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The negative mobility: an outcome of the electric field at the hole-injecting metal/organic semiconductor interface that varies as a linear function of the applied bias

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Abstract. The published (room temperature) negative hole mobility, i.e. diminishing hole mobility with an increasing electric field, E_a , of three different organic semiconductors are analyzed in terms of the processes at the hole injecting interface. The charge mobility is described by the product of the effective mobility, μ_{eff} , and the algebraic function of the argument defined by the ratio of the electric field at the charge injecting metal/organic interface, E_{int} , to the externally applied electric field, E_a . It is shown that the negative hole mobility is directly related to the electric field at the hole injecting metal/organic interface, E_{int} , determined to be a *linear* function of E_a while the effective mobility, μ_{eff} , remains (almost) E_a independent. In particular, for the well-defined P3HT 12 (poly(3-hexylthiophene)) sample in films of (relatively) greater crystallinity a considerably *augmented* but still negative hole mobility as determined by the current-voltage method has been reported recently. Based upon the above formulation of the charge mobility, it is shown that principally it is the effective mobility, μ_{eff} , which is affected by the changing degree of the sample crystallinity while its bias dependence still remains governed by the *linear* dependence of E_{int} on E_a that is a characteristic feature of the negative mobility. For the P3HT enhanced crystallinity film the range and the magnitude of the interfacial electric field are changed in a way that the ensuing hole density decrease as a function of E_a then signifies an increased transparency for hole transport within such an organic bulk. It appears that the enhanced crystallization favors conditions for augmentation of the effective hole mobility in conjunction with efficiently increased hole injection at the interface. Consequently, it is the effect occurring at the charge injecting metal/organic junction, described by the algebraic function of the argument E_{int}/E_a that decisively modulates the E_a dependence of the experimental negative charge mobility. Supported by the presented results this work may then provide a physically viable alternative to otherwise phenomenological descriptions of the negative mobility as described in the literature.

Keywords: organic semiconductors, solid-solid interface, interfacial electric field, negative charge mobility

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