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Nano-scale energy transfer between optically active impurity ions: Experimental and theoretical methods of studying the local environment

Energy transfer between optically active impurities, such as rare-earth ions, in dielectric or semiconducting materials takes place at distances of less than a nanometer. The sizes of materials in which these processes are investigated are typically orders of magnitudes larger. Bottom-up growth or down-milling of nano-particles has two or even three disadvantages, i) the considerable size variation of the nano-particles, ii) the creation of surface states with considerably different optical properties, and iii) the structural modification of nano-particles by the down-milling process. A more convenient option is the deposition of a thin film, with only one or several few-nanometer-thick sheets within the thin film containing the impurities.

Even then the optical investigation includes a large amount of impurities. Therefore, one has to combine scaling down the material to nano-size with a theoretical model that can cope with the individual optical environments of many impurities. We propose a stochastic model of energy-transfer processes. The model distinguishes between different classes of impurities, namely single impurities which have no optically active neighbors in the first coordination sphere, pairs in which each impurity has one active neighbor, and larger formations of active neighbors. The model allows for the combination with any type of equations describing the interaction between neighboring ions, such as simple or more sophisticated sets of rate equations, where each set describes one class of impurities. We have applied such models to rare-earth-activated Al₂O₃ thin films, with excellent results concerning the description of the spectroscopic dynamics of the rare-earth ions.

Biography

Markus Pollnau received M.Sc. and Ph.D. degrees in physics from the Univ. of Hamburg in 1992 and the Univ. of Bern in 1996, respectively. In 2004 he became a Full Professor at the Univ. of Twente. Currently he works as a full professor at the Univ. of Surrey. He has contributed to more than 500 reviewed journal and international conference papers and 13 book chapters and served as Program and General Co-chair of important international conference, as well as Topical Editor for international journals. He is a fellow of the Optical Society of America and the European Physical Society.

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