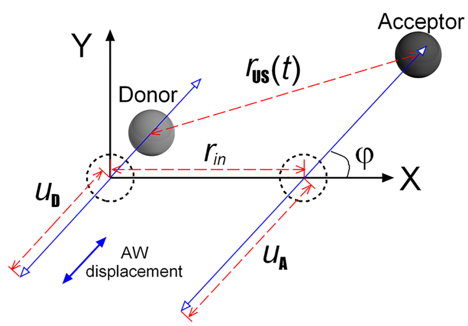
Scilight

24 January 2018

Ultrasonic loading leads to reversible changes in electronic properties of silicon crystals

Adam Liebendorfer

Silicon n^+-p-structured crystals show altered shunt resistance, carrier lifetime and ideality factors when interacting with ultrasound frequencies after exposure to reactor neutrons or ^{60}Co gamma radiation.



As semiconductor materials become increasingly tailored for applications, understanding and controlling the defects and impurities in these materials are often at a premium. Ultrasound shows promise as a defect engineering tool for its abilities to work locally within a material and fine-tune its effect to meet the polarization and resonance features called for by the material's use. Work published in the *Journal of Applied Physics* sheds new light on the effects ultrasound techniques have on the current-voltage characteristics of semiconductor devices.

The work focused on silicon n^+-p-structured crystals, one of the most common forms of nonpiezoelectric semiconductor materials used in applications such as solar cells, LEDs and integrated circuits. Reactor neutrons and gamma rays from a ^{60}Co source induced different types of defects in <111> oriented p–type boron doped Czochralski silicon wafers. Applied at the sample base, 4.2 megahertz transverse acoustic waves traveled in the <111> direction during *I-V* measurements of the ultrasound loaded crystals. Analysis models of coupled defect-level recombination, Shockley-Read-Hall recombination and dislocation-induced impedance described the changes in electrical characteristics that were brought on by the acoustically induced modification of the defects.

The ultrasound loading of the n^+-p-structure leads to reversible decreases in minority carrier lifetime and shunt resistance. The material's ideality factor, a measure of the effect defects have on a semiconductor's electronic properties, also varied from the acoustic wave interactions.

These changes were more pronounced in samples irradiated with reactor neutrons or ^{60}Co gamma radiation. While interstitial carbon-interstitial oxygen complexes do not take part in acousto-defect interactions, further analysis revealed that divacancy in neutron-exposed structures and vacancy-interstitial oxygen pairs in irradiated samples could be modified with ultrasound. The authors hope their recent work will lead to better controllability and selectivity when it comes to using ultrasound for defect engineering.

Source: "Acousto-defect interaction in irradiated and non-irradiated silicon n^+-p-structures," by O. Ya. Olikh, A. M. Gorb, R. G. Chupryna, and O. V. Pristay-Fenenkov, *Journal of Applied Physics* (2018). The article can be accessed at https://doi.org/10.1063/1.5001123.