AML

Collaboration opportunities in:

Wafer Bonding
Polymer Micro-Nano Embossing
Custom machines

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NMP Finland 16-17 April

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AML History

- Company founded 1992 - Private SME
- Long history of design & manufacture of MEMS
- Over the last 9 years AML moved to equipment manufacturer & service provider centred around WAFER BONDING
- Wafer bonding equipment - Worldwide installed base of machines
- Wafer Bonding services - BONDCENTRE

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How it started
AML Capacitive Sensors 1985

- Silicon micromachined capacitive Pressure & Force sensors

Pressure
Silicon
Au electrode
Capacitance gap 0.5 µm
Glass
Insulator

MEMS to Wafer bonding

Founders made first in-situ aligner-wafer bonder in 1985

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Wafer bonding has found many applications in the field of MST, MEMS, III-V, ICs & Optical devices:

- **MEMS devices - Pressure Sensors, Accelerometers, Microfluidics**
- **Vacuum encapsulation (absolute pressure, IR detectors…)**
- **1st Level Packaging to isolate package induced stresses.**
- **Wafer scale Packaging – MEMS & IC**
- **III-Vs e.g. high performance LEDs bonded reflector - heat sink**
- **3D Interconnects**
- **Temporary bonds for handle wafers (interlayer & direct)**
- **Advanced bonded substrates e.g. Si on Glass (SOG), GaAs on Si…**
- **Layer transfer - Smart cut**

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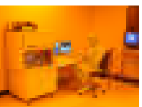
Products

- Aligned Wafer Bonding machines
- Aligned Nano Polymer Emboss tool
- Advanced Substrates: Si-Glass, Si-Quartz….

Services - BONDCENTRE

- Commercial Wafer Bonding service & Products (substrates)
- Bonding process development, tech transfer & training
- Associated Processes: cleaning, activation, structuring e.g. Powder blasting (holes) Deposition; Glass frit, Eutectic Electroplating (e.g.vias), CMP & wafer characterisation; Profile, TTV, Ra, & inspection; SAM, IR..



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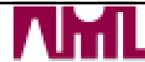
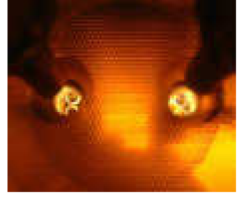
AML Wafer Bonders



Wafer bonding capabilities:-

- Anodic Bonding Si-Glass
- Direct Bonding e.g. Si-Si
- Glass Frit Bonding
- Eutectic Bonding
- Thermo-compression
- Adhesive Bonding
- Aligned Embossing



In situ chamber alignment & bonding

= more process flexibility & higher throughput

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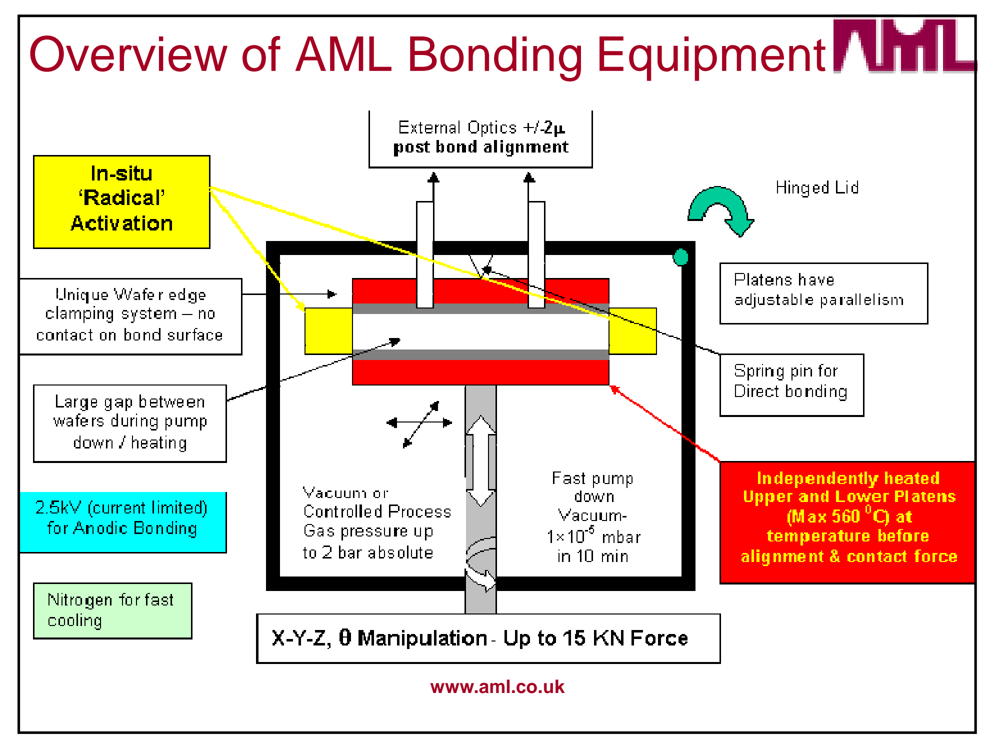
Overview of AML Bonding Equipment



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BONDCENTRE SERVICES OFFERED

- Development of Wafer Bonding & associated Processs e.g. for many novel materials; silicon, glass, sapphire, strained silicon, InP, GaAs,…
- Wafer Bonding process selection & design for your application
- Commercial Wafer Bonding Service prototype to production & products e.g substrates
- Wafer Bonding Technology Transfer (inc Equipment) & Training
- Associated Processes (Pre & Post Bond)
- Applications knowledge for:

  MEMS
  Advanced Substrates
  3D integration
  Temporary Bonding
  LEDs
  Smart cut layer transfer
  Wafer Level Packaging
  Vacuum Encapsulation

Recognised experts & Funded by UK Government to provide services to Industry

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Pre & Post Bonding Services & Equipment

- WAFER ALIGNER BONDERS 4 machines in Class 10
- Wafer METROLOGY; AFM, Ra, PROFILE, TTV
- WAFER CLEANING MEGASONIC & Activation
- NEW 'RAD' dry ACTIVATION
- INSPECTION: ACOUSTIC MICROSCOPE (SAM) & IR
- ELECTROPLATING: e.g. VIAS in Au, In, Cu & Ni
- SCREEN PRINT - GLASS FRIT/ADHESIVE
- Structuring e.g. Holes via POWDER BLASTING
- CMP

Also access via long term collaboration with CMF @ Rutherford to:

- PHOTOLITHOGRAPHY DEPOSITION- PVD & CVD & FURNACES
- Standard ETCHING – DRY & WET
- WAFER SAW WIRE & BUMP BONDING
- METROLOGY: THIN FILM, LINE WIDTH, SEM

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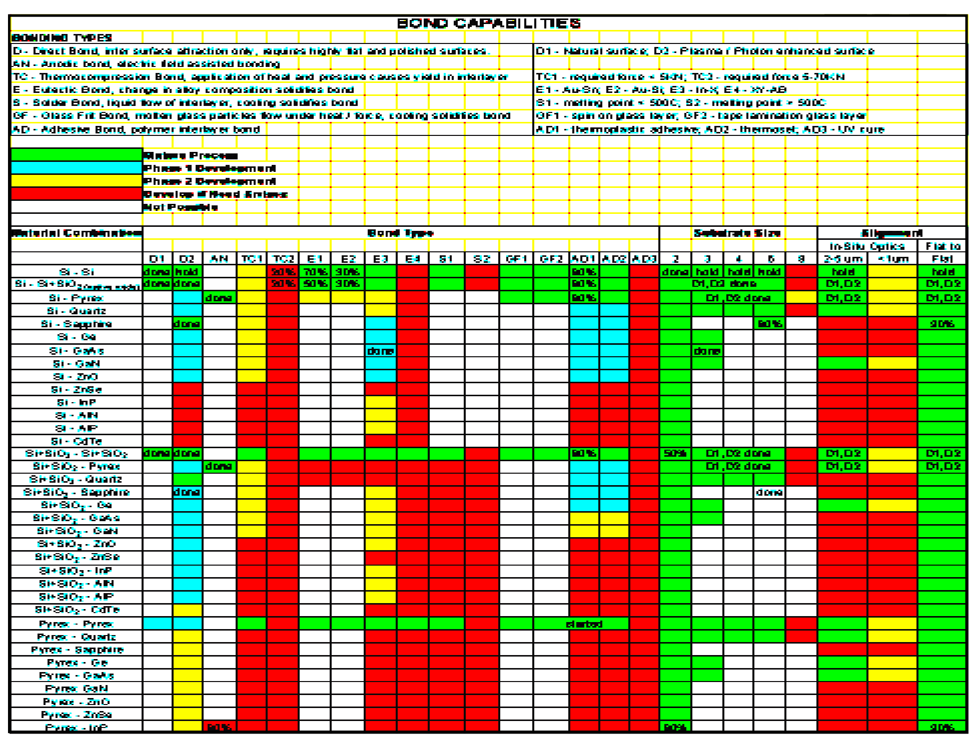

BOND CAPABILITIES

BONDING TYPES

D - Direct Bond, inter surface attraction only, requires highly flat and polished surfaces.	D1 - Natural surface; D2 - Plasma / Photon enhanced surface
AN - Anodic bond, electric field assisted bonding	
TC - Thermocompression Bond, application of heat and pressure causes yield in interlayer	TC1 - required force < 5kN; TC2 - required force 5-70KN
E - Eutectic Bond, change in alloy composition solidifies bond	E1 - Au-Sn; E2 - Au-Si; E3 - In-X; E4 - XY-AB
S - Solder Bond, liquid flow of interlayer, cooling solidifies bond	S1 - melting point < 500C; S2 - melting point > 500C
GF - Glass Frit Bond, molten glass particles flow under heat / force, cooling solidifies bond	GF1 - spin on glass layer; GF2 - tape lamination glass layer
AD - Adhesive Bond, polymer interlayer bond	AD1 - thermoplastic adhesive; AD2 - thermoset; AD3 - UV cure

Colour	Status
Green	Mature Process
Cyan	Phase 1 Development
Yellow	Phase 2 Development
Red	Develop if Need Arises
White	Not Possible

Material Combination	Bond Type																Substrate Size					Alignment		
																						In-Situ Optics		Flat to
	D1	D2	AN	TC1	TC2	E1	E2	E3	E4	S1	S2	GF1	GF2	AD1	AD2	AD3	2	3	4	6	8	2-5 um	<1um	Flat
Si - Si	done	hold			90%	70%	30%							90%			done	hold	hold	hold		hold		hold
Si - Si+SiO2	done	done			90%	50%	30%							90%				D1, D2 done				D1,D2		D1,D2
Si - Pyrex			done											90%				D1, D2 done				D1,D2		D1,D2
Si - Quartz																								
Si - Sapphire		done																		90%				90%
Si - Ge																								
Si - GaAs								done										done						
Si - GaN																								
Si - ZnO																								
Si - ZnSe																								
Si - InP																								
Si - AlN																								
Si - AlP																								
Si - CdTe																								
Si+SiO2 - Si+SiO2	done	done												90%			50%	D1, D2 done				D1,D2		D1,D2
Si+SiO2 - Pyrex			done															D1, D2 done				D1,D2		D1,D2
Si+SiO2 - Quartz																								
Si+SiO2 - Sapphire		done																		done				
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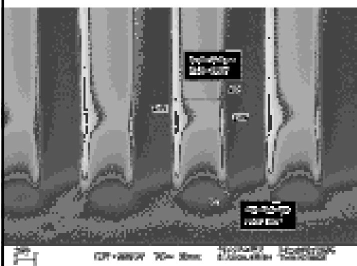
Si+SiO2 - AlP																								
Si+SiO2 - CdTe																								
Pyrex - Pyrex														started										
Pyrex - Quartz																								
Pyrex - Sapphire																								
Pyrex - Ge																								
Pyrex - GaAs																								
Pyrex GaN																								
Pyrex - ZnO																								
Pyrex - ZnSe																								
Pyrex - InP			90%														90%							90%

New Polymer Micro-Nano Hot Emboss & Print tool



Applications: e.g.
Bio-sensors & Microfluidics
Polymers: SU8, PDMS, PMMA..

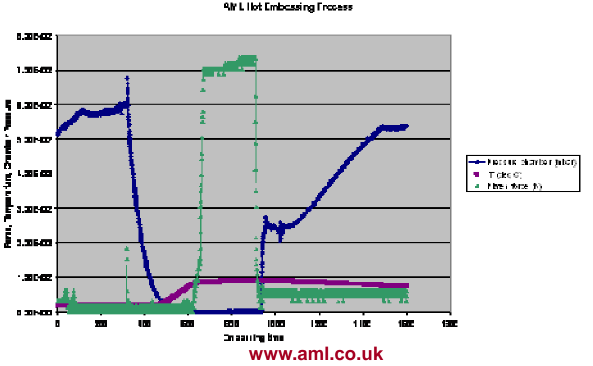
Outline Specification	
Force up to15kN	Stroke < 750 microns to 2mm
T </= 500 C	700N De-emboss force
Operation in Vacuum	2 micron alignment between stamp & substrate

EMBOSS & BOND WITH ONE MACHINE

Long stroke with high lateral precision for the formation of high aspect ratio embossed structures

Outline Specification:

- Wafer Substrate –any sizes up to 150mm
- Max emboss force – 15kN
- In-situ de-emboss force – 630N
- Max temperature of platens - 450oC
- Platen temperature uniformity - +/-2.5oC (100mm wafers) +/-3.5oC 150mm wafers)
- Z stroke – 2mm or <750 microns for Piezo drive actuation
- XY error over full Z stroke 1.4µm (NB XY error for shorter strokes is pro rata, i.e. 1.4nm for a 2µm stroke)
- Alignment accuracy - +/- 2µm
- Operation in Vacuum or controlled pressure
- 2 micron alignment between stamp & substrate



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Collaboration

- AML keen to collaborate with Finnish organisations in wafer bonding and Micro Nano embossing - imprinting

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