Temperature dependence of electrical characteristics of thin-film field-effect transistors

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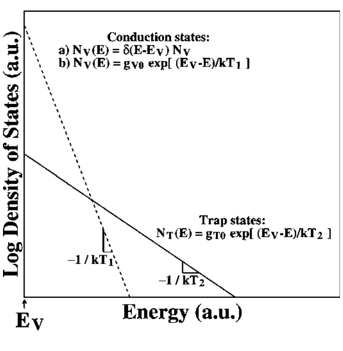
The temperature dependence of thin-film field effect transistors (TFTs) is described. As a starting model, the theory of two-dimensional TFTs is used [1]. This model predicts a current and mobility that is independent of temperature, contrary to what is normally observed in (organic) TFTs. To explain temperature dependence, the model is extended with the inclusion of abundant traps. It is shown that a discrete trap will cause a temperature dependence of current and as-measured mobility. To further extend the theory and explain gate-bias-dependent mobilities, non-discrete distributions of trap states and conduction states are tried. It is shown that when the traps have an exponential density of states (DOS), the mobility is both temperature and bias dependent, resulting in the observation of the Meyer-Neldel Rule [2]. When also the conduction states are non-discrete, the temperature dependence disappears, although the mobility is still strongly bias-dependent. The table below summarizes this. The results are compared to models of Poole and Frenkel [3] and Shur and Hack [4]. The results are also compared to results obtained by us in TFTs of sexithiophene (T6)[5].

Conduction states (N_V)	Trap states (N_T)	Temperature dependent mobility	Bias dependent mobility
discrete	absent	no	no
discrete	discrete	yes	no
discrete	exponential	yes	yes
exponential	exponential	no	yes



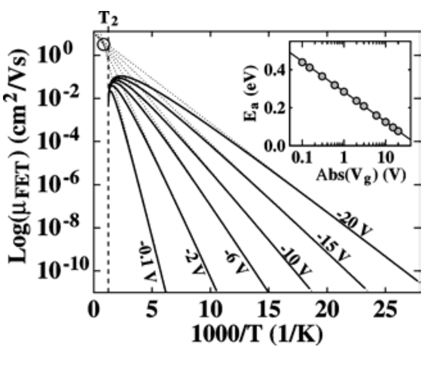


Table: summary of results. Figures: Density of states used for the calculations (left). In the case of discrete conduction states (a) and exponentially distributed trap states (solid line), the resulting Arrhenius plots of as-measured mobility μ_{FET}, are bias dependent, as shown on the right, resulting in so-called Meyer-Neldel Rule.

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[2] W. Meyer and H. Neldel, Z. Tech. **18**, 588 (1937) (german).
[3] S. M. Sze, "Physics of semiconductor devices", 2nd edition, Wiley Interscience, (1981).
[4] M. Shur and M. Hack, J. Appl. Phys. **55**, 3831 (1984).
[5] P. Stallinga, H.L. Gomes, F. Biscarini, M. Murgia, D.M. de Leeuw, J. Appl. Phys. **96**, 5277 (2004).