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Towards tunable single molecule photon sources

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Abstract:

Race to miniaturize light emitting diodes has led to develop interesting molecular designs capable of converting an electric current into light when connected to metallic leads. This imposes conflicting demands for the molecule-electrode coupling. To conduct, the molecular orbitals need to hybridize with the electrodes. To emit light, they need to be decoupled from the electrodes to prevent fluorescence quenching. Typically, this can be achieved by so called self-decoupled molecules that consist of a chromophore linked to anchoring groups. However, these designs are complex in nature and often the molecules either lack the needed electronic decoupling or they lack reproducibility of the light emission spectrum. Here we study the light emitting molecules in a low temperature (~ 4.4 K), ultra-high vacuum scanning tunnelling microscope (STM)[1]. In this STM geometry, novel design naphthalene diimide (NDI) chromophore is linked to a gold substrate via a molecular tripod and via the vacuum barrier to the silver coated tip. This allowed us to control the fluorescence quenching by varying the vacuum barrier. The proposed tripodal anchoring group provides sufficient electronic decoupling to the light emitting chromophores, and in turn, a high quantum yield of $\approx 2 \times 10^{-3}$ photons/electron is observed. These molecules also allow us to probe intriguing phenomena like over-bias emission[2], and hot electroluminescence[2]. The novelty of this approach lies in the fact that this platform can be used to mount different chromophores to achieve tunable single molecule photon sources.

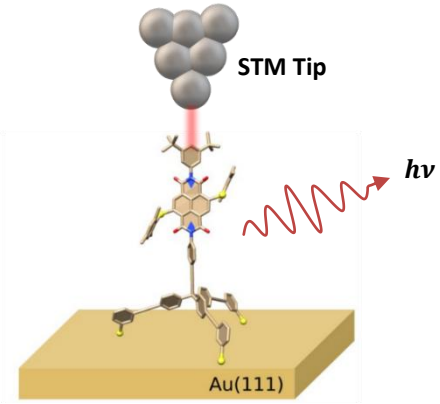

Figure : Adsorption geometry of the NDI complex on Au(111) in the STM junction.

References:

[1] K. Edelmann, L. Gerhard, M. Winkler, L. Wilmes, V. Rai, M. Schumann, C. Kern, M. Meyer, M. Wegener, and W. Wulfhekel, Rev. Sci. Instrum. **89**, (2018).

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