Mapping of Recombination Mechanisms in Hydrogenated Amorphous Silicon with Coherent Spin Control -- a 21st Century Approach to Unsolved 20th Century Solar Cell Efficiency Challenges

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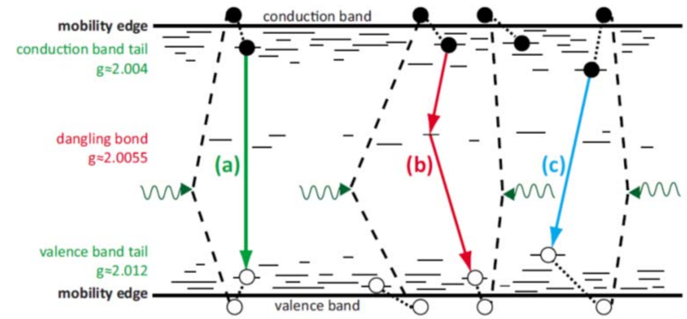
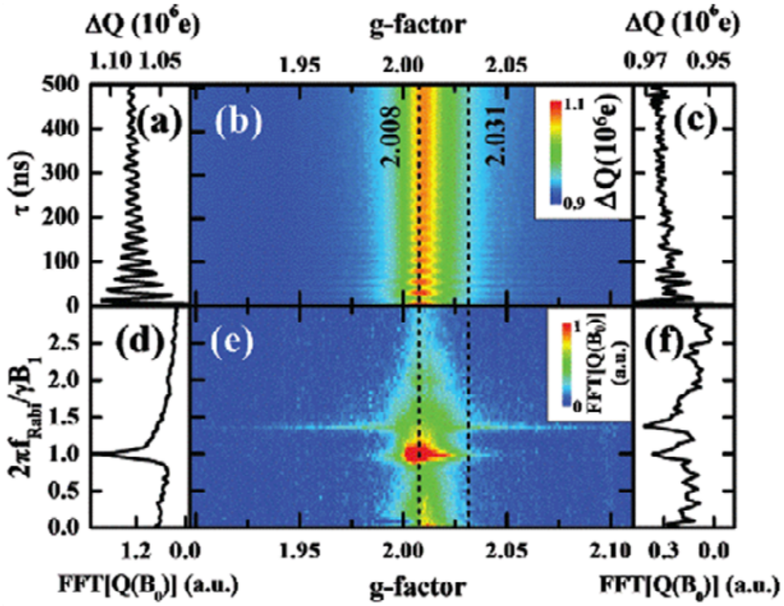
Pulsed optically (pODMR) and electrically (pEDMR) detected magnetic resonance was used to investigate how microscopic defects influence electronic properties of hydrogenated amorphous silicon (a-Si:H), a thin film semiconductor used for photovoltaic and detector applications.

During the first year of this project, a mapping of the different charge carrier recombination processes was accomplished which resolved a long debated question about which of the recombination processes are geminate (without effect on conductivity) and which are non-geminate (with effect on conductivity).



Sketch: The bandgap of a-Si:H has high densities of localized states due to the disorder of the material.



Charge carrier recombination in nitrogen doped a-Si:H (non-stoichiometric silicon rich silicon nitride, a-SiN_x:H) was investigated in the second year. PEDMR measurements (see plots on the left) reveal signal components which strongly differ from pEDMR of a-Si:H but they are similar to the pODMR signals of a-Si:H, indicating that many geminate processes of a-Si:H are non-geminate in a-SiN_x:H. This confirms the hypothesis that charge carriers can easier dissociate in a-SiN_x:H into non-geminate pairs.

The dependence of the dynamics of dangling bond (db) recombination on the a-Si:H degradation state was also investigated. Db-recombination transients were measured on the same device in the undegraded state, two different degraded states (48, 77hours light soaking), and an annealed state. These experiments revealed strong evidence that degradation induced dbs are of the same microscopic nature than dbs of nondegraded a-Si:H.