S4-9: Dependence of maximum pumping frequency on the profile of the quantum-dot potential in quantum dot-based single electron pumps

Authors: Ye-Hwan Ahn\textsuperscript{1,2}, Changki Hong\textsuperscript{3}, Young-Seok Ghee\textsuperscript{1,4}, Yunchul Chung\textsuperscript{3}, Myung-Ho Bae\textsuperscript{1}, and Nam Kim\textsuperscript{1}

Affiliation of authors: \textsuperscript{1}Korea Research Institute of Standards and Science, Daejeon 34113, Republic of Korea, \textsuperscript{2}Department of Physics, Korea University, Seoul 02841, Republic of Korea, \textsuperscript{3}Department of Physics, Pusan National University, Busan 46241, Republic of Korea, \textsuperscript{4}Department of Physics, Chonnam National University, Gwangju 61186, Republic of Korea

Speaker: Nam Kim or Ye-Hwan Ahn

Speaker email: namkim(at)kriss.re.kr or muta0719(at)gmail.com

Abstract: Our quantum-dot (QD) electron pump has uniqueness in design that the QD potential shape can be manipulated, especially its potential depth can be controlled by a plunger gate [1]. We find that there exist strong correlations between the potential depth of the QD and the maximum pumping frequency, $f_m$, when the modulating microwave power is fixed. As the depth of the QD potential was deepened, $f_m$ showed decreasing characteristics while the flatness of the 1$^{st}$ current plateau was increased. We confirmed the same trend for five different devices. We quantitatively analyzed these correlations by using the notion of so called ‘non-adiabatic Coulomb blockade gap energy’, $\Delta E_{LU}$ [2]. We found that $\Delta E_{LU}$ parameters being under control by a plunger gate is proportional to the pumping frequency $f$. The flatness parameter of 1$^{st}$ current plateau, $\delta_2$ is also found to be proportional to $\Delta E_{LU}$. Our numerical calculations based on master equations reproduced qualitatively the frequency dependence of $\Delta E_{LU}$, which is consistent with the decay cascade model [3]. Based on its frequency dependence, we could estimate semi-quantitatively the maximum operation frequency $f_m$ at a fixed modulating microwave power. Consequently, we arrive at provisional conclusions that the $f_m$ observed in our experiments is due to the deficiency of the modulating power and in order to get higher pumping frequency we should decrease $\Delta E_{LU}$ by sacrificing the flatness parameter $\delta_2$. For more quantitative analysis we need further study.