ISMP 2003
The 2nd International Symposium on Microelectronics and Packaging

Low Temperature Bonding and its Applications in Microelectronics

September 24-25, 2003
COEX Conference Center, Seoul, Korea

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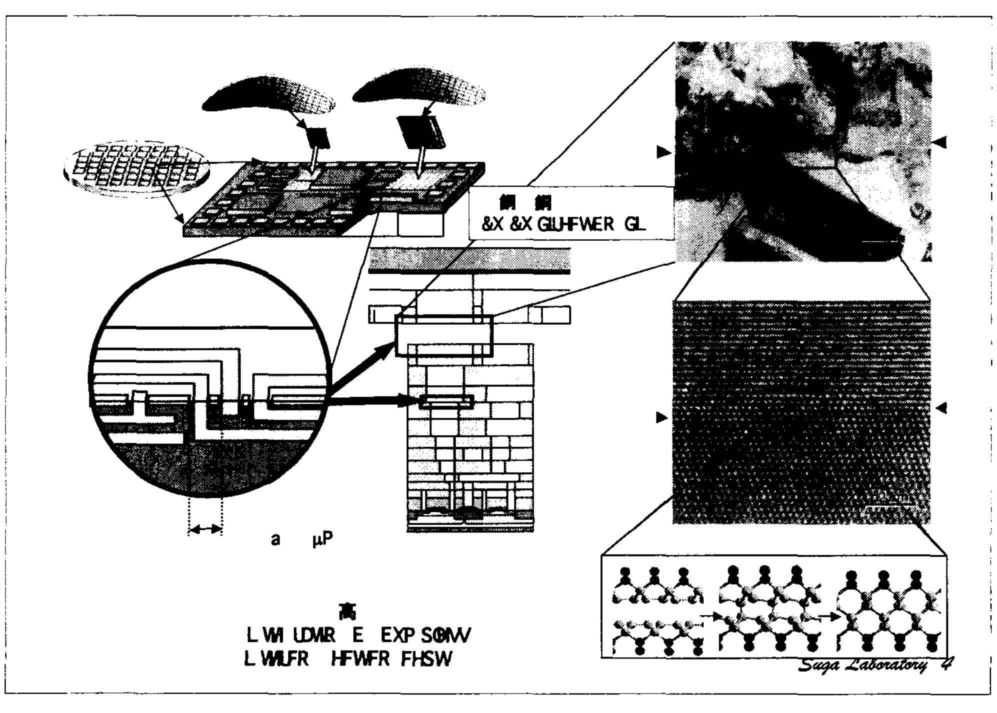
The University of Tokyo

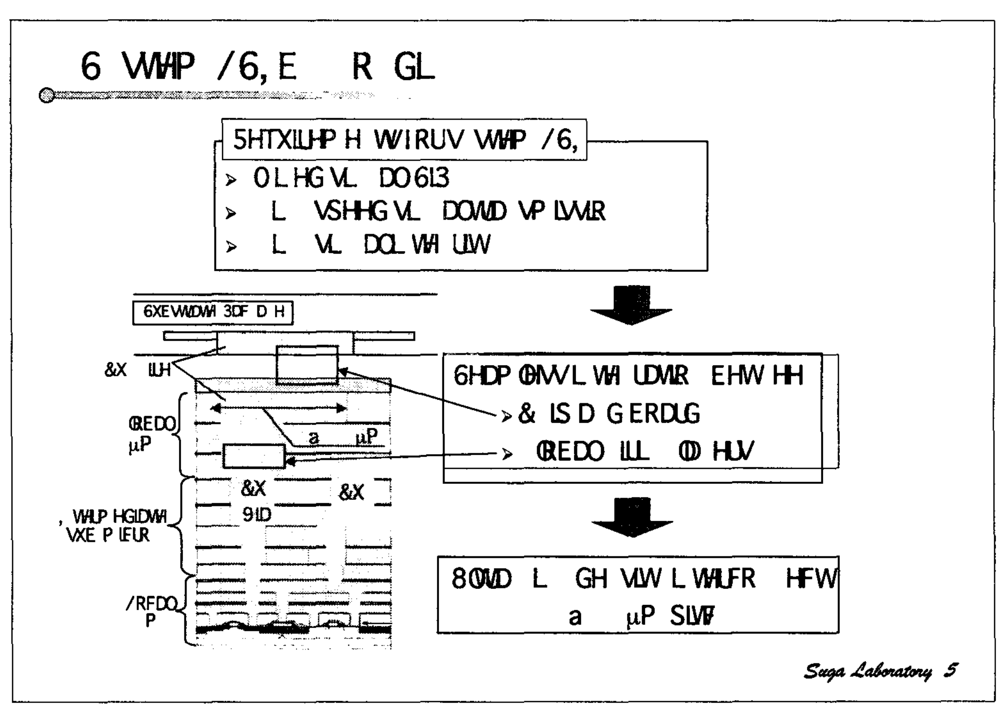
Outline

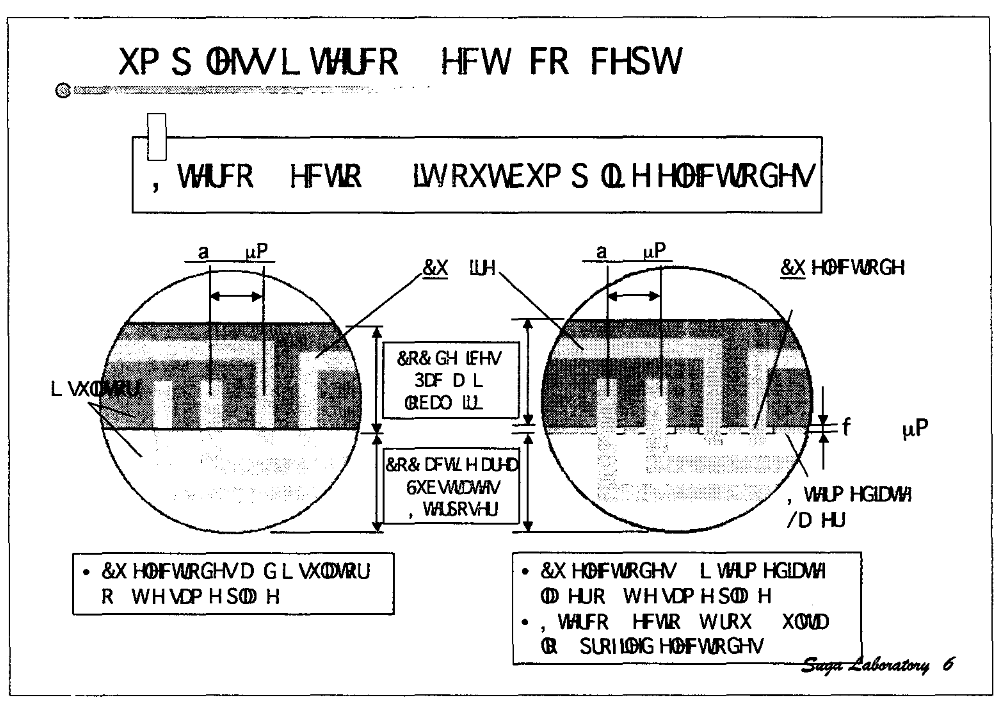
- Background
- Room temperature bonding: Surface Activated Bonding (SAB)
- Applications of SAB
- Bumpless interconnect

Suga Laboratory 2

Bumpless Interconnect
&
Surface Activated Bonding (SAB)




Suga Laboratory 5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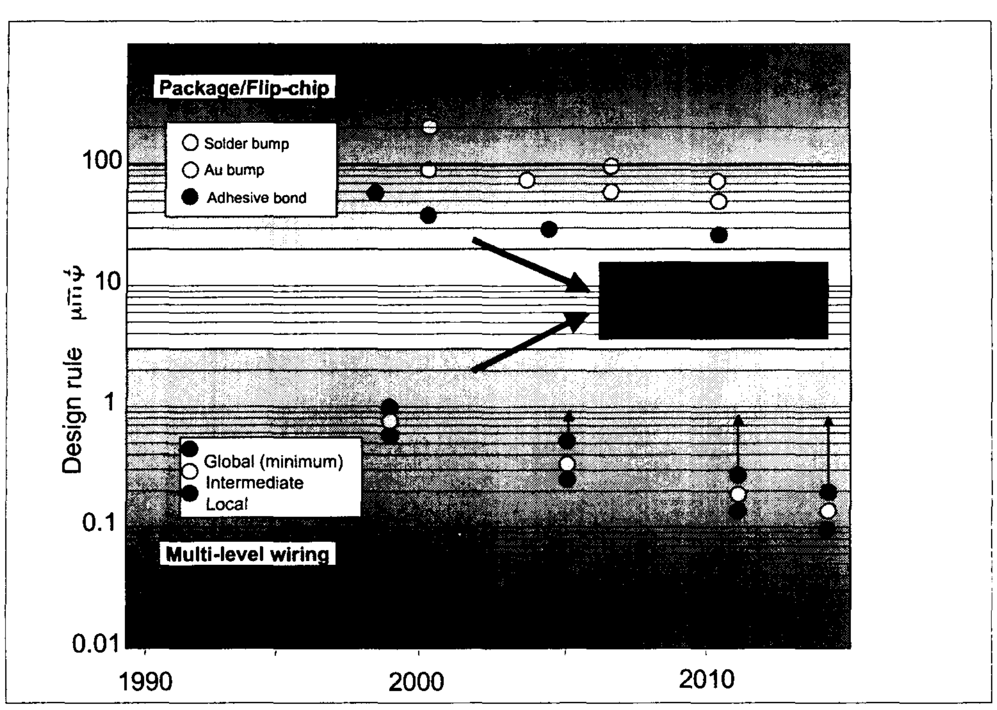
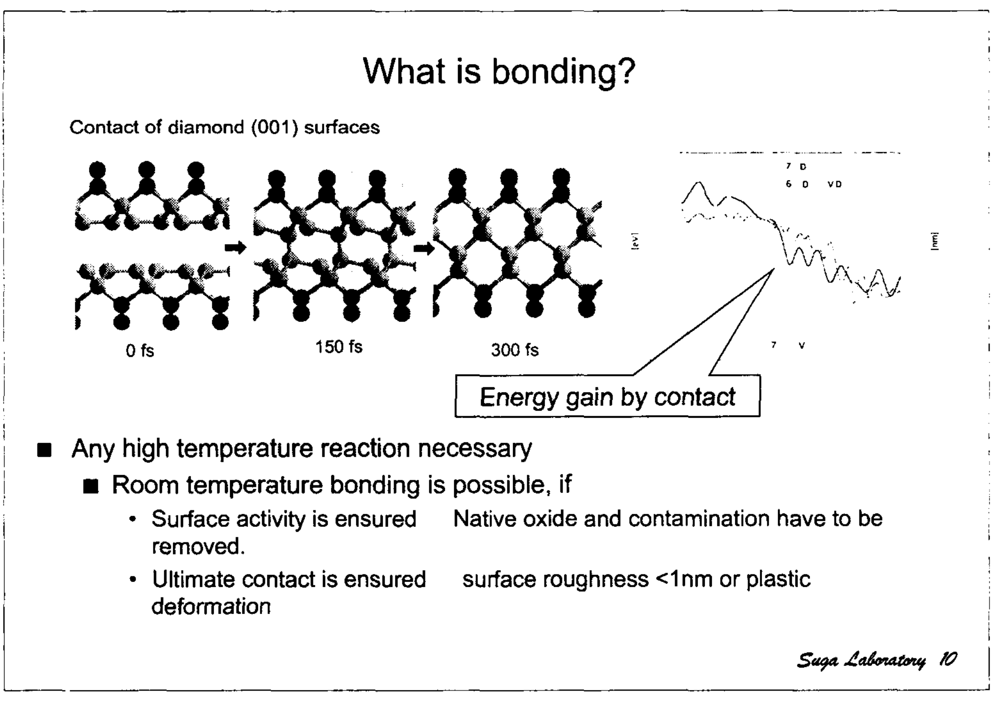

Package/Flip-chip
Solder bump
Au bump
Adhesive bond
100
10
1
0.1
0.01
Design rule
Global (minimum)
Intermediate
Local
Multi-level wiring
1990
2000
2010


What is bonding?
Contact of diamond (001) surfaces
0 fs
150 fs
300 fs
Energy gain by contact
Any high temperature reaction necessary
Room temperature bonding is possible, if
Surface activity is ensured Native oxide and contamination have to be removed.
Ultimate contact is ensured surface roughness <1nm or plastic deformation
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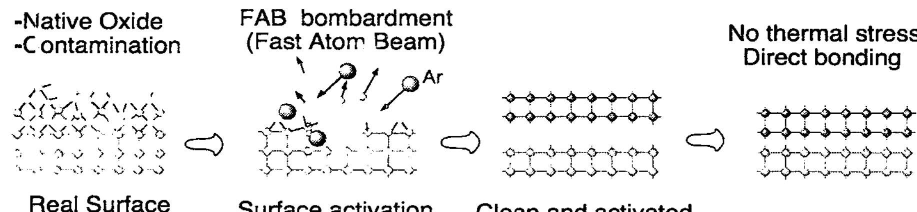
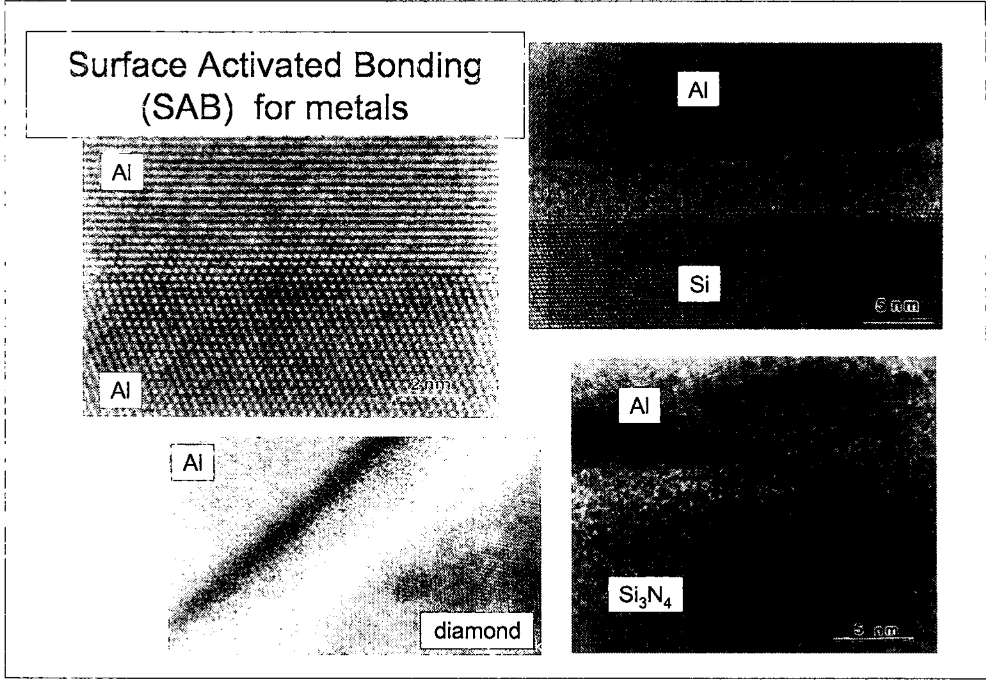
Surface Activated Bonding (SAB)



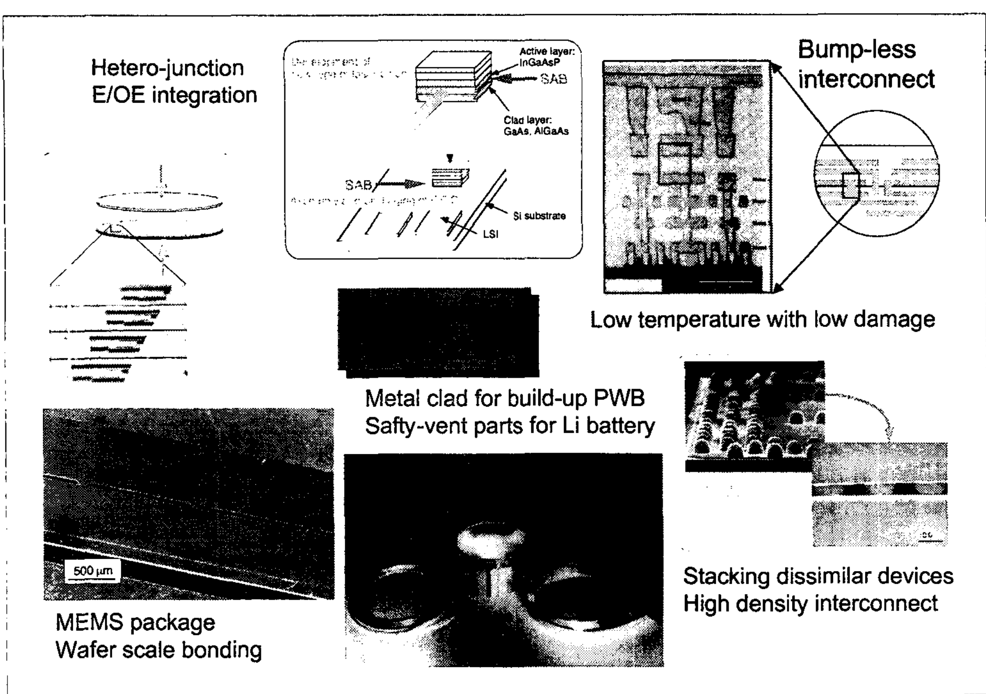
- Room temperature process
- Direct bonding without intermediate



dpt hqdl dnsr enq anncdhmf

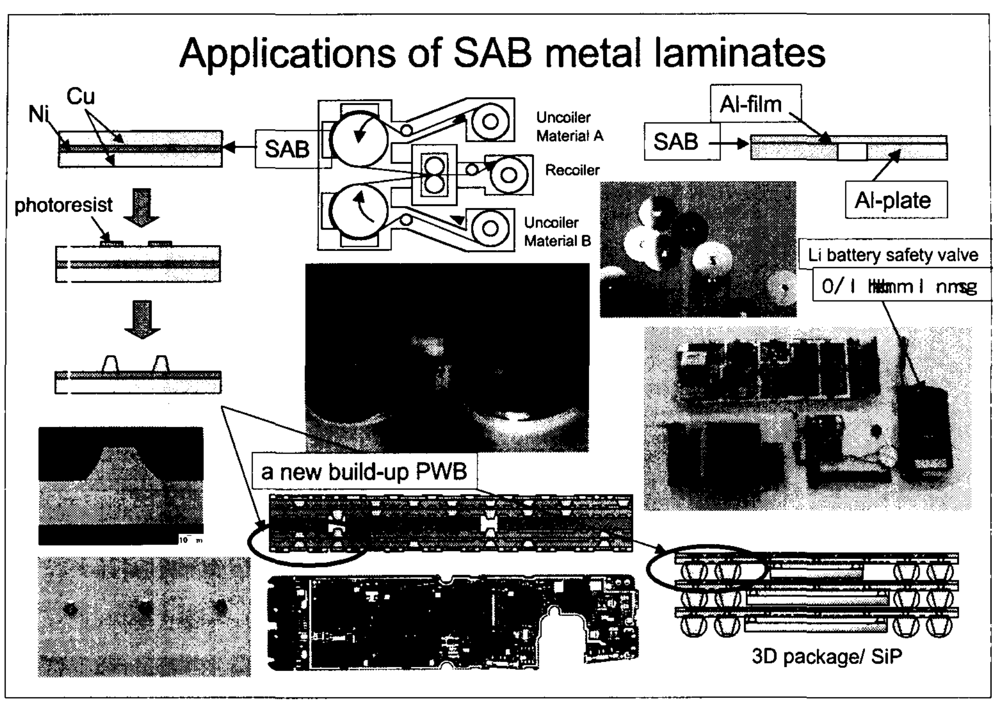
- wonrd sgd rt qe bd snl r ax qdl nulmf sgd m shud nwhcd
  - hmmad l hqq ch shmm R A(
  - aqd cnv mne nwhcd k xdq ax cdend shmm
  - cheet rlmmax gd shmf bnmudmshmm kanmchmf (
- Bnms bs snl r nmmdlf gandhmf rt qe bdr
  - ek smdrr R A(
  - ok rshb cdend shmm
  - rnesdmhmf ax gd shmf bnmudmshmm kanmchmf

Applications of SAB



SAB laminates

Metal-metal
Metal-polymer(LCP)



Cu-Cu bumpless interconnect

on 3 μm pad - 100,000 pins

Relaxation effect of interface structure by annealing

- Bonding: vacuum 1.0 x 10^{-4} Pa, load 50 kgf/16 mm^2
- Annealing 200°C 120min + 300°C 0/30/60min
- Strain relaxed, voids disappear, and waviness of interface reduced

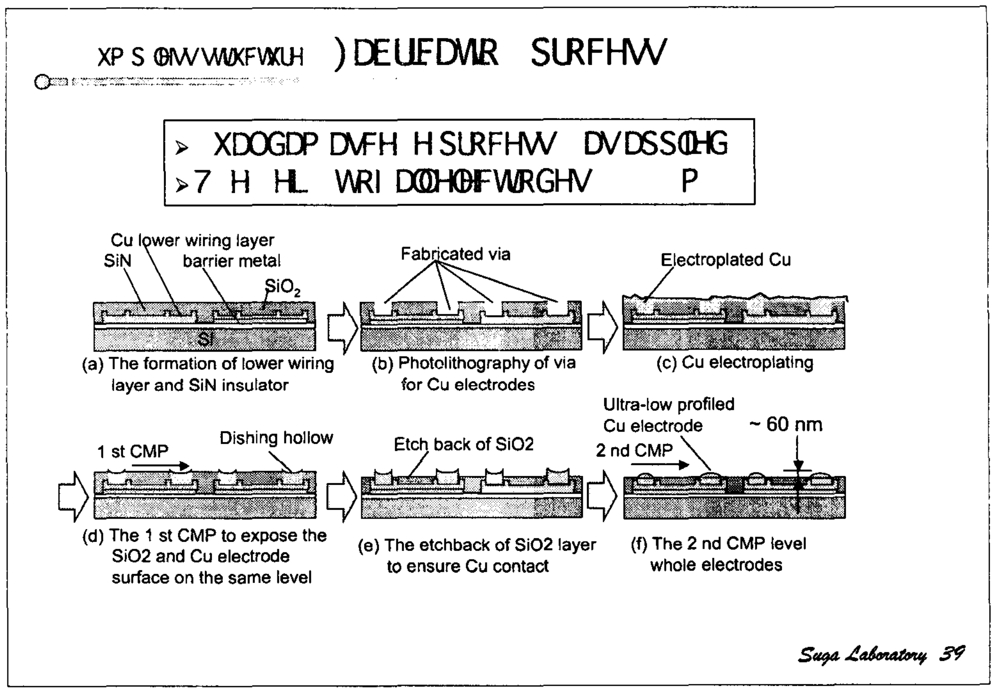
加熱前

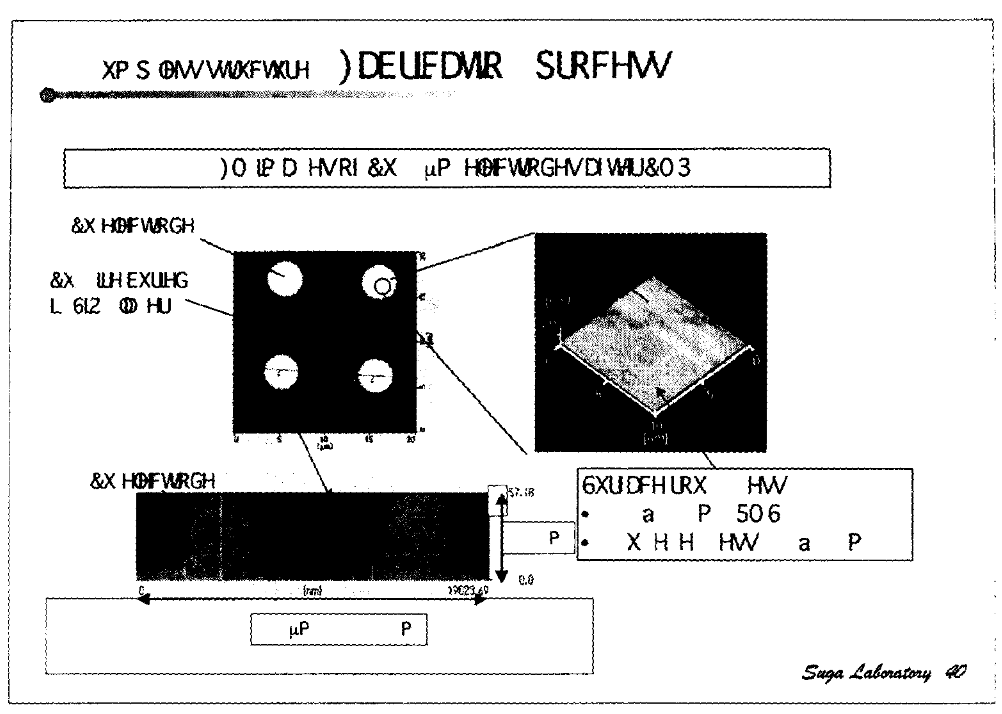
加熱200℃120分
（150℃36時間程度に相当）

加熱200℃120分＋300℃30分
（150℃700時間程度に相当）

加熱200℃120分＋300℃60分
（150℃1345時間程度に相当）

...boratory 38

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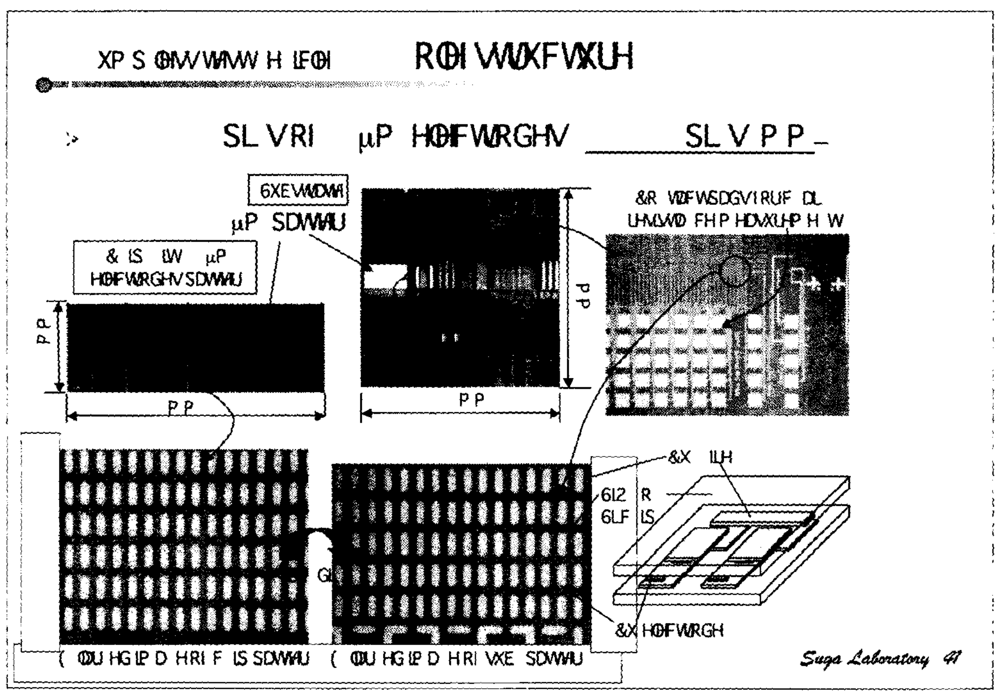
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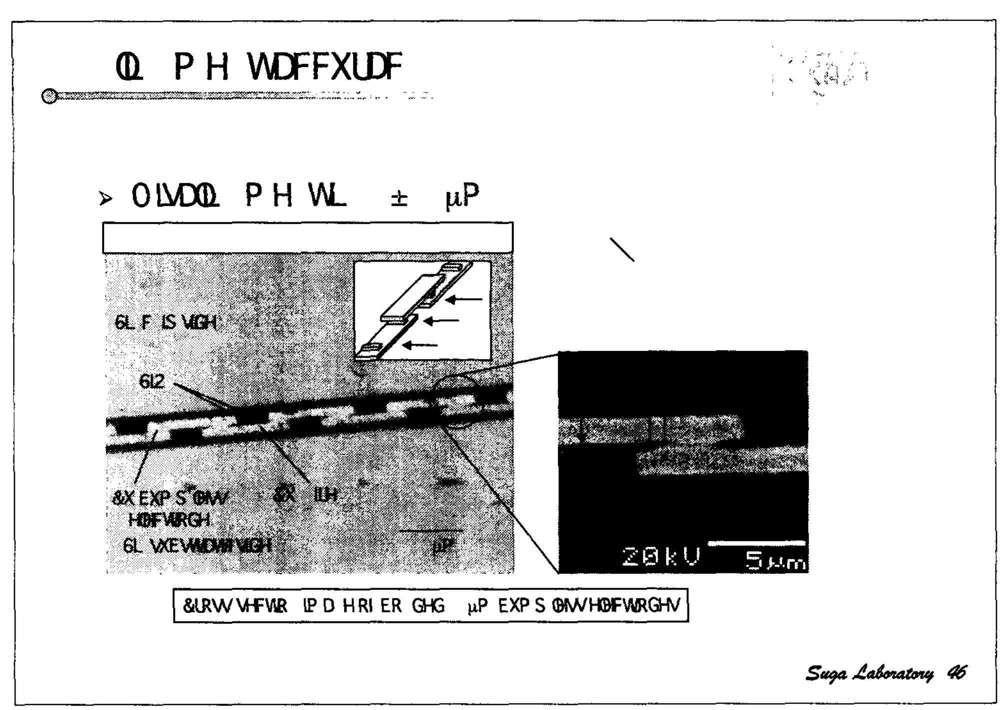
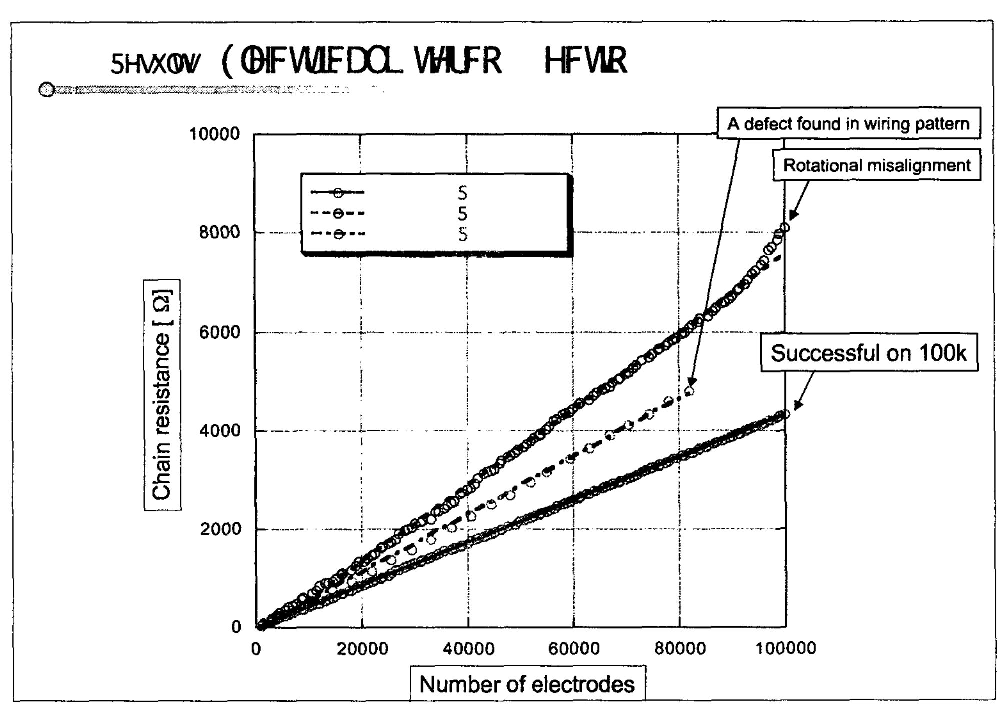
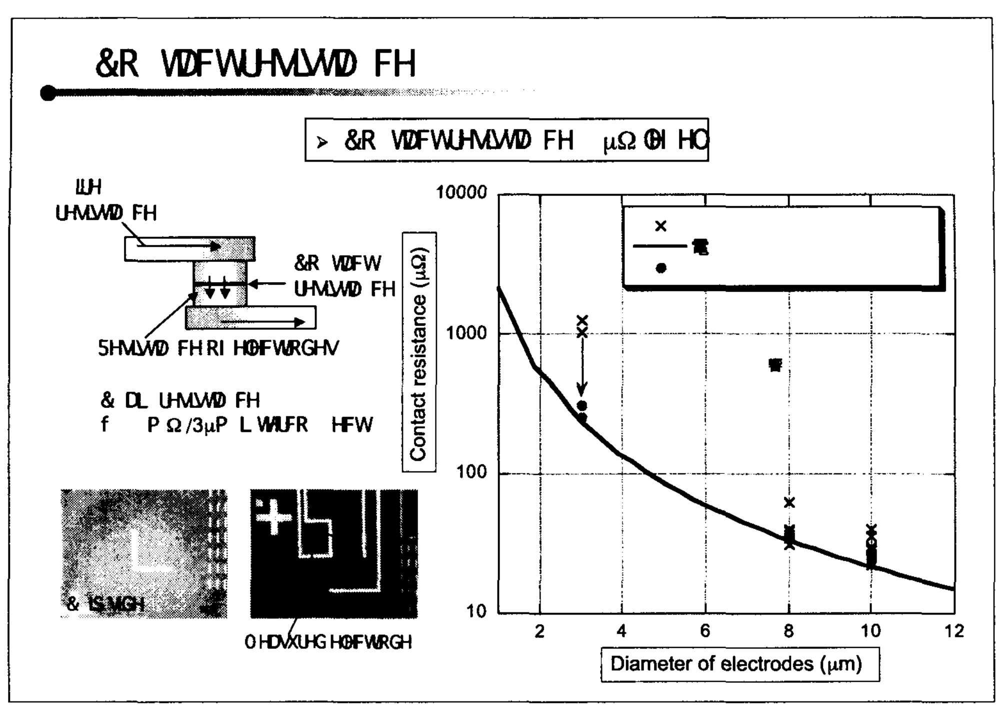

20kV
5μm
Suga Laboratory 46

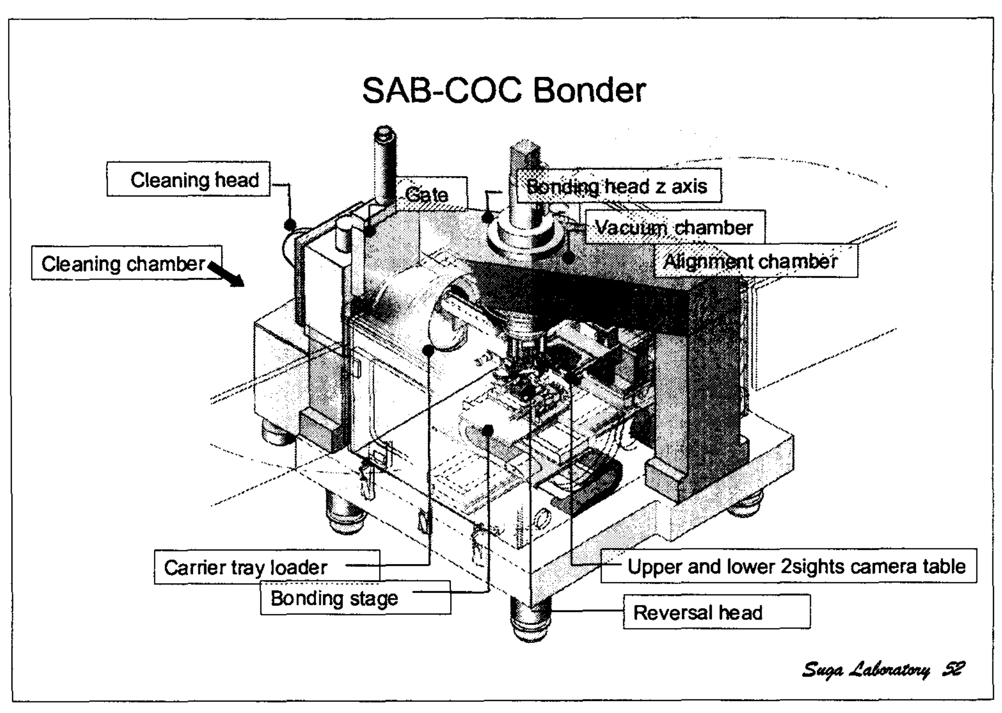

A defect found in wiring pattern
Rotational misalignment
Successful on 100k
Chain resistance [Ω]
Number of electrodes
10000
8000
6000
4000
2000
0
0
20000
40000
60000
80000
100000

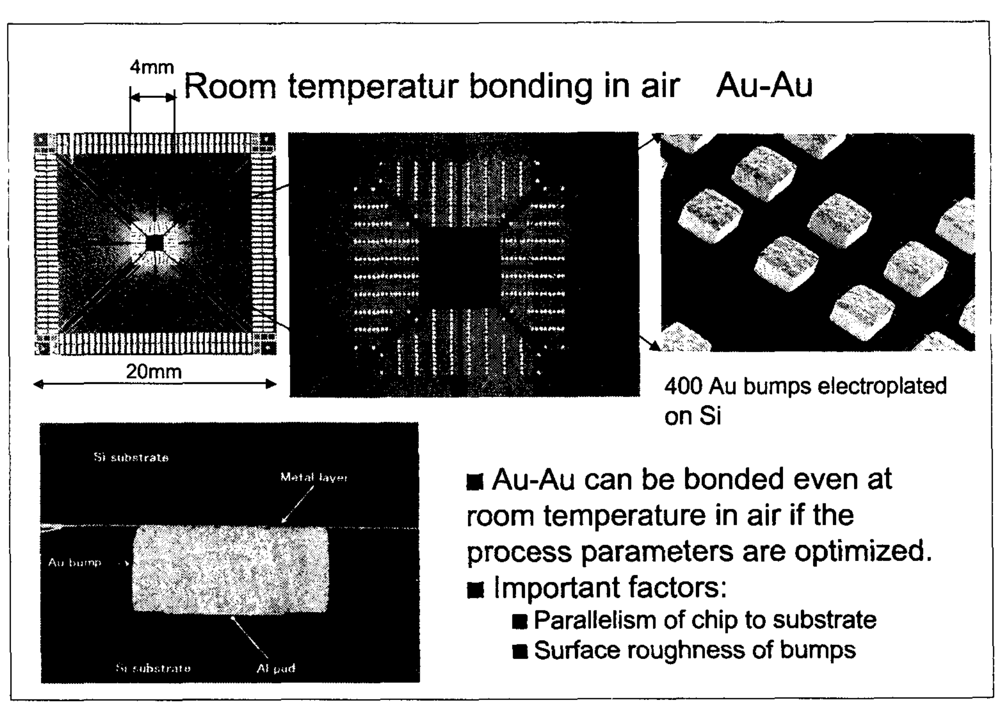


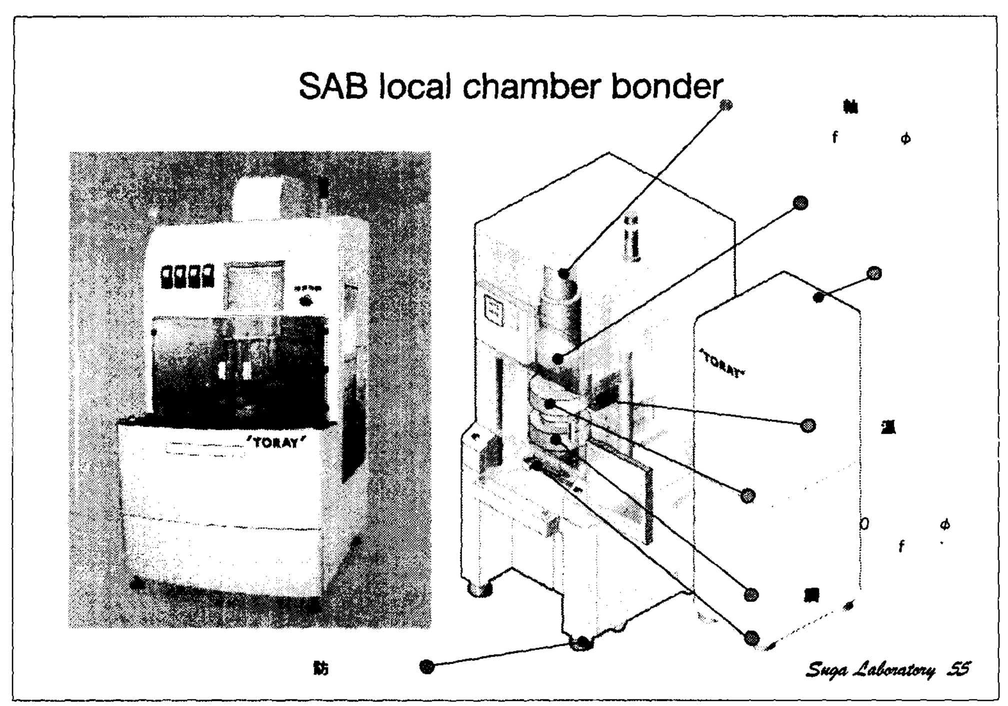
SAB room temperature bonding

in air

Au-Au bump

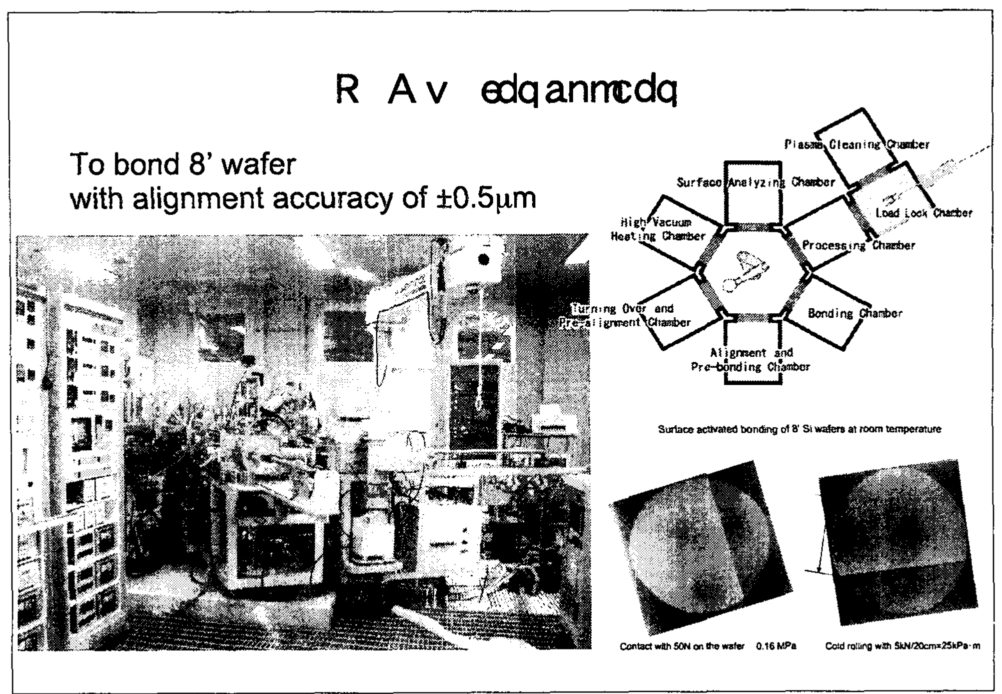

SAB-COC Bonder
Cleaning head
Gate
Bonding head z axis
Vacuum chamber
Alignment chamber
Cleaning chamber
Carrier tray loader
Bonding stage
Upper and lower 2sights camera table
Reversal head
Suga Laboratory 52

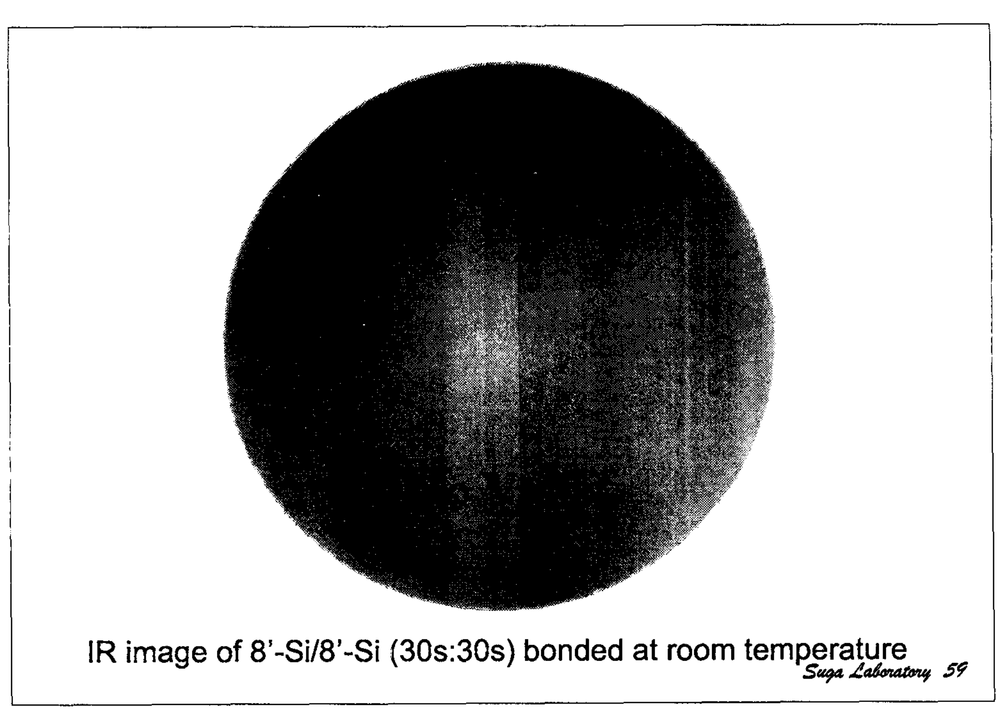

Room temperatur bonding in air Au-Au
4mm
20mm
400 Au bumps electroplated on Si
Si substrate
Metal layer
Au bump
Si substrate
Al pad
■ Au-Au can be bonded even at room temperature in air if the process parameters are optimized.
■ Important factors:
■ Parallelism of chip to substrate
■ Surface roughness of bumps

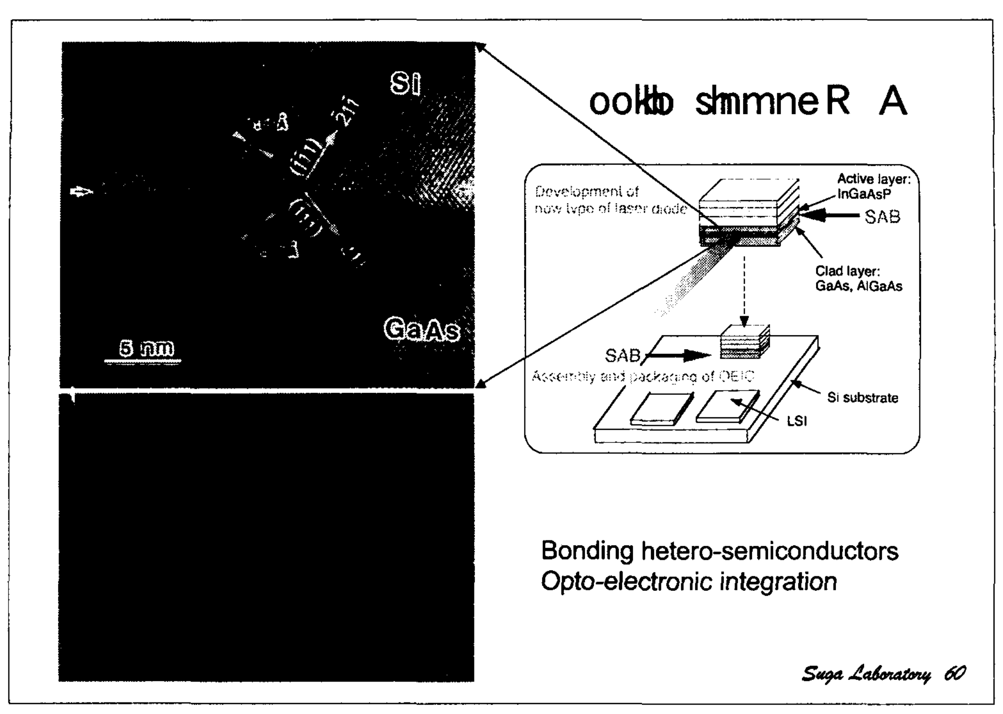


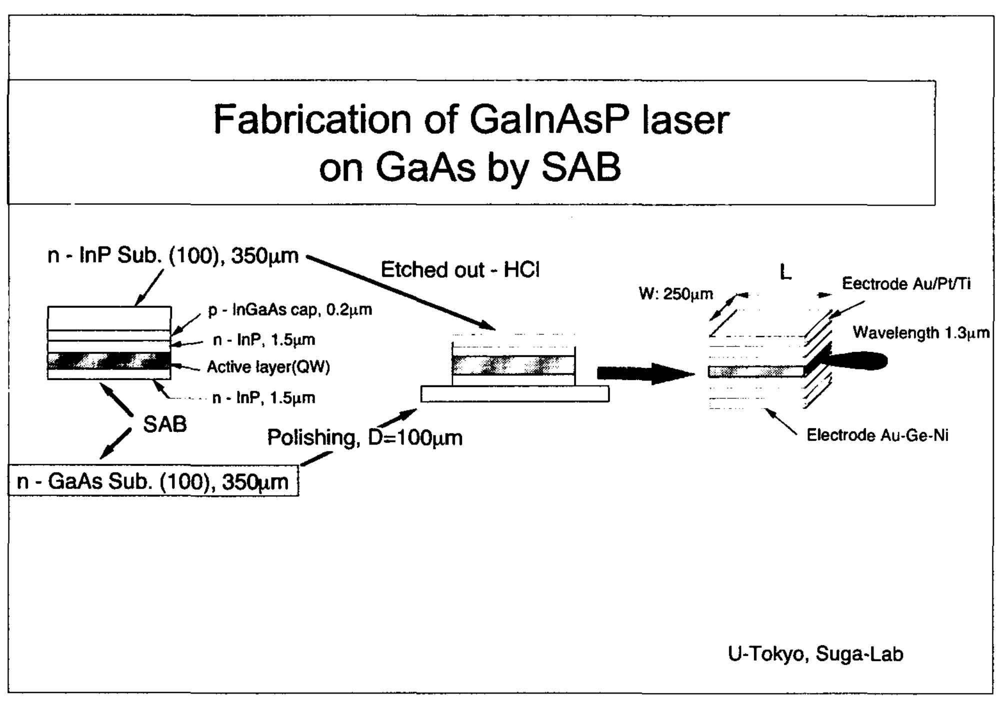
SAB wafer bonding

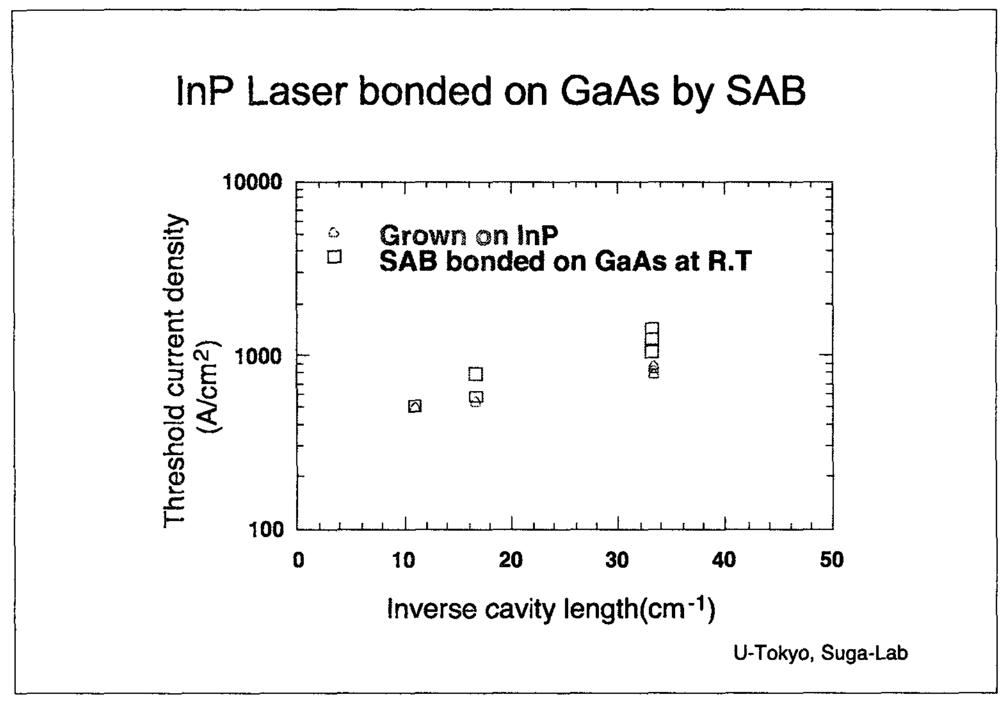
MEMS Packaging

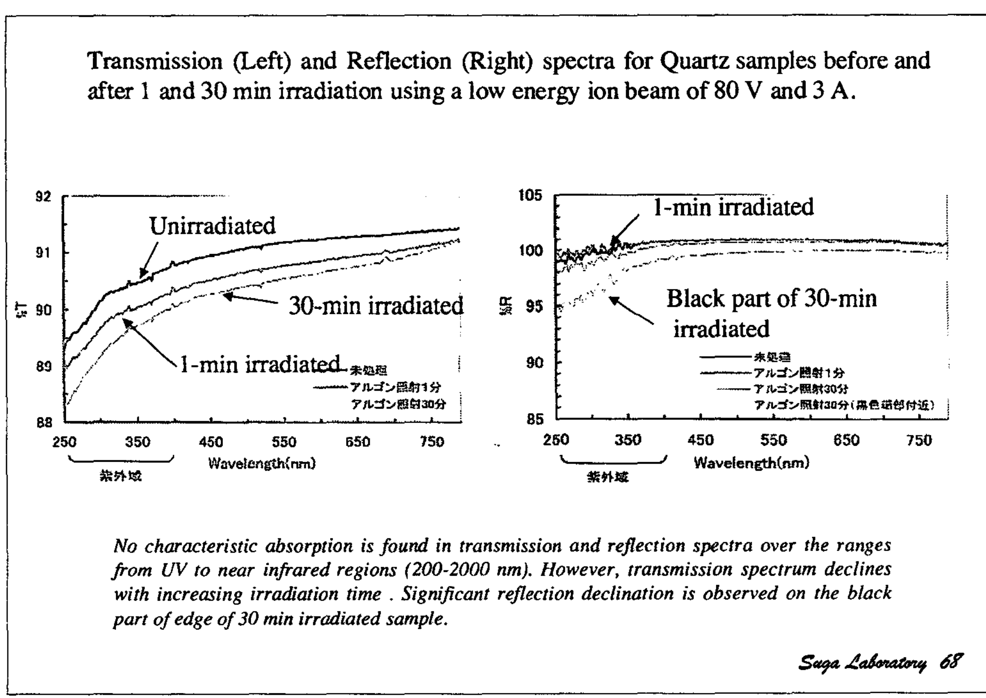

R Av edqanmcdq
To bond 8' wafer
with alignment accuracy of ±0.5μm
Plasma Cleaning Chamber
Surface Analyzing Chamber
Load Lock Chamber
High Vacuum
Heating Chamber
Processing Chamber
Turning Over and
Pre-alignment Chamber
Bonding Chamber
Alignment and
Pre-bonding Chamber
Surface activated bonding of 8' Si wafers at room temperature
Contact with 50N on the wafer 0.16 MPa
Cold rolling with 5kN/20cm=25kPa·m


IR image of 8'-Si/8'-Si (30s:30s) bonded at room temperature
Suga Laboratory 59

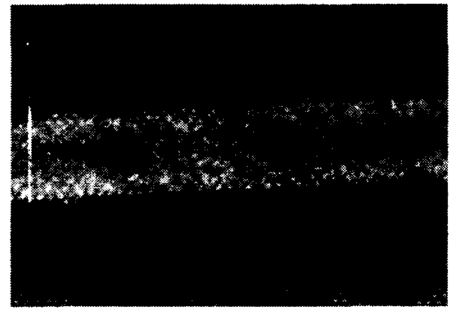

Si
GaAs
5 nm
Development of new type of laser diode
Active layer: InGaAsP
SAB
Clad layer: GaAs, AlGaAs
SAB
Assembly and packaging of OEIC
Si substrate
LSI
Bonding hetero-semiconductors
Opto-electronic integration
Suga Laboratory 60


Fabrication of GaInAsP laser
on GaAs by SAB
n - InP Sub. (100), 350μm
Etched out - HCl
p - InGaAs cap, 0.2μm
n - InP, 1.5μm
Active layer(QW)
n - InP, 1.5μm
SAB
Polishing, D=100μm
n - GaAs Sub. (100), 350μm
W: 250μm
L
Eectrode Au/Pt/Ti
Wavelength 1.3μm
Electrode Au-Ge-Ni
U-Tokyo, Suga-Lab

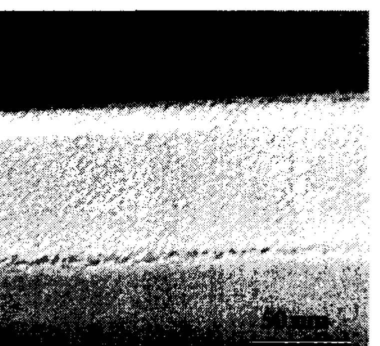

InP Laser bonded on GaAs by SAB
Grown on InP
SAB bonded on GaAs at R.T
Threshold current density (A/cm^2)
10000
1000
100
0
10
20
30
40
50
Inverse cavity length(cm^{-1})
U-Tokyo, Suga-Lab


Transmission (Left) and Reflection (Right) spectra for Quartz samples before and after 1 and 30 min irradiation using a low energy ion beam of 80 V and 3 A.
Unirradiated
30-min irradiated
1-min irradiated
Black part of 30-min irradiated
%T
%R
Wavelength(nm)
未処理
アルゴン照射1分
アルゴン照射30分
アルゴン照射30分(黒色部付近)
紫外域
No characteristic absorption is found in transmission and reflection spectra over the ranges from UV to near infrared regions (200-2000 nm). However, transmission spectrum declines with increasing irradiation time . Significant reflection declination is observed on the black part of edge of 30 min irradiated sample.
Suga Laboratory 68

Interfaces bonded at room temperature using UV transparent intermediate



Si / Si

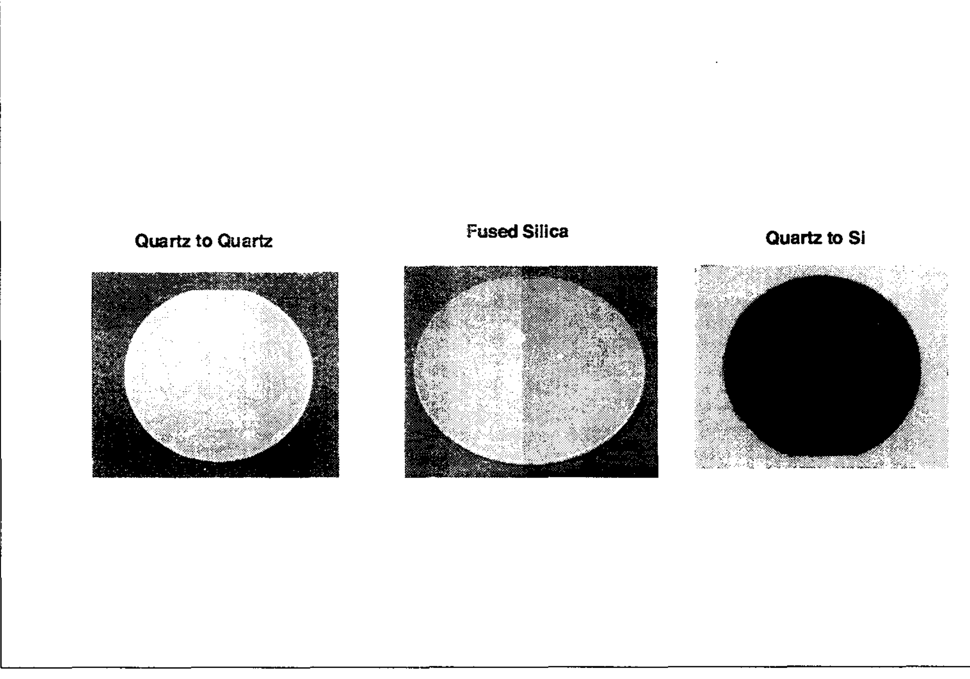


Quartz / Quartz

Suga Laboratory 69

h aN Rh edqanmclmf sqnnl sdl odq stqd

Suga Laboratory 70

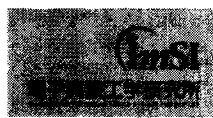


Perspective of SAB

Chip on chip/ Chip on wafer
with ultra-high density of bumpless interconnect
MEMS packaging by stacking Si and non-Si wafers
EcoDesign

Institute for advanced Micro-System Integration (IMSI)

Consortium founded in 1998 for collaboration with University of Tokyo



- Development of GHz system packaging
- Room temperature bonding for ultra-high density interconnect
- Environmentally conscious design for packaging

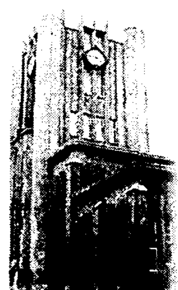
Alliance Members	Liaison Members
Oki Electric Industry Co., Ltd.	Ibiden Co., Ltd.
SANYO Electric Co., Ltd.	SEIKO EPSON Co.
Sharp Co.	Hitachi Chemical Co., Ltd.
Sony Co.	Shinko Electric Industries Co., Ltd.
Toshiba Co.	KYOCERA Co.
NEC Co.	Toyo Kohan Co., Ltd.
Hitachi Ltd.	CMK Co.
Fujitsu Ltd.	Mitsui Chemicals, Inc.
Matsushita Electronic Co.	SUMITOMO BAKELITE Co., Ltd.
Mitsubishi Electric Co.	Fiji Xerox Co.
ROHM Co.,Ltd.	Toray Engineering Co., Ltd.
	Fuji Film Co., Ltd.
	Ayumi Industry Co., Ltd.
	Olympus Optical Co., Ltd.
	Japan Texas Instruments Co., Ltd.
	Toyota Motor Co.
	Matsushita Electric Works, Ltd.

東京大学

The University of Tokyo, RCAST
Research Center for Advanced Science & Technology
Nanometer-scale Manufacturing Science Lab.
Micro-system Integration and Packaging Lab.

cooperation with

Institute for advanced Micro-System Integration (IMSI)



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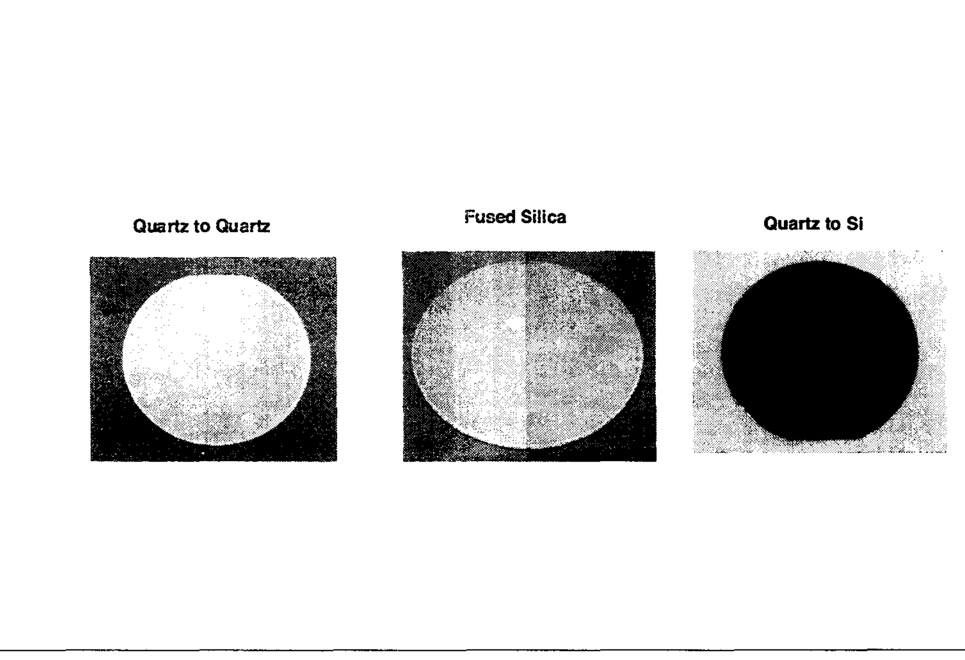
Associate Researcher Dr. Naoe Hosoda (NIMS)
Assistant Researcher Mr. Ken'ichi Kataoka
Associate Prof. Dr. Matiar Hawlader
Prof. Dr. Katsuya Okumura
Prof. Dr. Jun Fujimoto (Asia-EcoDesig Project)
Assistant Researcher Mr. Kazuhiko Nakamura
Secretary Ms. Natsuko Kawamata



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NEC Co.	Toyo Kohan Co., Ltd.
Hitachi Ltd.	CMK Co.
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Matsushita Electronic Co.	SUMITOMO BAKELITE Co., Ltd.
Mitsubishi Electric Co.	Fiji Xerox Co.
ROHM Co.,Ltd.	Toray Engineering Co., Ltd.
	Fuji Film Co., Ltd.
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	Japan Texas Instruments Co., Ltd.
	Toyota Motor Co.
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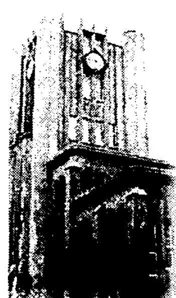

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