Ionization Energies of Shallow Donor States in ZnO Created by Reversible Formation and Depletion of H Interstitials

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The electronic effects of H atoms at interstitial sites in ZnO have been investigated by high resolution electron energy loss spectroscopy (HREELS). A reversible doping is achieved by exposing single crystalline $(000\bar{1})$-oriented ZnO substrates to atomic hydrogen. At low temperatures, interstitial H atoms form shallow donor states. At sufficiently high temperatures, the electrons are excited into the conduction band. We use EELS to demonstrate the presence of plasmons resulting from this finite density of charge carriers in the conduction band. Above temperatures of 100 K, a strong, plasmon-induced broadening of the quasielastic peak in the HREELS data is observed. The analysis of the temperature dependence yields a donor level ionization energy of 25 ± 5 meV.

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