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PAPER

The self-assembled, atomically defined, flexible and highly tunable bilayered Au/L-cysteine/Cu(II/I) junctions capable of voltage-gated coherent multiple electron/hole exchange

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Abstract

Contemporary 2D spintronics (spin-based electronics) is a highly interdisciplinary field with numerous elaborated branches, mostly focusing on atomically thin, layered nano-junctions functionalized within 'dry' or 'wet' cells/cubicles/circuits. The charge carriers' spin-implicated aspects emerge throughout, albeit the most nanotechnologically promising issue (implying the information and energy transfer/storage aspects) among them, is perhaps the uniquely complex yet robust and rather universal phenomenon of a hybrid inter- and intra-layer Bose–Einstein-like (BE) condensation. However, this issue is still not sufficiently explored, especially, in the framework of the 'wet' spintronic domain. Thus, searching for new types of bilayer junctions, and testing of charge/spin allocation and flow within respective nano-devices, is a primary task of current 2D spintronics. In this paper we report on the novel effort towards an extension of the voltage-gated 'wet' 2D spintronics enabled through the self-assembling of bilayered Au/L-cysteine/Cu(II/I) junctions, and their rigorous, yet preliminary current-voltage testing towards the hidden collective spin-related manifestations. Our experimental efforts led to a cascade of rare, uniquely combined observations encompassing the temperature induced, directly visible (irreversibly shape-shifting) single-stage transformation of a CV signal (the natural signature of a voltage-gated interlayer Faradaic process). The ultra-thin shape of the resulting CV signal (unavoidably emerging under certain 'standard' conditions), turned to be readily explainable by the Laviron's general statistical formalism, as due to a multi-charge exchange process with the number of transferred electrons/holes ranging within 4 to 16 (per single elementary act) or even out of this range, being extra tunable via the experimental variables. Furthermore, cathodic and anodic peaks of the 'new' signal are moderately separated from each other and have nearly similar shapes. Additional experiments with a variation of the voltage scan rate, demonstrated the exceptional, very regular decaying of a number of simultaneously transferred electrons/holes (extracted from the peak-shape analysis) on the voltage scan rate; although the former parameters shows some fluctuational scatter in time, and/or from sample to sample. The subsequent multi-theory-based analysis of a whole scope of obtained Voltammetric data, allowed for a preliminary conjecture of the formation of a hybrid BE-like

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dipolar superfluid encompassing electron/hole-hosting clusters emerging within the bilayer junction. The specific electron/hole ratio within the layers is switchable (gated) by the interlayer potential (voltage) bias. The clusters' dimensions, charge distribution and dynamic exchange are reasonably fluctuative and essentially tunable through the applied potential (i.e. the voltage-gating). New experiments are on their way, revealing unlimited future promises of our current endeavor.

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