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(54) **METHODS FOR WAFER BONDING AND FOR NUCLEATING BONDING NANOPHASES USING WET AND STEAM PRESSURIZATION**

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H01L 21/18 (2006.01)

(52) **U.S. Cl.**
CPC ***H01L 21/187*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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(57) **ABSTRACT**

Substrates may be bonded according to a method comprising contacting a first bonding surface of a first substrate with a
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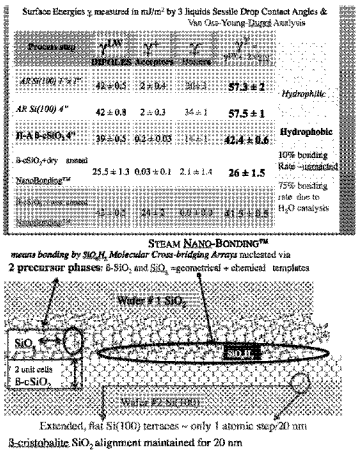


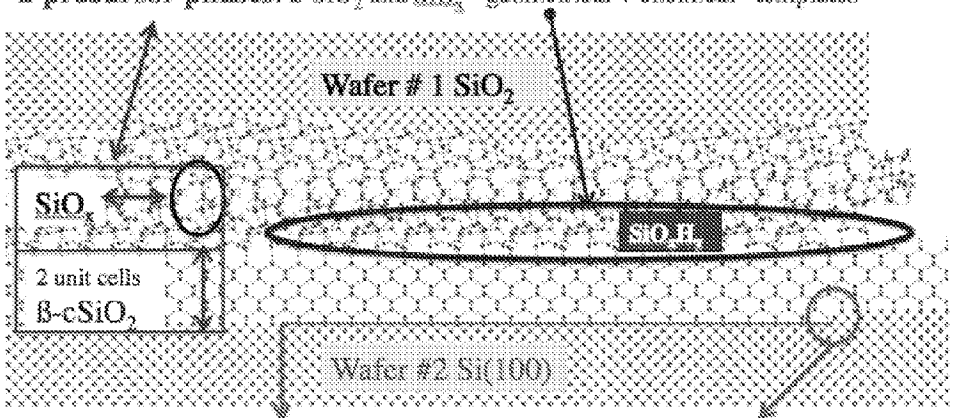
Surface Energies γ measured in mJ/m² by 3 liquids Sessile Drop Contact Angles & Van Oss-Young-Dupré Analysis

Process step	γ^{LW} DIPOLES	γ^{+} Acceptors	γ^{-} Donors	$\gamma^{T} = \gamma^{LW} + 2\sqrt{\gamma^{+}\gamma^{-}}$	
AR Si(100) 1"x 1"	42 ± 0.5	2 ± 0.4	30± 3	**57.3 ± 2**	*Hydrophilic*
AR Si(100) 4"	42 ± 0.8	2 ± 0.3	34 ± 1	**57.5 ± 1**	
H-A ß-cSiO$_2$ 4"	39 ± 0.5	0.2 ± 0.03	14 ± 1	**42.4 ± 0.6**	**Hydrophobic**
ß-cSiO$_2$+dry anneal NanoBonding™	25.5 ± 1.3	0.03 ± 0.1	2.1 ± 1.4	**26 ± 1.5**	10% bonding Rate –unreacted
ß-cSiO$_2$ +wet anneal NanoBonding™	42 ± 0.5	24 ± 2	0.0 ± 0.0	**41.5 ± 0.5**	75% bonding rate due to H_2O catalysis

STEAM NANO-BONDING™

means bonding by SiO_xH_x Molecular Cross-bridging Arrays nucleated via

2 precursor phases: ß-SiO_2 and SiO_x =geometrical + chemical templates



Extended, flat Si(100) terraces ~ only 1 atomic step/20 nm

ß-cristobalite SiO_2 alignment maintained for 20 nm

FIG 11