New Angles of Phonon Refraction

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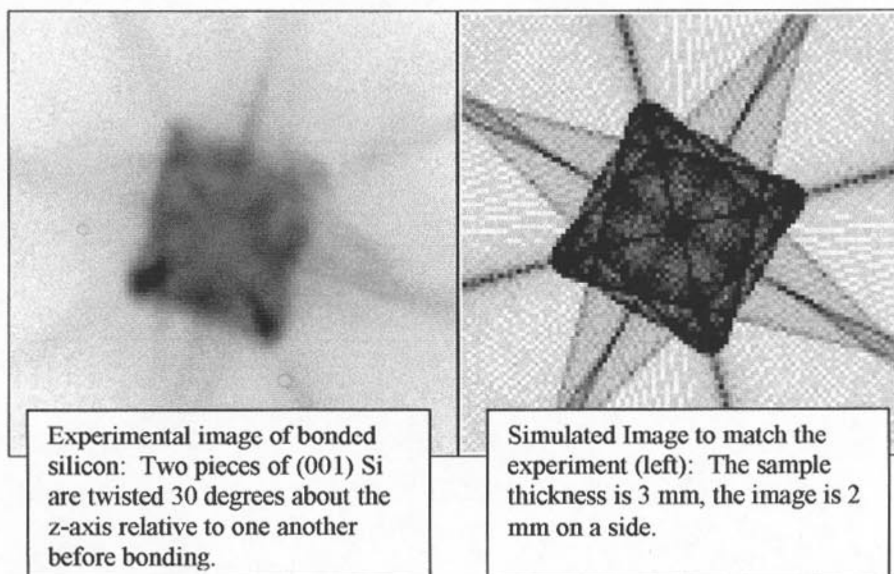
The true phonon analog of optical focusing is the redirection of flux at an interface, where continuity requirements on interface strains require conservation of the perpendicular wave-vector component on either side. Such refraction is observable only at extremely clean defect-free interfaces. We have conducted phonon imaging studies of a variety of wafer-bonded samples in which the bonded materials have a large lattice mismatch at the interface (e.g., [210] GaAs bonded to [100] GaAs). The materials on either side of the bond are of the same crystalline type but are acoustically distinct because of the deliberate misorientation of the sample faces. Phonon imaging reveals a combination of refraction and diffusive scattering at these interfaces. Comparison of the experimental images to computer simulations confirms the dominance of refraction without energy down-conversion at high quality interfaces and provides interesting evidence of inelastic phonon-defect interactions.



Experimental image of bonded silicon: Two pieces of (001) Si are twisted 30 degrees about the z-axis relative to one another before bonding.

Simulated Image to match the experiment (left): The sample thickness is 3 mm, the image is 2 mm on a side.