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Piezospectroscopy of the p3/2 and Fano series of singly ionised Zn in Ge

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Abstract

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EFFECT OF SHALLOW-DEEP INSTABILITY ON FORMATION OF THERMAL DONORS IN Si

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Earlier [1] a rapid variation was found in the forward reaction rate constants for the first species in thermal donor (TD) series formed in Cz-Si crystals at T=300-500°C. In present work it is shown that such a variation can be associated with some peculiarities in electronic properties of these centers. The prominent feature of the first three TD species is bistability: they can exist in two different configurations associated with shallow and deep donor states. Assuming that the TD growth rates in specific configurations may differ essentially we have developed a new kinetic model. When calculating the configuration occypancy probability the negative-U properties of the TDs were taken into account. The comparison of this model with experimental data has shown that the formation of early TDs most probably occurs in the neutral (deep donor) state. It is argued that this result may provide further insight into the TDs origin.

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Piezospectroscopy of the $p_{3/2}$ and Fano Series of Singly Ionised Zn in Ge*

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The spectrum of singly ionised zinc in Ge shows two series of excitations in the spectral range of 60-120 meV. One, the well known $p_{3/2}$ series, occurs in the range 60 - 90 meV; its most prominent lines are labelled D, $C^{(2)}$, B and A [1]. The other, consisting of asymmetric, broad features, lies in the range 100-120 meV and is comprised of Fano resonances [2] associated with the $p_{3/2}$ transitions and the localised zone centre optical phonon of Ge [1,3]; the continuum states involved in these Fano processes are those of the $p_{3/2}$ band. The effect of a compressive uniaxial force, **F**, on transitions in both series has been examined with F||<100> and <111>. The three lines labelled $C^{(1)}$, $C^{(2)}$ and $C^{(3)}$ of the $p_{3/2}$ series [1] have been identified as having the levels $3\Gamma_8^+$, $1\Gamma_7^-+3\Gamma_8^-$ and $4\Gamma_8^+$, respectively, as final states, in reasonable agreement with theory [4]. The Fano resonances show various typical shapes and experience splittings under stress which are close in magnitude to those of their counterparts in the $p_{3/2}$ series, although there are some deviations which are not understood. The shapes of the Fano G components change with stress, possibly due to the mixing of its final states with those of the dominant D line [5]. The piezo-Fano selection rules, derived using symmetry considerations [6], show how the restrictions for $p_{3/2}$ transitions are relaxed for the associated Fano resonances. This is supported by experiment; for example, two of the stress induced components of the Fano D line are observed for F||<100> and E||F, while their $p_{3/2}$ counterparts are forbidden; **E** is the electric field of the radiation.

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HYDROGEN-RELATED SHALLOW ISOELECTRONIC CENTRES IN RADIATION-DAMAGED SILICON

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Neutron irradiation of Si saturated with hydrogen followed by annealing for a short period at 450°C gives rise to a number of shallow luminescence systems known as the X-lines. Previous investigations [1] of these systems, produced in Si grown in a hydrogen atmosphere, have shown that they can be identified with the decay of excitons bound to isoelectronic centres with binding energies in the range 4 to 20 meV, and that they have characteristic partially forbidden transitions from the ground states.

In this paper we report the results of creating these centres in material deliberately doped with hydrogen, deuterium and hydrogen-deuterium mixtures, which have revealed that at least six different centres contain hydrogen. The zero-phonon lines corresponding to transitions from the ground and first excited states have identical and surprisingly large isotope shifts (0.2 to 0.4 meV). Doping with both hydrogen and deuterium gives rise to complicated isotope splitting which shows that either two or more hydrogen atoms are incorporated, located at either equivalent or inequivalent sites.

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