# Structural, thermal, and electrical transport correlations in p-type Si as a function of carrier concentration: the effect of intrinsic and extrinsic defects

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Studying the thermophysical properties of semiconductor materials used in the electronics industry is essential to improve electronic device design and integrated circuits, where performance depends heavily on electro-thermal interactions. These materials can transfer heat through lattice vibrations and energy transport by free electrons [1].

Intrinsic (carrier distribution, carrier lifetime, diffusion coefficient, recombination velocity) and extrinsic (defect densities, pressure for growing, annealing) parameters are involved in silicon (Si) wafers machining. Electronic-phonon interactions and carrier concentration variations from $10^{17}$ to $10^{21}$ $cm^{-3}$ have been considered in the thermal conductivity modelling. Due to the increase in the carrier density, there is an increase in the electronic thermal conductivity; therefore, the phononic thermal conductivity decreases by up to 45 % [2].

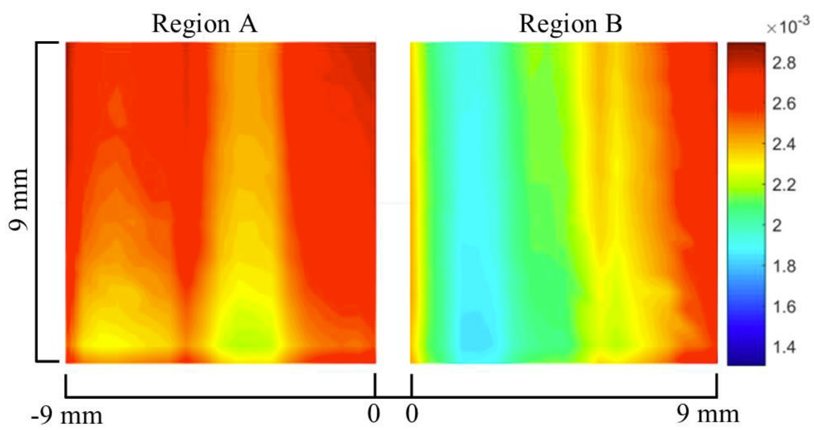


**Fig. 1.** Photocarrier images for two regions located at the centre of a Si wafer with a resistivity of 0.1 Ω·cm.

In monocrystalline semiconductor material, its structural properties govern thermal and electrical ones. Here, it was investigated the effect of defects induced by intrinsic and extrinsic parameters on the structural, thermal, and electrical properties during manufacturing processes and samples preparation in *p*-type Si wafers with different carrier concentrations. Photocarrier images showed that Boron carrier distribution exhibits local variation across a wafer as is indicated in Fig. 1. Fig. 2 shows a thermal diffusivity mapping for a wafer without cuttings where local variations in this property are evidenced. The Hall effect measurements in cut and polished samples delivered structural damages effecting the carrier lifetime changes. The crystalline quality obtained by studying the FWHM of the X-Ray patterns elucidated the effect of intrinsic carrier contribution on the structural properties. Thermal diffusivity and heat capacity of the cut samples exhibit a decrease as carrier concentration increases and are negative affected by the crystal damage. Thermal and electrical properties are governed by structure state determined by intrinsic and extrinsic parameters.

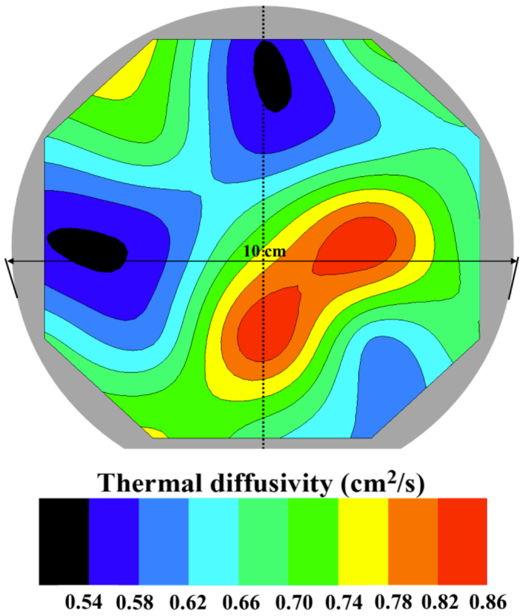


**Fig. 2.** Thermal diffusivity contour map taken from a p-type Si wafer with a resistivity of 0.1 Ω·cm.

## References

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