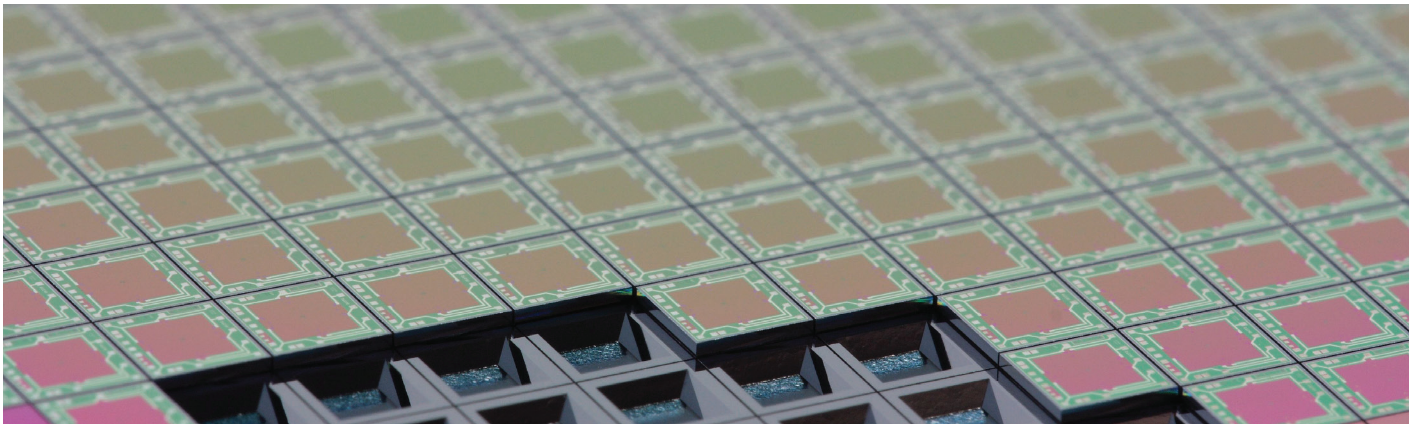
DIRECT BONDING USING CHEMICAL REACTIVE PLASMA DISCHARGE



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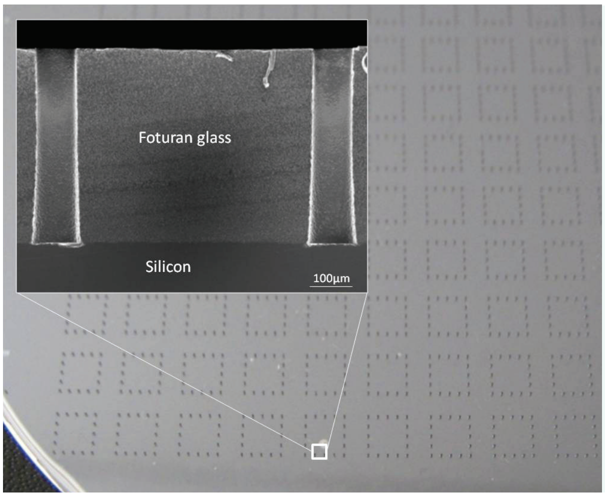
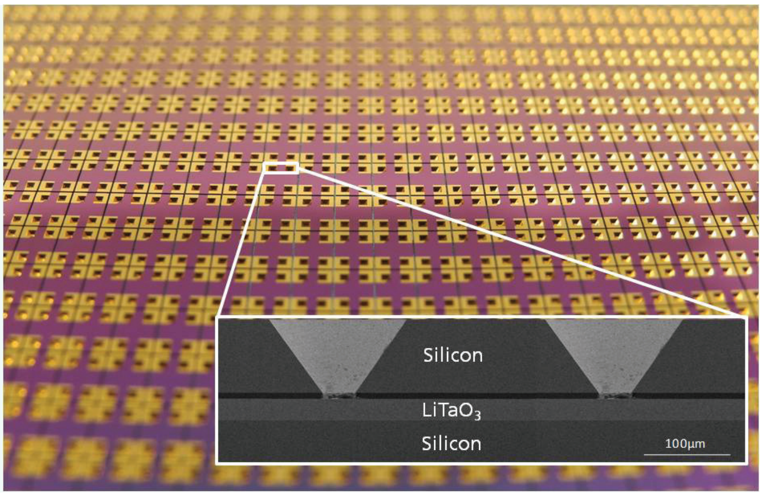
Description

Joining two substrates without intermediate layer, the surface roughness is very important. While small variations in the surface roughness can be easily compensated by thick intermediate layers such as glass paste or epoxy resins, the atomic contact is crucial to form a strong and stable bond based on techniques without intermediate layers. For instance, anodic bonding is carried out with surface roughnesses R_a below 1 nm. Other technologies require special pretreatments, like plasma activation with special gases or a wet chemical treatment, in order to create a smooth hydrophilic or hydrophobic surface.
Besides a wet-chemical pretreatment of the wafers, a chemical-reactive plasma discharge prior to bonding increases the mechanical strength of the direct bonded stack. The plasma activation can be applied to the whole substrate or limited to small areas and structures atop the wafer. Even at curing temperatures of 200 °C, the resulting bonding strength is comparable to high-temperature bonds. The pretreatment with plasma followed by low-temperature bonding can be used for joining material with different coefficients of thermal expansion. It therefore enables the integration of new materials and heterogeneous materials like lithium tantalite ($LiTaO_3$), stainless steel or foturan glass.

Advantages of this bonding technology

- Short bonding time
- High bonding strength
- No additional intermediate layer
- Independent on bonding environment, such as vacuum and nitrogen





Successfully bonded material combination on wafer-level

	Silicon	Borosilicate glass	Foturan glass	Quartz glass	$LiTaO_3$	LTCC (ceramic)	Stainless steel
Silicon	x	x	x	x	x	x	
Borosilicate glass	x	x	x	x	x		x
Foturan glass	x	x	x	x	x		
Quartz glass	x	x	x	x	x		
$LiTaO_3$	x	x	x	x	x		
LTCC (ceramic)	x						
Stainless steel		x					

Figures:
page 1: pressure sensor in cooperation with EPCOS AG after Silicon Fusion bonding using chemical reactive plasma discharge.

page 2: Silicon-foturan wafer level stack including through holes in foturan glass (SEM cross-section) (left); Silicon-$LiTaO_3$-silicon wafer level stack including silicon interposer (SEM cross-section) (right).

Photo acknowledgements: Fraunhofer ENAS