Phonon-Assisted Electroluminescence from Metallic Carbon Nanotubes and Graphene

S. Essig[1,2], C.W. Marquardt[1,2], A. Vijayaraghavan[1], M. Ganzhorn[1,2], S. Dehm[1], F. Hennrich[1], F. Ou[3], A. A. Green[4], C. Sciascia[7], F. Bonaccorso[7], K.-P. Bohnen[5], H. v. Löhneysen[2,5,8], M.M. Kappes[6,8], P. Ajayan[3], M.C. Hersam[4], A.C. Ferrari[7], R. Krupke[1,8,§]

[1] Institut für Nanotechnologie, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany,

[2] Physikalisches Institut, Karlsruhe Institute of Technology, 76128 Karlsruhe, Germany,

[3] Department of Mechanical Engineering & Materials Science, Rice University, Houston, TX 77005, USA,

[4] Department of Materials Science and Engineering, Northwestern University, Evanston, IL 60208-3108, USA,

[5] Institut für Festkörperphysik, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany,

[6] Institut für Physikalische Chemie, Karlsruhe Institute of Technology, 76128 Karlsruhe, Germany,

[7] Department of Engineering, University of Cambridge, Cambridge CB3 0FA, UK,

[8] DFG Center for Functional Nanostructures (CFN), 76028 Karlsruhe, Germany.

[§]ralph.krupke@kit.edu

Supporting Information: Optical absorption spectra (S1), device characteristics (S2), electroluminescence data (S3-S5).

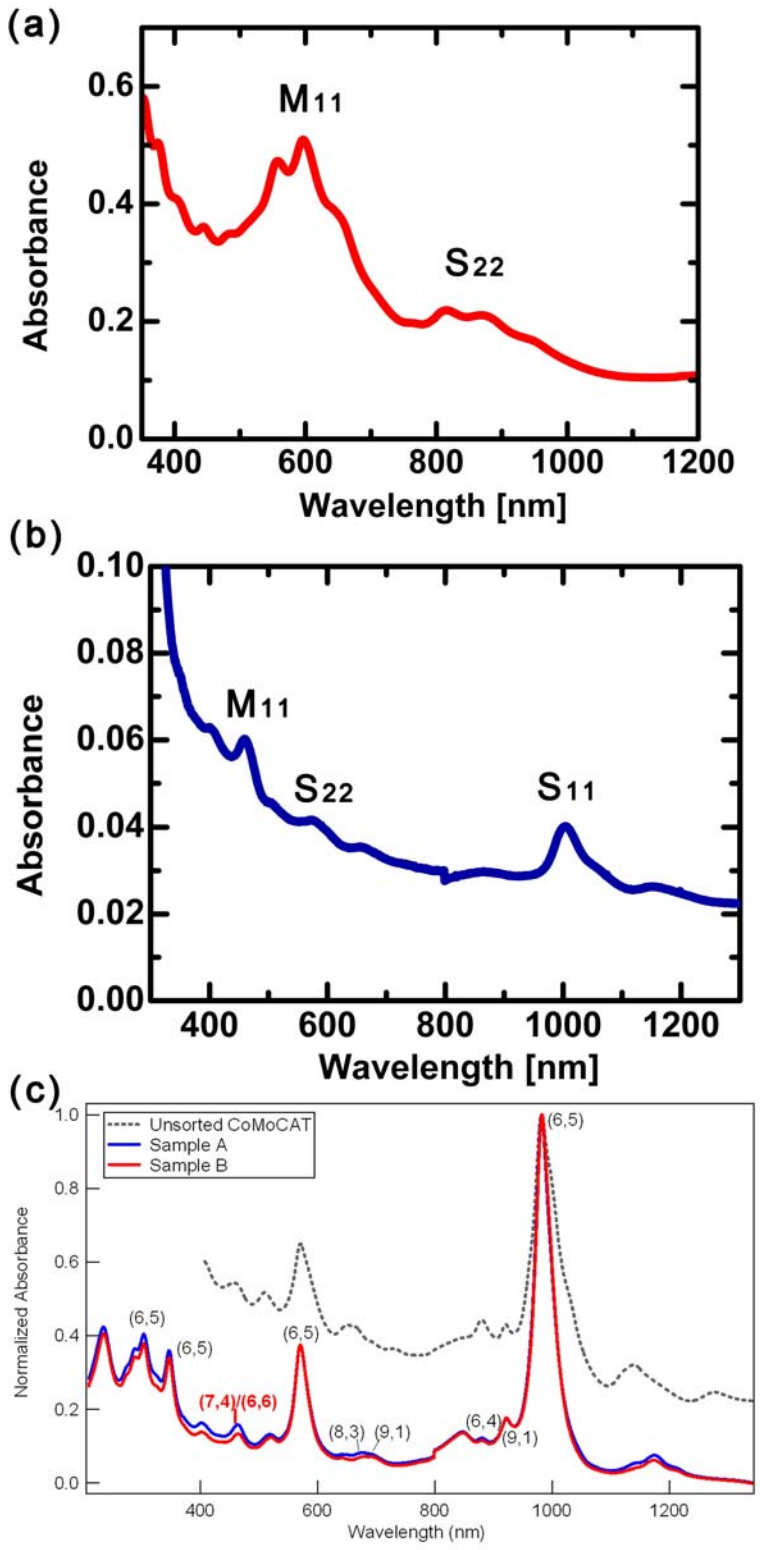

Fig. S1: Optical absorption spectra of suspensions SWNT#A (a), SWNT#B (b), and SWNT#C (c).

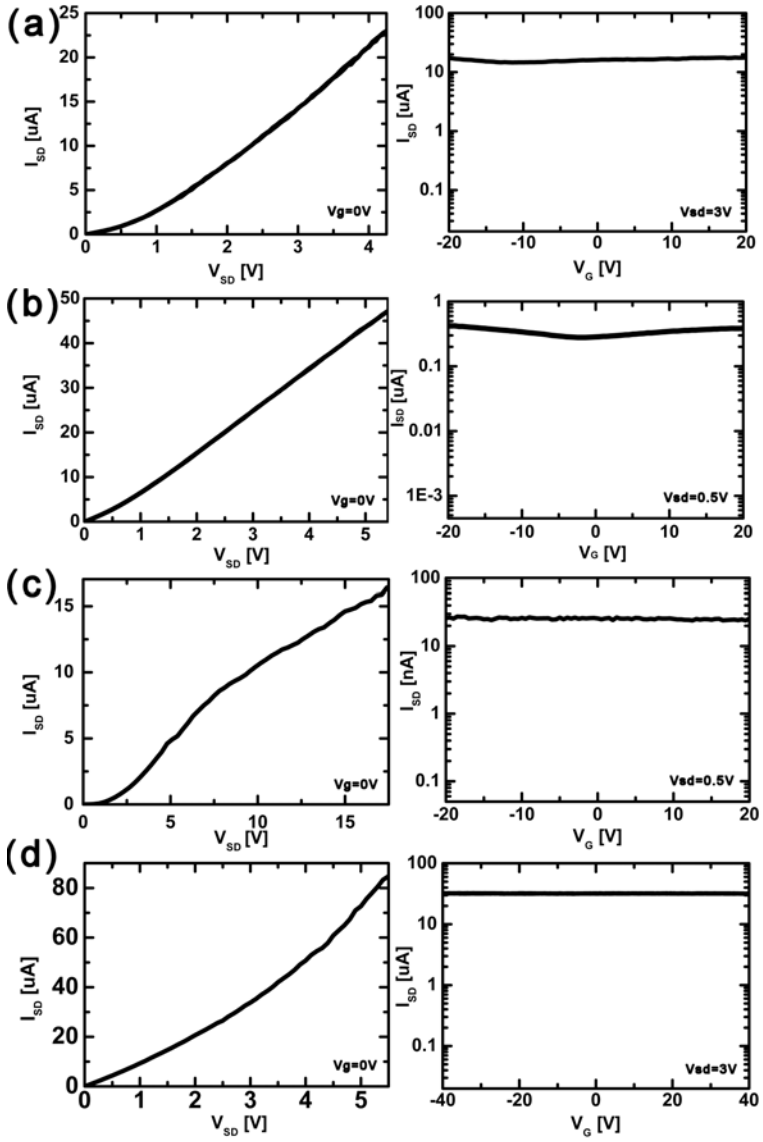

Fig. S2: Source-drain current I_{SD} vs. source-drain voltage V_{SD} and vs. gate voltage V_G of the SWNT#A (a), SWNT#B (b), SWNT#C (c), and FLG#D (d) devices.

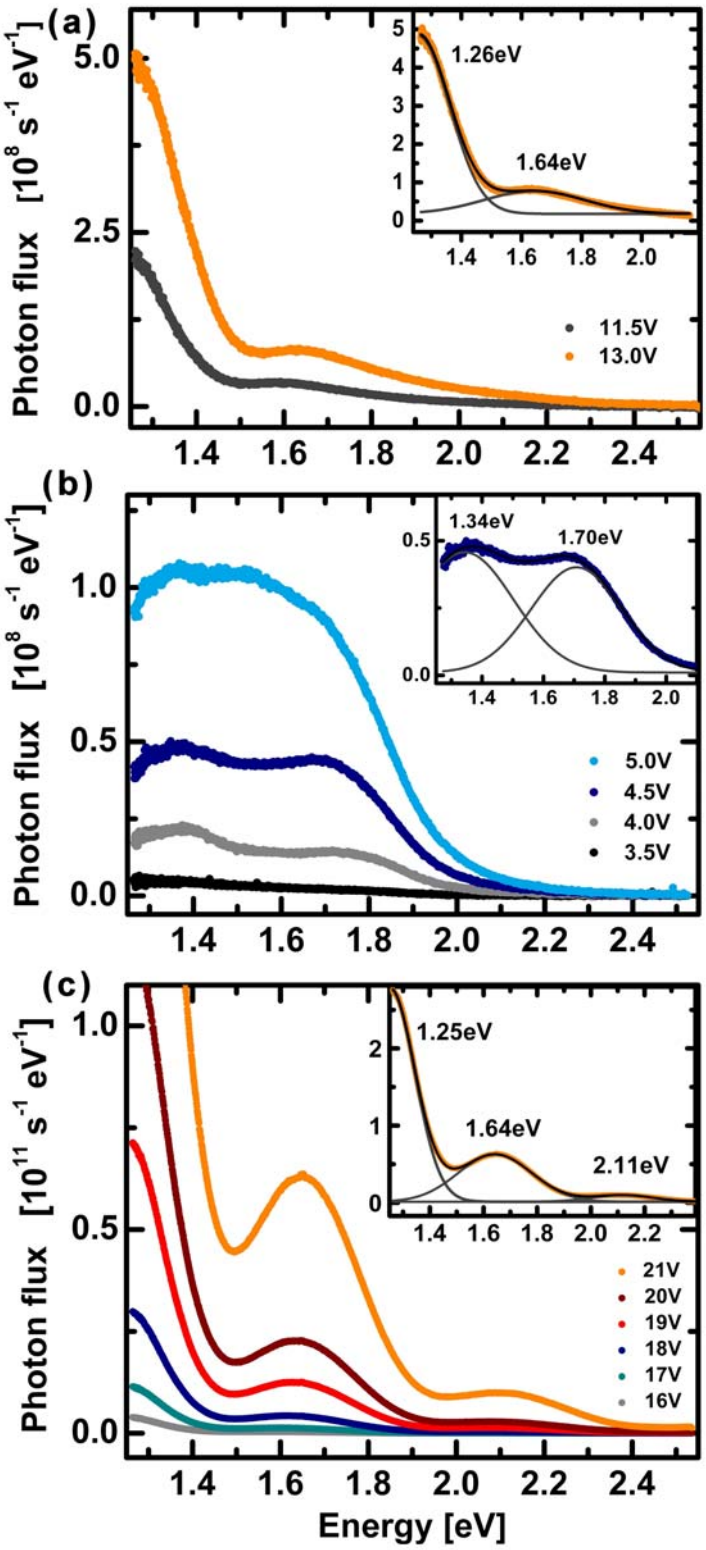

Fig. S3: Electroluminescence spectra of devices prepared from SWNT#A tubes on Al_2O_3 substrate with Au/Cr electrodes (a) from SWNT#A tubes on Al_2O_3 substrate with Pd/Ti electrodes (b), and from MWNT#E tubes on SiO_2/Si substrate with Pd/Ti electrodes (c). Indicated are traces with increasing source-drain voltage V_{SD}. Insets show the Gaussian fits with the fitted peak positions.

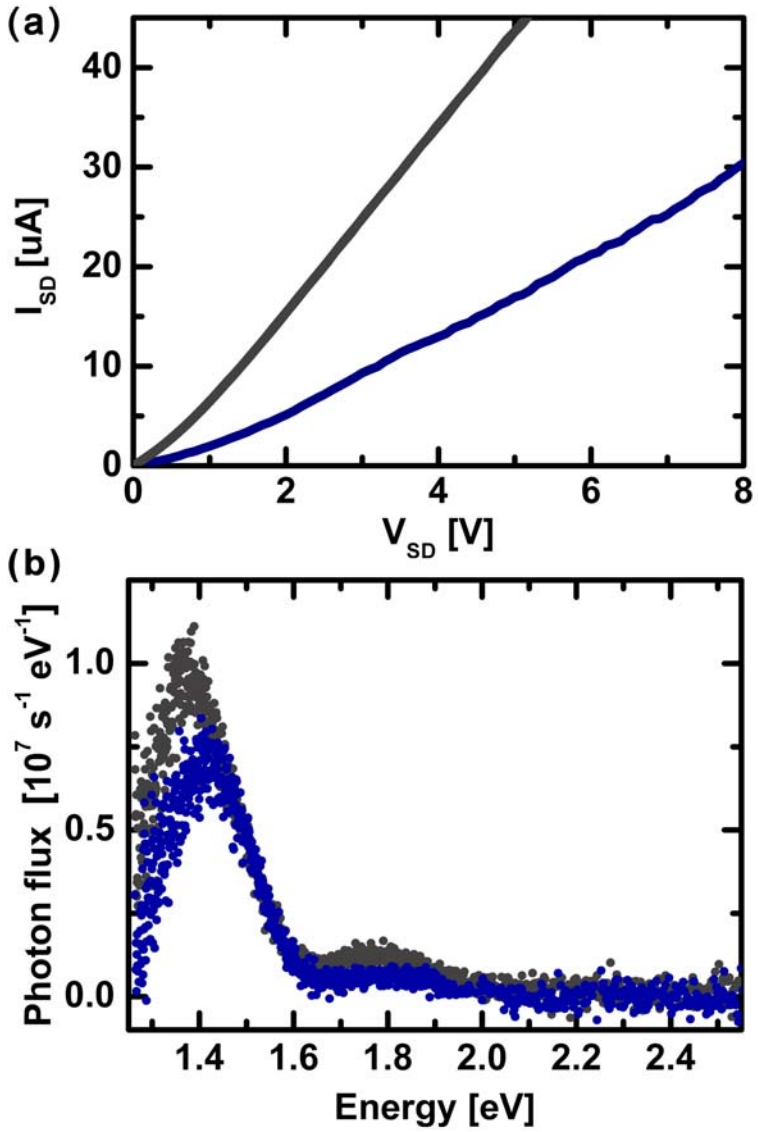

Fig. S4: Source-drain current I_{SD} vs. source-drain voltage V_{SD} (a) and electroluminescence spectra (b) of a device prepared from SWNT#B before (black) and after (blue) oxidation with MCPBA.

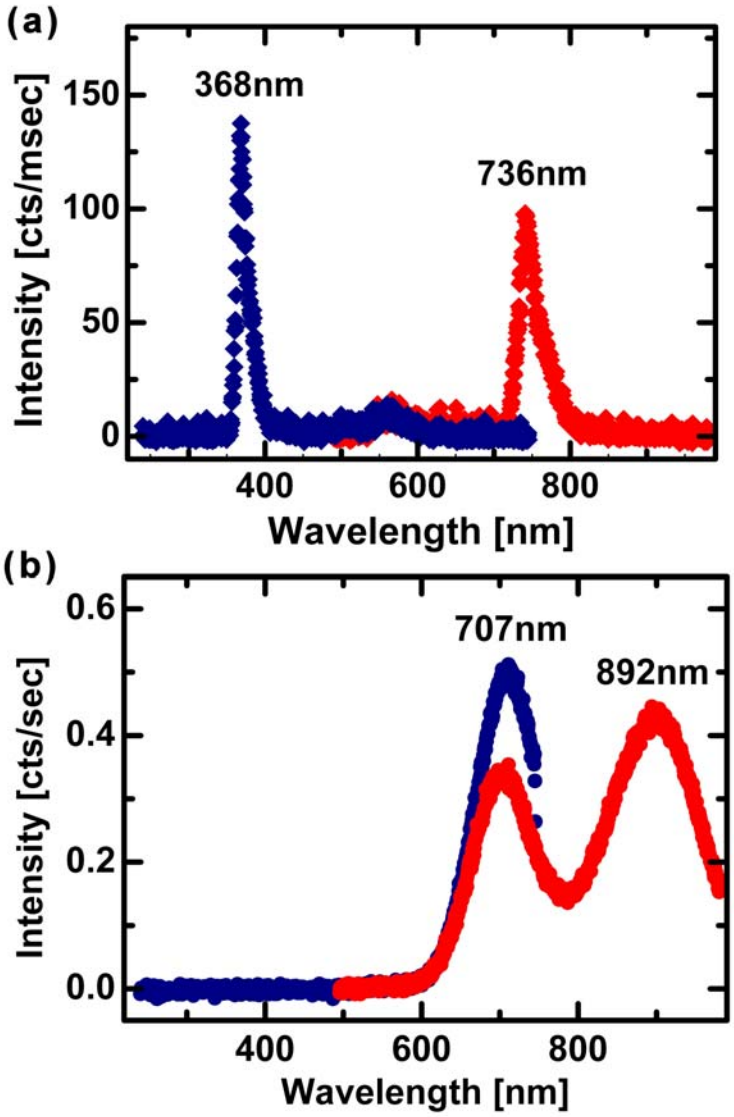

Fig. S5: Spectra measured at two grating positions (blue, red). (a) UV light reflected from a Si surface. The diode emits at 368 nm. The signal at 736 nm is a second order signal. (b) Electroluminescence raw data with the two emission peaks at 707 nm and 892 nm. The signal must be of first order due to the absence of intensity between 350 nm and 400 nm.