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Critical cone channelling in directly bonded wafers

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Directly bonded semiconductor wafers have been investigated using ultrasonic transmission tomography and imaging of the phonon focusing patterns at ultrasonic frequencies. Beside of total disbonds, several bonded wafers contained defects that are fully transparent to normally incident waves of longitudinal polarization, and are fully opaque to those of transverse polarization. These defects, which are due to slip boundary conditions at the wafer-wafer interface, generate an additional acoustic mode by mode conversion at the interface. The additional mode is clearly observable in the experimental phonon focusing patterns and is indicative of the critical cone channelling phenomenon, which is caused by the generation of pseudo-surface and head waves at weakly bonded solid-solid interfaces. The effect is also expected to be present in the case of weakly-bonded isotropic materials. Since the strong pseudo-surface wave resonance exists only in the case of boundary conditions that allow for the relative displacement of the two adjoining media along the interface, the critical cone channelling effect can serve as a measure of the type and quality of the bond.