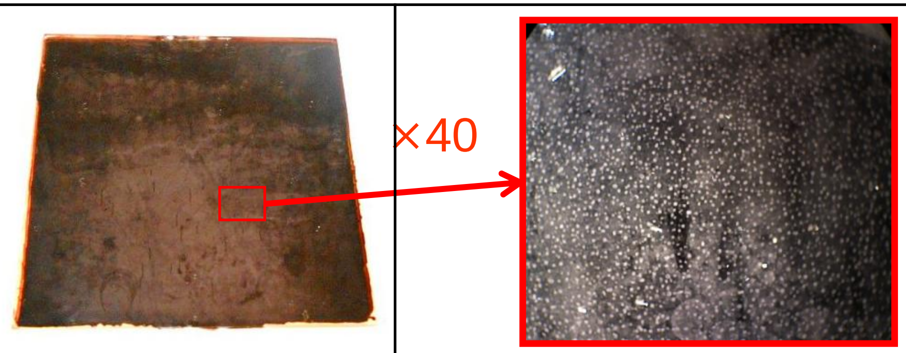
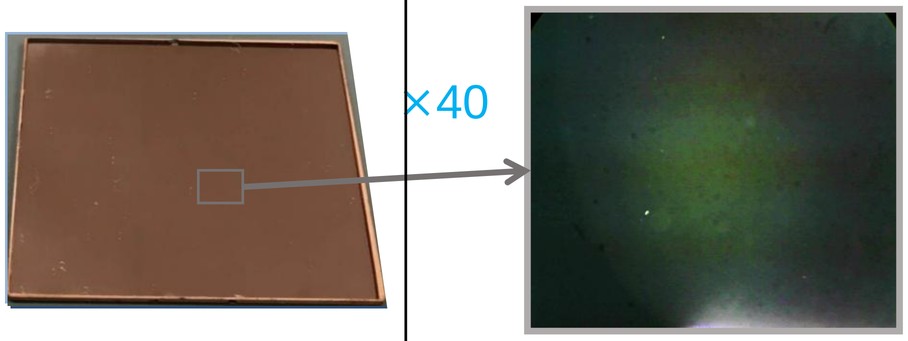
KOTO GWC process



GWC
Glass Wet Cu Plating

KOTO

UV Irradiation effect

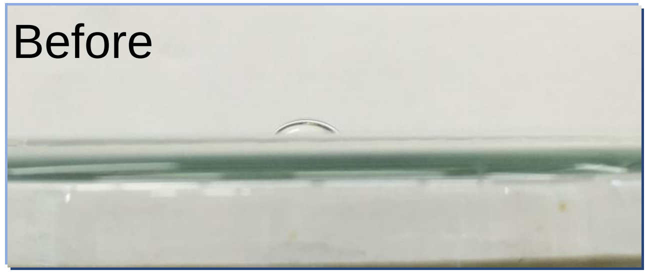
UV treatment	Appearance of copper plating
Without	
With	

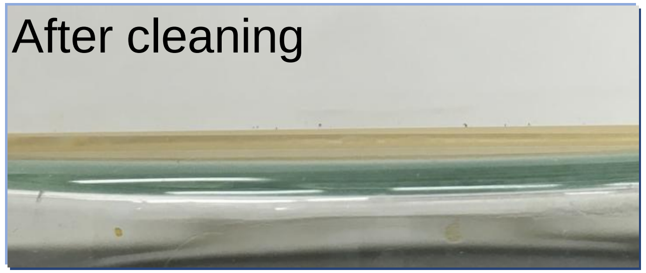
Micro-blisters at the Cu metal film – glass interface were decreased by cleaning the glass surface using UV.

Comparison of cleaning solutions

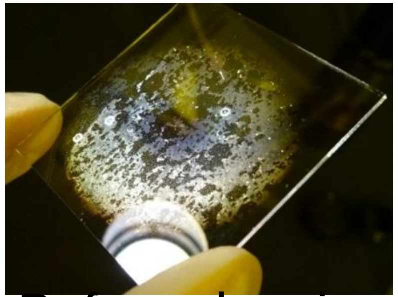
	Wettability	Stain	Appearance
NaOH solution	Fine	Not clear	No Blister
With Chelate solution	Fine	Clear	No Blister
With Surfactant solution	Fine	Clear	Blisters
Methanol	Not bad	Not clear	Blisters

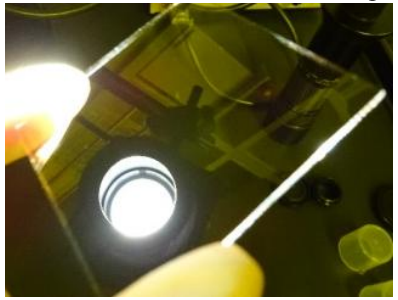
Wettability





Stain


Before cleaning


Chelate solution

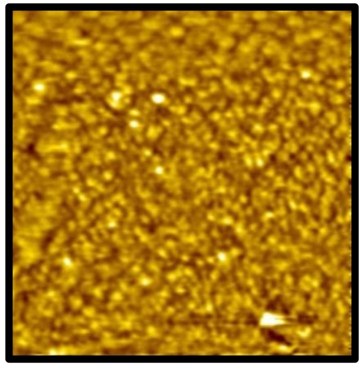
Appearance after plating

Adhesion mechanism of this process

After Cu Plating

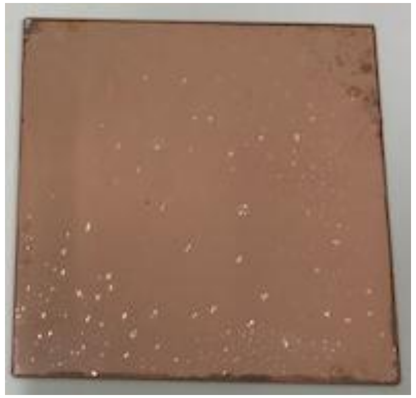
No Blister

After Catalyzing



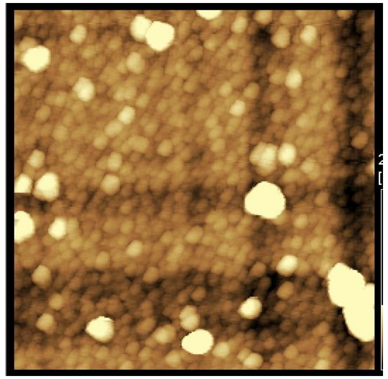
Rz=8.86nm

After Cu Plating



Blister NG

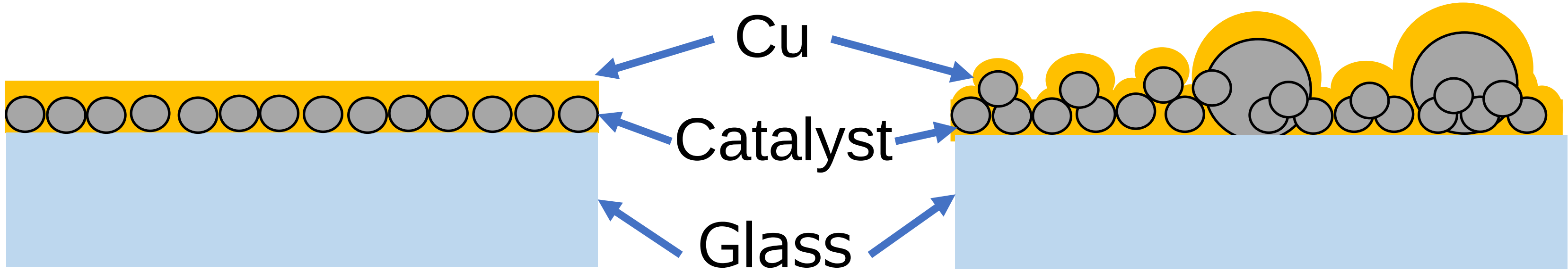
After Catalyzing



Rz=37.5nm

Fine Pd catalyst adsorption

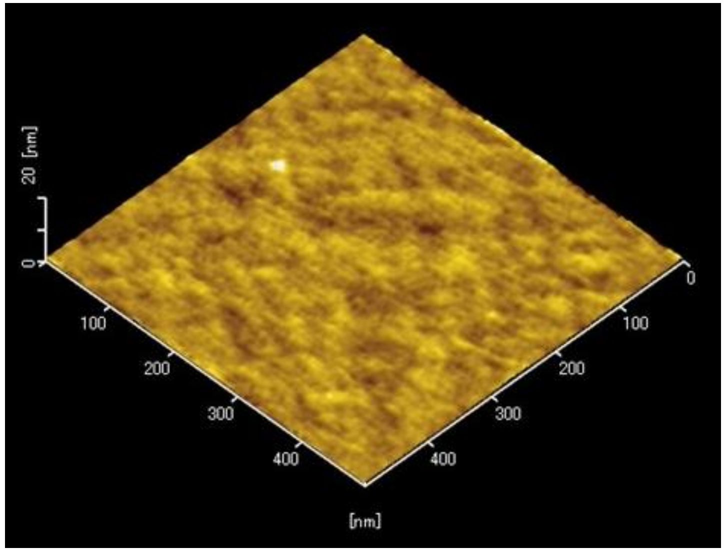
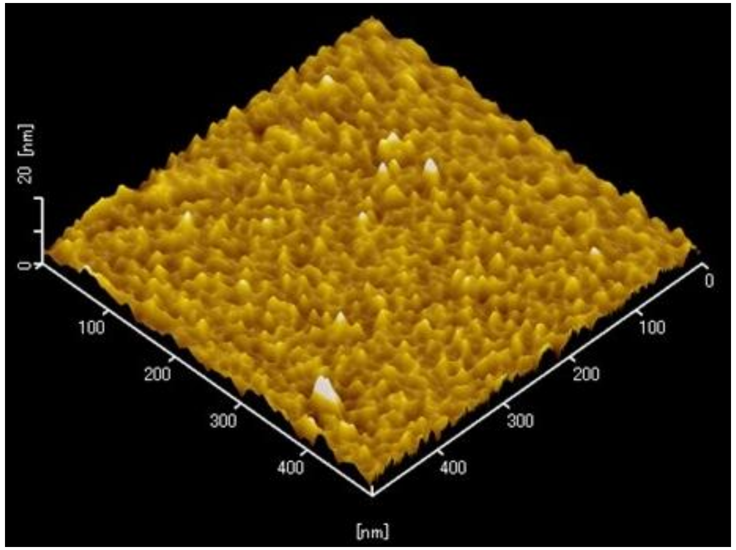
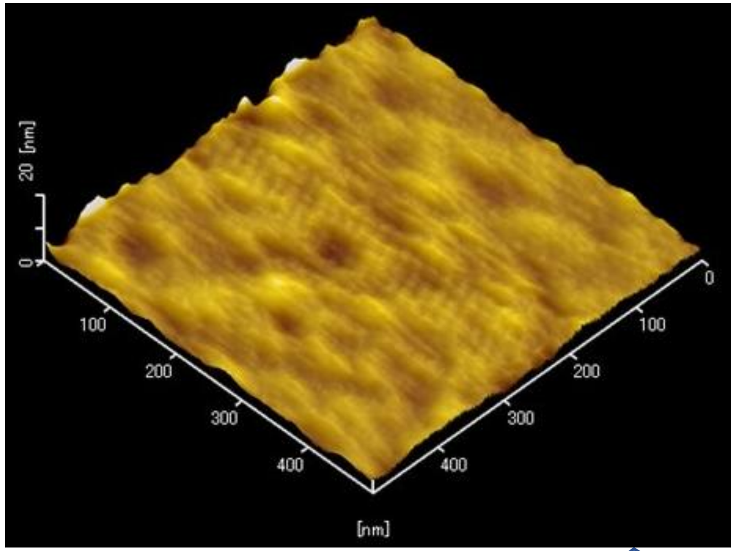
Rough Pd catalyst adsorption

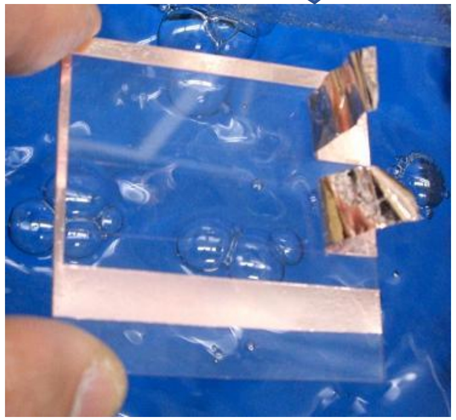


Good

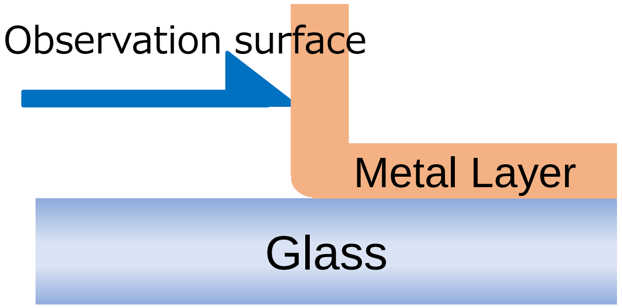
Weak

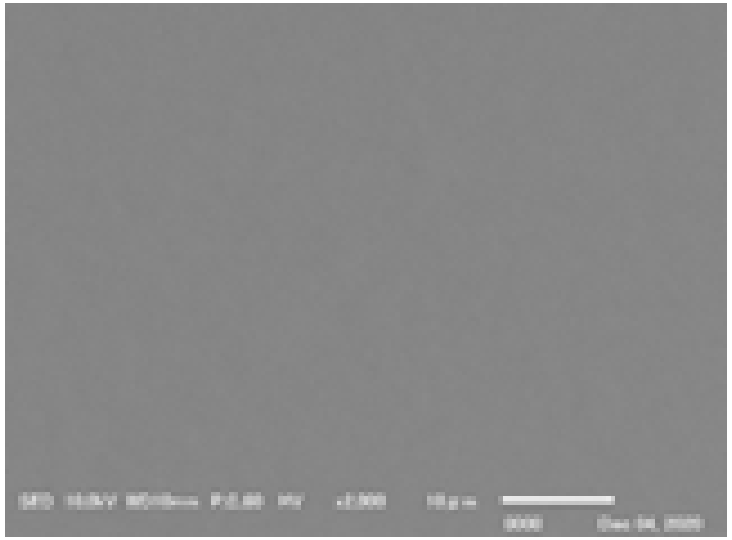
Smoothness of the glass surface

Bare Glass	After Catalyzing	After Cu film peeling
		
Rz=1.73nm	Rz=8.86nm	Rz=5.83nm



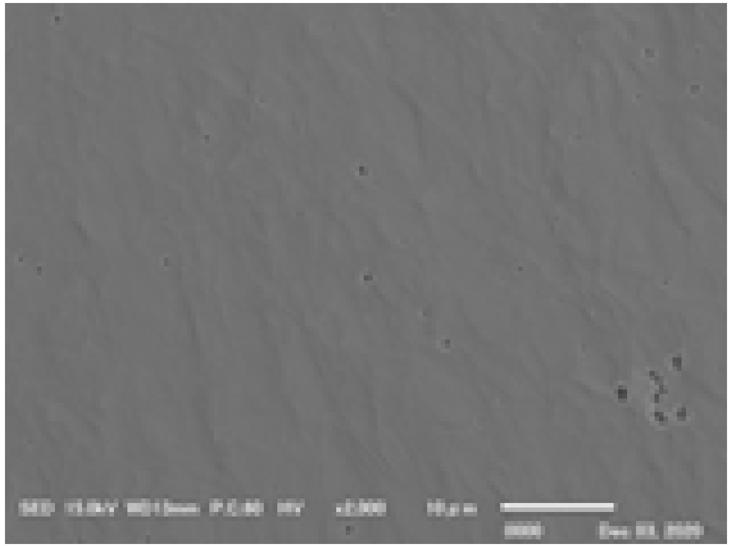
Glass Cu interface





Sample A
Peel strength
0.01kN/m

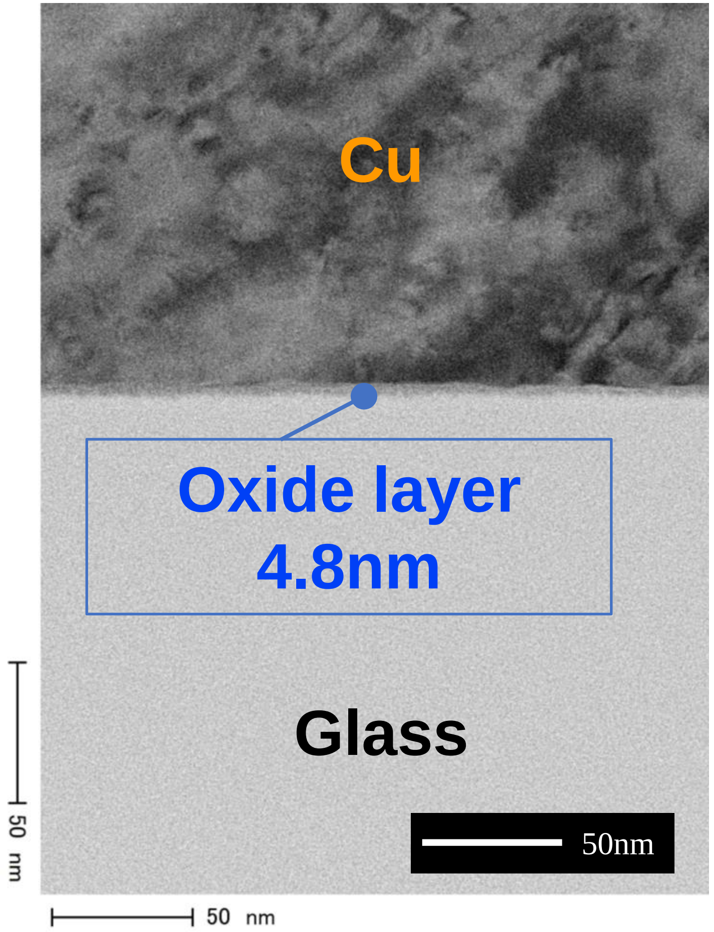
	wt %
O	0.23
Cu	99.77

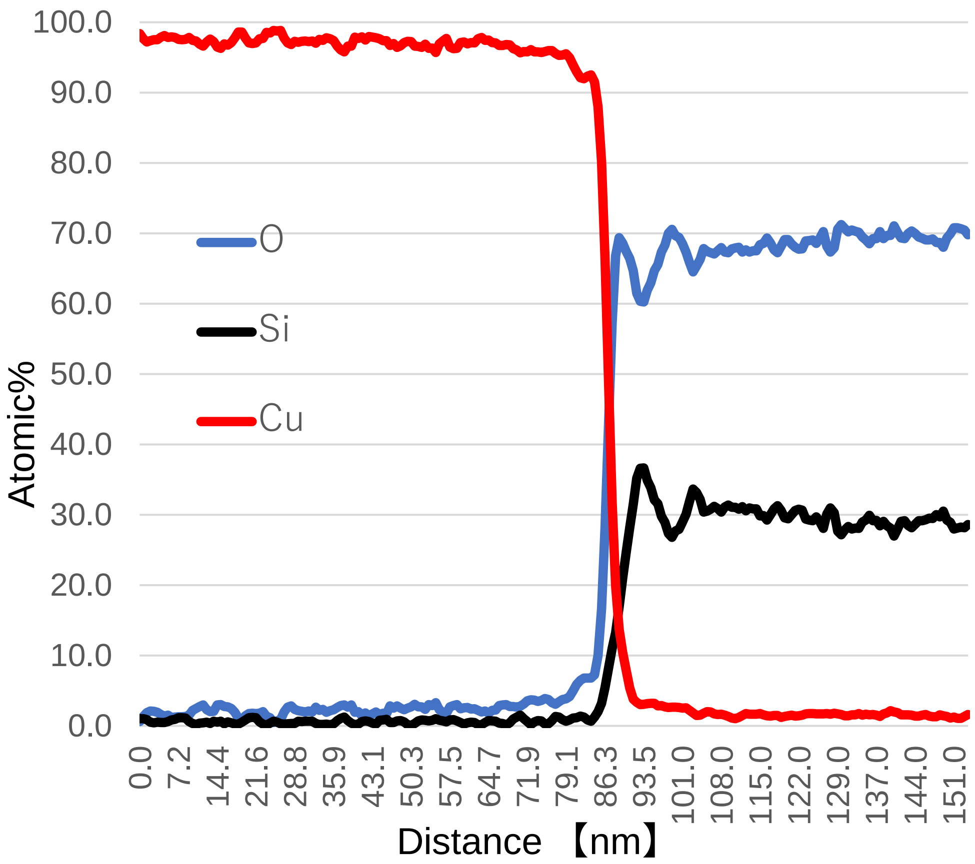


Sample B
Peel strength
0.5kN/m

	wt %
O	1.25
Si	0.35
Cu	98.36

Glass – Cu interface

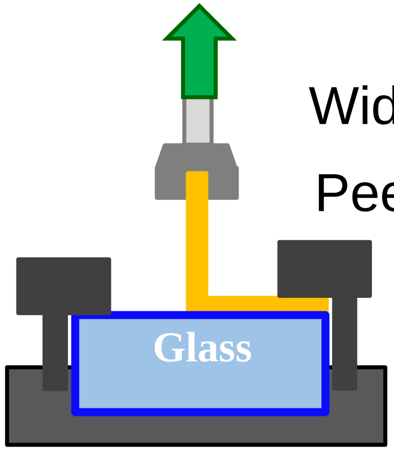




Sample：Non alkali glass

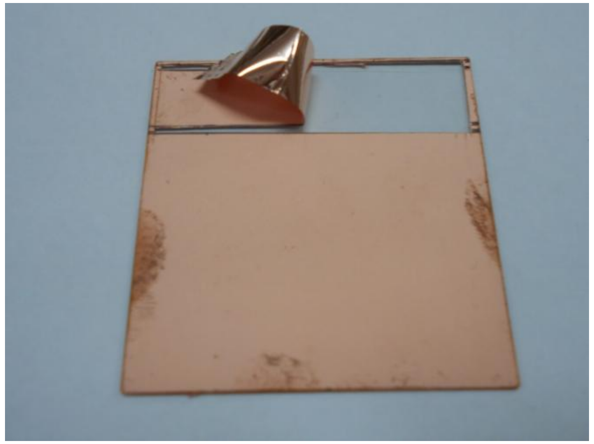
Evaluation of adhesion strength

Vertical peeling test



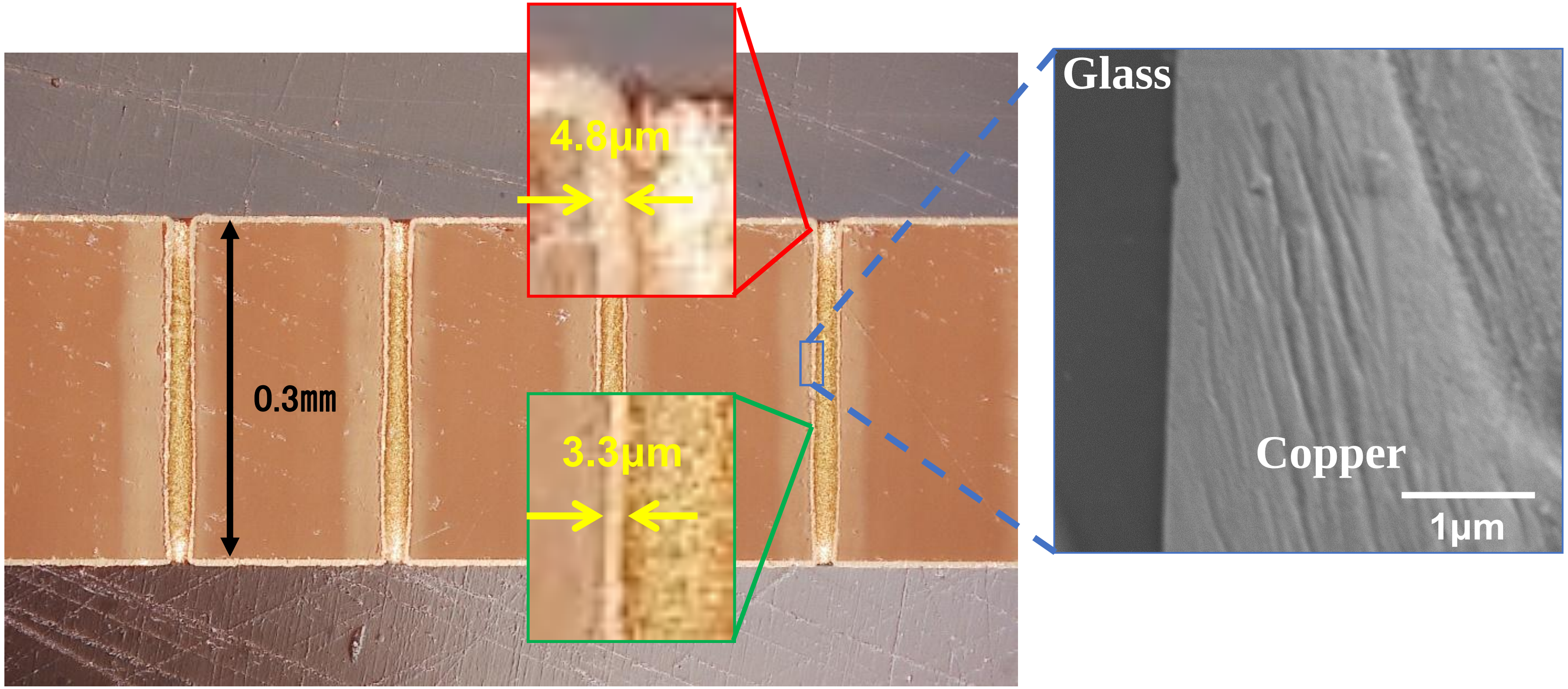
Width : 10 mm

Peeling speed : 50mm/min.



Glass	Peel strength
Non-alkali glass	0.8 kN/m
Soda-lime glass	0.8 kN/m
Borosilicate	0.5 kN/m
Quartz	0.3~0.4 kN/m

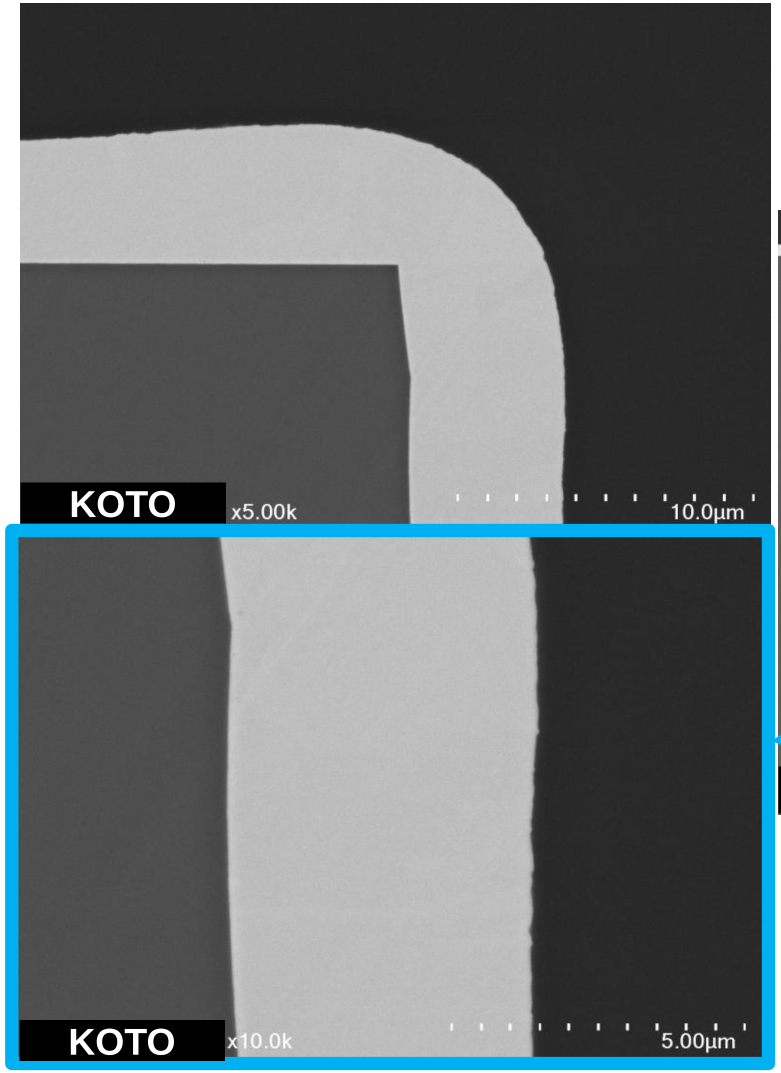
Cross section of TGV

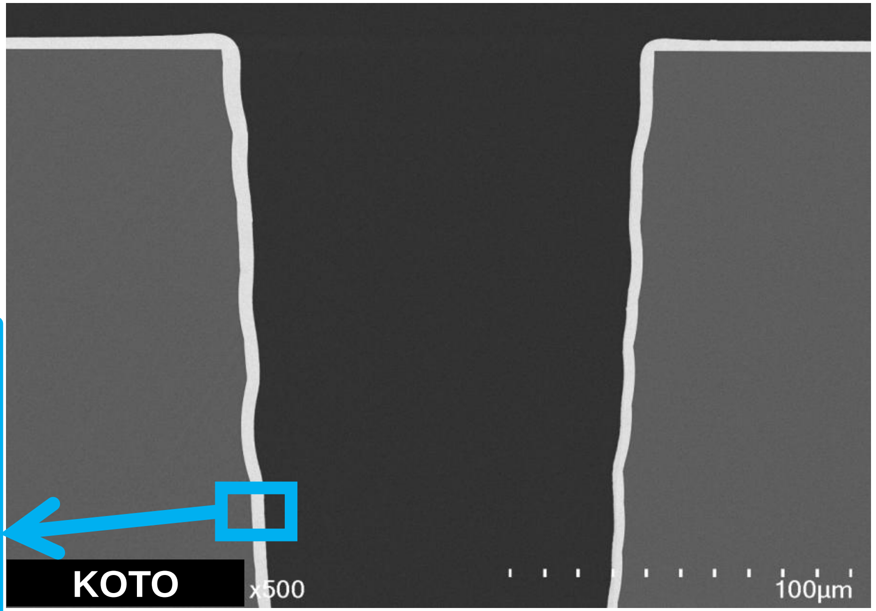


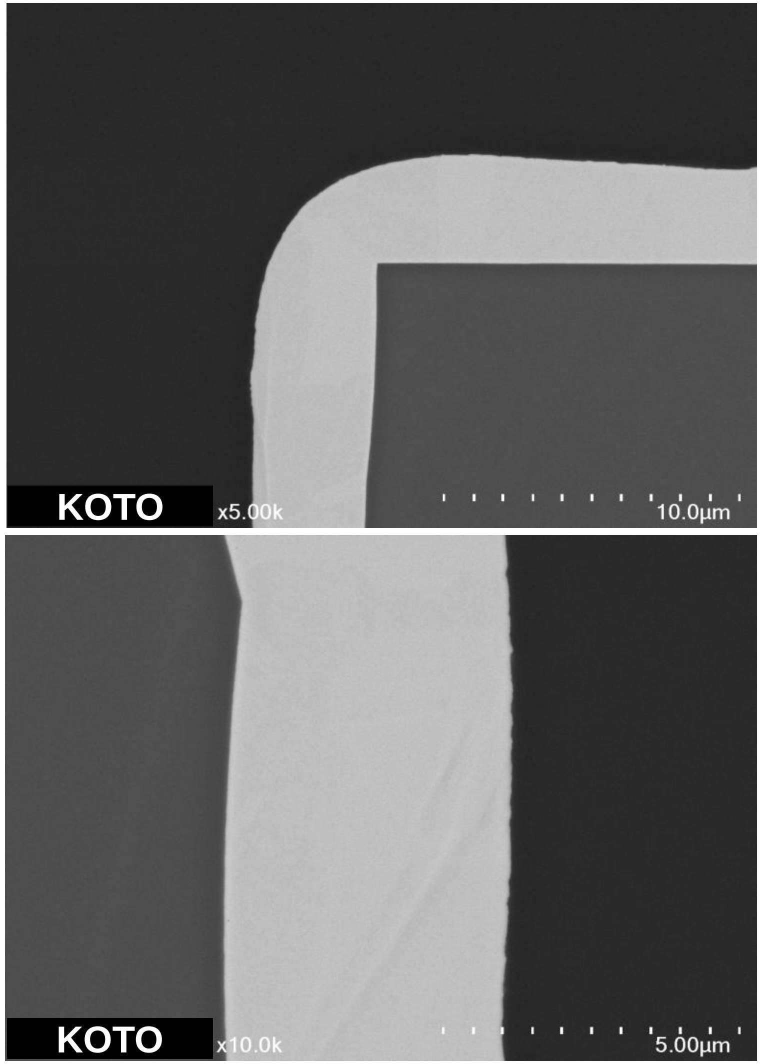
Thickness	0.3㎜
Via φ	30μm

Our process enables forming high aspect ratio (A.R= 10) TGV on glass substrate.

Cu plating uniformity inside TGV with SEM







A.R. 10

Glass TGV application

Glass substrate

- **Strong: Almost no warpage, very good registration accuracy + enough thickness**
- **Solid : No humidity absorption, Lower CHE → No drift**
- **Low CTE: 3ppm + under control**
- **Flatness / Very smooth surface**

→ Good for Antenna application, IPD RF Filter & Sensor

+

- **Thermal isolation**
- **High heat resistance** **→ Good for Optical application & sensor**
- **Optical transparence**

Not Cost, High performance application

April 2022 @ EuMC London

Special glass for packaging of high frequency electronics

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	fused silica	**SCHOTT 8325**	**BOROFLOAT® 33**	**AF 32®**	**Rogers3003**	**Isola Astra MT77**	**Panasonic Megtron 77**
$\alpha_{25C-300C}$ / ppm/K	0.55	3.28	3.29	3.2	16-25	12-70	14-42
T_g / ^{o}C	1600	467	528	728		200	200
typical surface roughness (RMS)	10nm	<1nm	<1nm	<1nm	$\sim 1\mu$m	$\sim 1\mu$m	$\sim 1\mu$m
dielectric constant, ϵ'	3.8	4.0	4.4	5.1	3.0	3.0	3.35
tanδ @10GHz	0.00006	0.0021	0.0075	0.0061	0.0010	0.0017	0.002
tanδ @77GHz		0.0047	0.0127	0.0114			
tanδ @110GHz		0.0061	0.0152	0.0128			

Cu peel off test

All wet process

Non Alkaline Glass

0.86 kN/m @ AH 5.5g /m^3 (24%@25℃)

0.45 kN/m @ Water drop test

0.80 kN/m After 125 ℃ / 96 hr

Fused Silica Glass

0.30 kN /m

New!!

Via AR (Aspect Ratio)

AR = *20* Via size: min 20 um

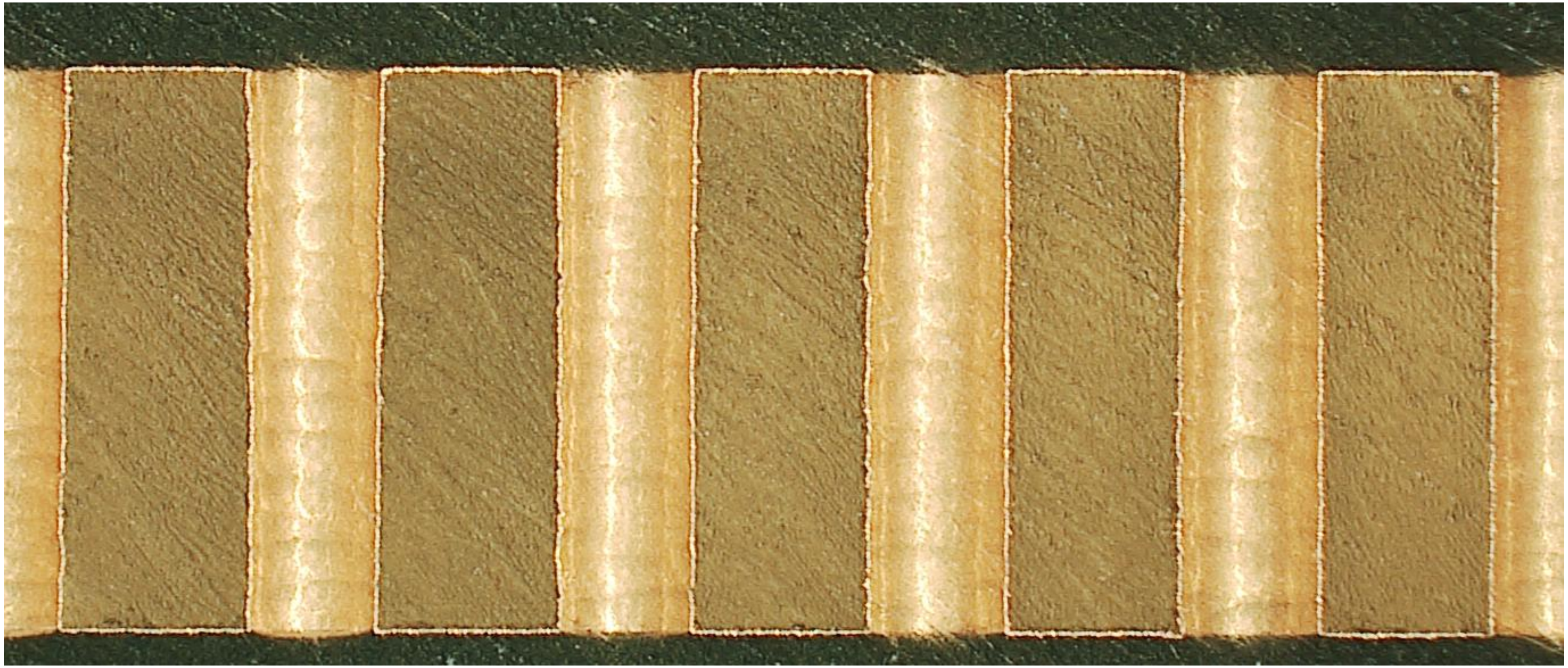
77 years Glass history

www.koto-jp.com

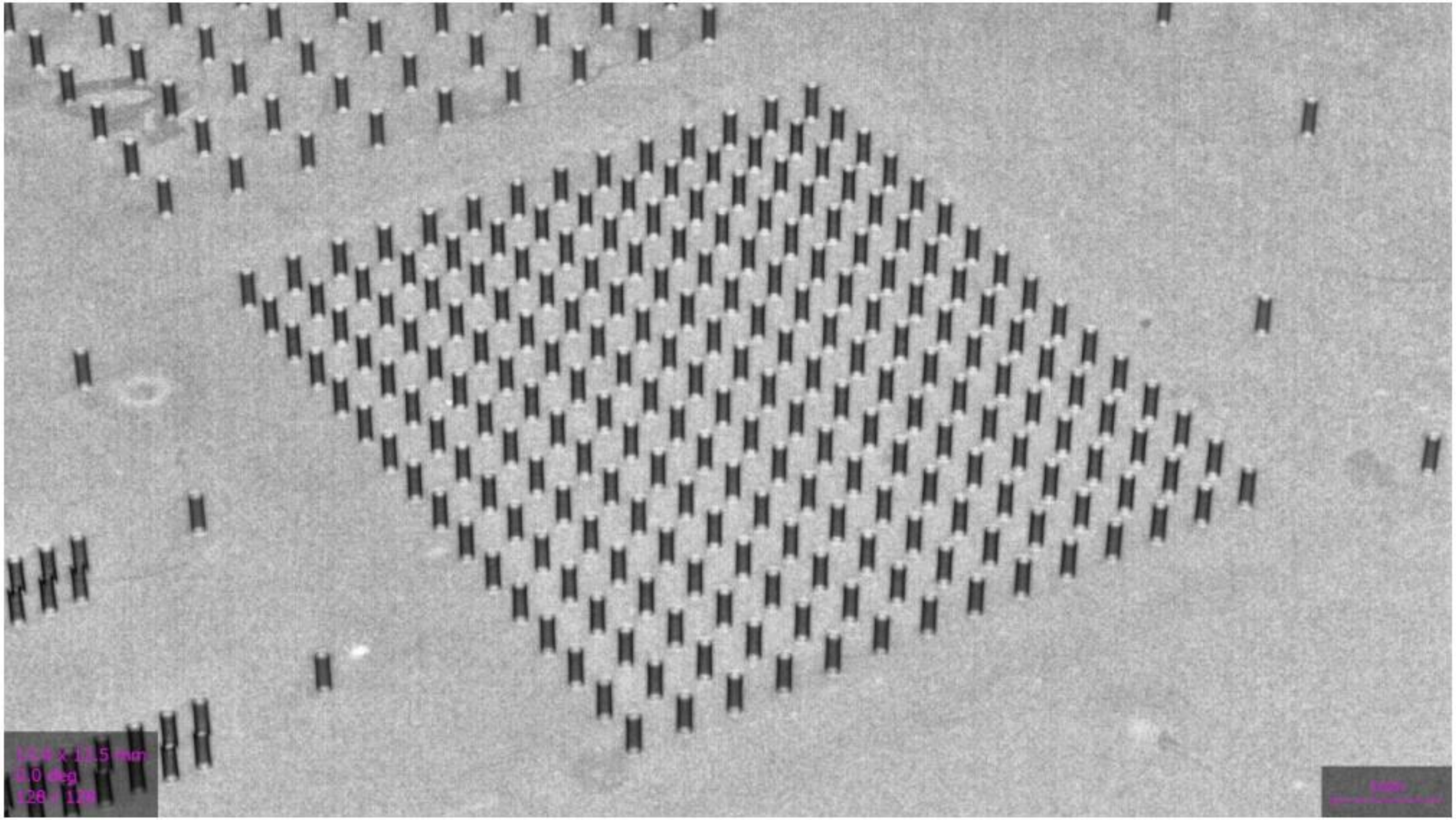
contact: info@koto-jp.com

KOTO

TGV Cu plating on quartz glass



TGV Cu plating on quartz glass X-ray image



Thank You
For Your Attention

www.koto-jp.com

ICEP2026

April 15-18, 2026

Hiroshima International Convention Center