Acoustic Solitons, Phonon Echoes, and Sound Amplification in Si:B at Very Low Temperatures.

Jean-Yves Prieur [1, 3], Jacques Joffrin [1], and Kurt Laβmann [1, 2]

1)Laboratoire de Physique des Solides, Bât. 510, Université Paris-Sud, F-91405 Orsay cedex
2)1. Physikalisches Institut, Universität Stuttgart, D-70550 Stuttgart
3) L.M.D.H. Université Pierre et Marie Curie, Place Jussieu, 75252 Paris cedex 05

Under stress, the fourfold degenerate Γ_8 ground state of acceptors like boron in silicon becomes a two-level system (TLS) of two two-fold degenerate Kramers-levels. Random internal strains originating from crystal defects will thus lead to distributions of the separations of these TLS. Such distributions have been previously investigated by measuring acoustic attenuation and saturation at frequencies between .5 to 12 GHz and at temperatures above 1 K [1].

Here we report on measurements of acoustic nonlinear phenomena in the 10 to 100 mK range. We take profit of the fact that the width of the distribution and the mean spatial distance of the TLS can be independently varied by the acceptor concentration and the density of strain-generating defects. In addition, an external magnetic field can be used to vary the concentration of TLS on speaking terms.

We discuss the observed dependence of relaxation times on the magnetic field and on crystal doping, trying to separate the influence of like and unlike spins on T_2. In addition, we report the observation of single and multiple acoustic solitons [2]. We present also the results for acoustic amplification. All these phenomena will be compared with those registered in glasses [3].

[1] A. Ambrosy et al., Phonon Scattering in Condensed Matter 1983, Springer Series in Solid-State Sciences 51 p. 361
[2] D.J.Kaup ; Phys.Rev.A Vol 16 N°2 (1977) 704
[3] J.-Y. Prieur et al., Europhys. Lett. 24 (1993) 409.

Multiple soliton development with input power