Supporting information

Efficient flexible graphene-based light-emitting device

Guangya Jiang[a,b,c,※], He Tian[a,b,※], Xue-Feng Wang[a,b], Thomas Hirtz [a,b], Fan Wu[a,b], Yan-Cong Qiao[a,b], Guang-Yang Gou[a,b], Yu-Hong Wei[a,b], Jing-Ming Yang[a,b], Sifan Yang[c], Yi Yang[a,b], Tian-Ling Ren[a,b]

a Institute of Microelectronics, Tsinghua University, Beijing 100084, China.
Email: RenTL@tsinghua.edu.cn； yiyang@tsinghua.edu.cn; tianhe88@tsinghua.edu.cn

b Beijing National Research Center for Information Science and Technology (BNRist), Tsinghua University, Beijing 100084, China.

c Graduate School at Shenzhen, Tsinghua University, Shenzhen 518055, China.

※ These authors contributed equally to this work.

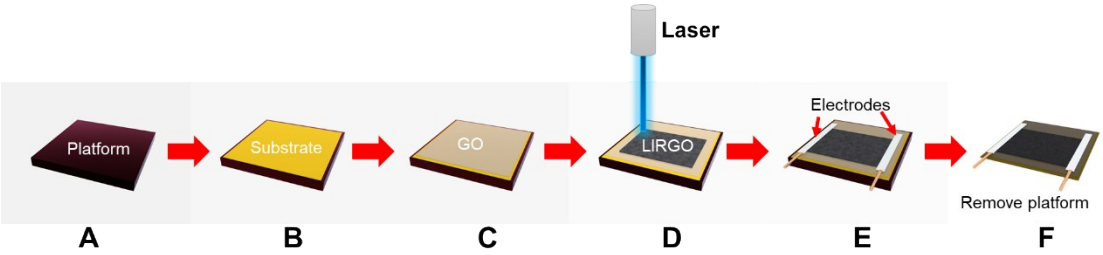

Fig. S1 Fabrication process of a LIRGO device. Firstly, PET substrate (or other substrates, like polyimide, heat-resistant paper, etc.) is spread on a flat platform. Then, the substrate is coated with a GO solution diluted with tetrahydrofuran. The GO film is formed by air-drying the solution. Thereafter, the surface of the GO film is scanned using a 448 nm laser, and the yellow GO film turned into black LIRGO. Next, silver electrodes and wires are respectively deposited and soldered on both sides of the LIRGO. Finally, the device is removed from the platform.

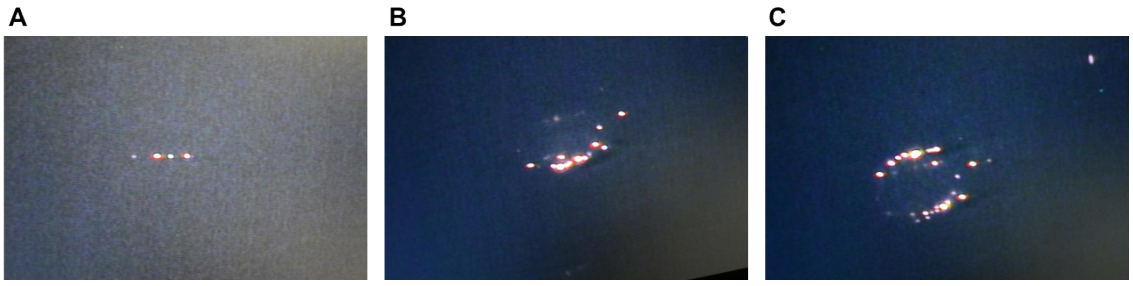

Fig. S2 (A), (B), and (C) are pictures of the illuminated LIRGO taken by the SLR camera, indicating that the lighting points have color differences.

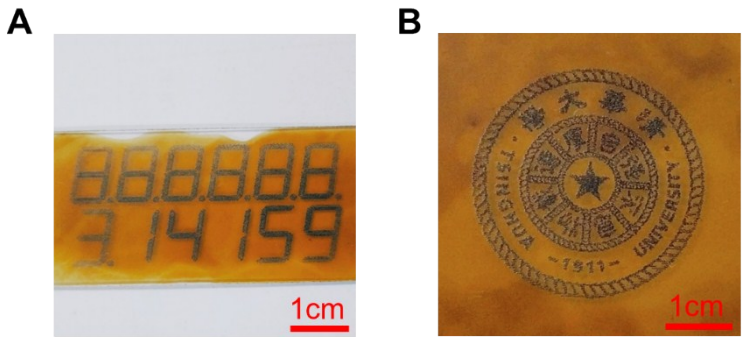

Fig. S3 LIGROs can be easily customized into different patterns by programmable laser reduction.

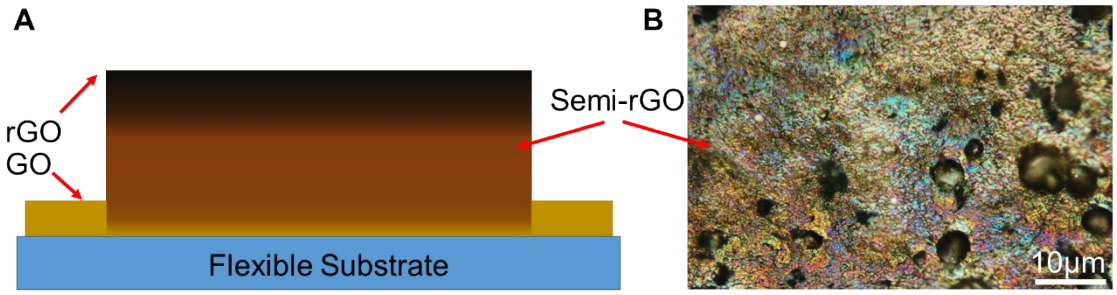

Fig. S4 (A) Schematic diagram of the cross section of LIRGO. RGO, semi-rGO, GO, and flexible substrates are distributed from top to bottom. (B) Optical photo of semi-rGO layer.

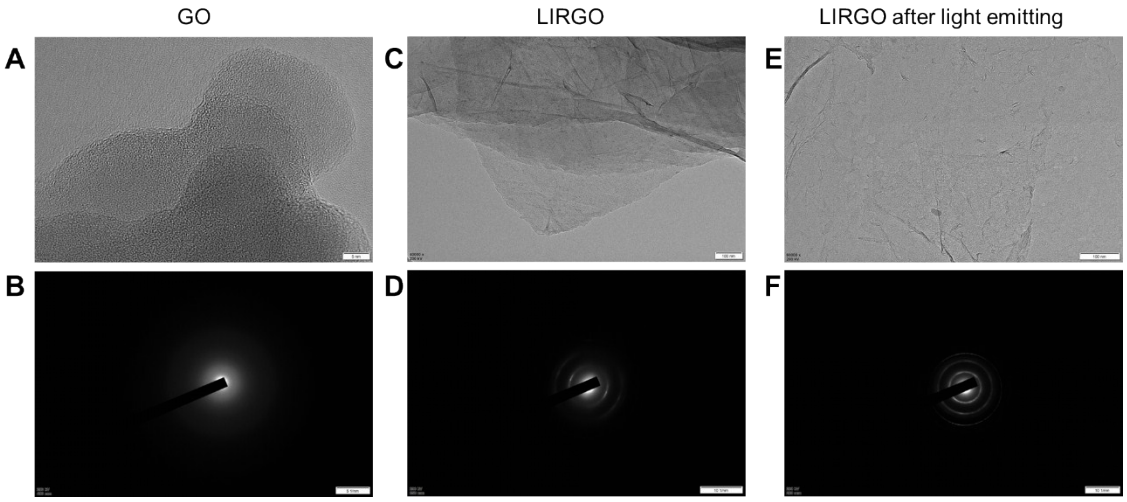

Fig. S5 TEM images and diffraction images of GO, LIRGO and LIRGO after the emission of light. (A) and (B) show that the lattice does not appear in GO. (C) and (D) show that LIRGO has some crystal lattices. (E) and (F) show that the lattice of LIRGO is not destroyed after luminescence.

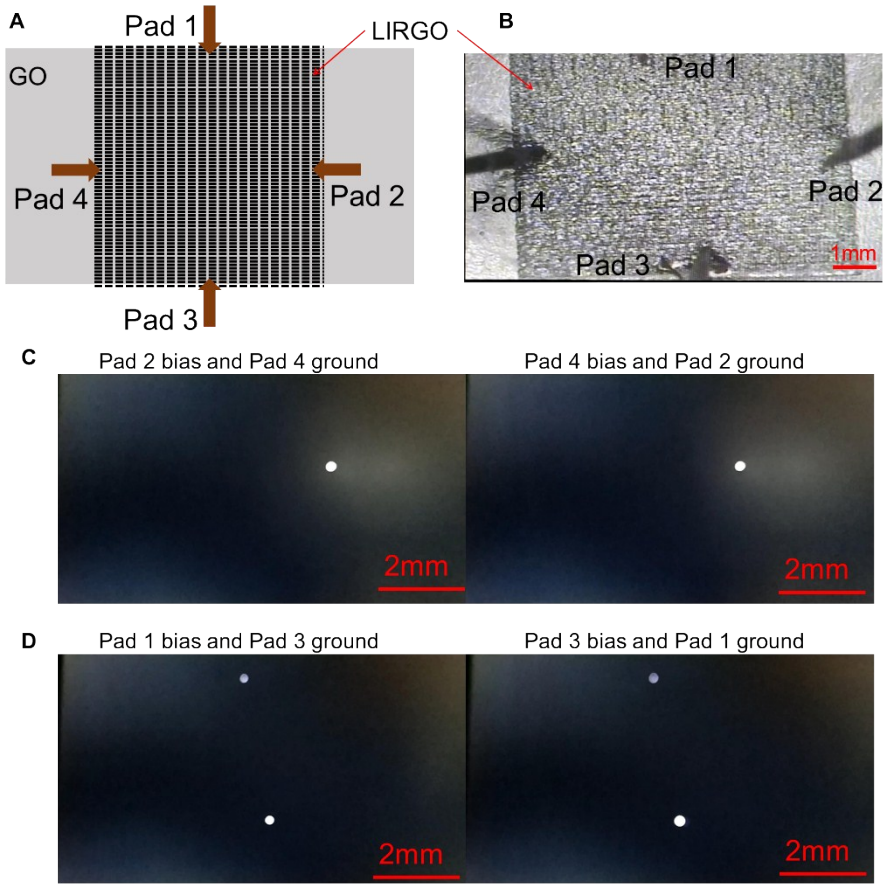

Fig. S6 Four pads measurements experiment related to the verification of non-polarity. (A) The schematic of four pads contacting LIRGO. (B) The real image of four probes contacting LIRGO. (C) Images of light emitting points using the pad 2 and 4. (D) Images of light emitting points using the pad 1 and 3. These observations verify that LIRGO is non-polar.

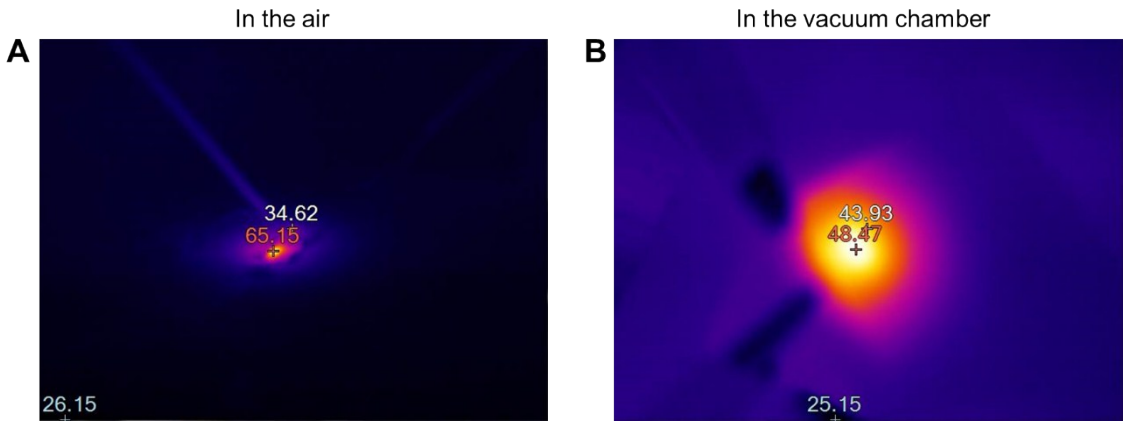

Fig. S7 Surface temperature of LIRGO during the light emission tested by infrared thermometer. (A) In the air, the temperature is 65.15 °C. In the vacuum chamber, the temperature is 48.47 °C. Please note that the infrared thermometer is placed outside the vacuum chamber. Therefore, the values measured are not so accurate but do have reference.

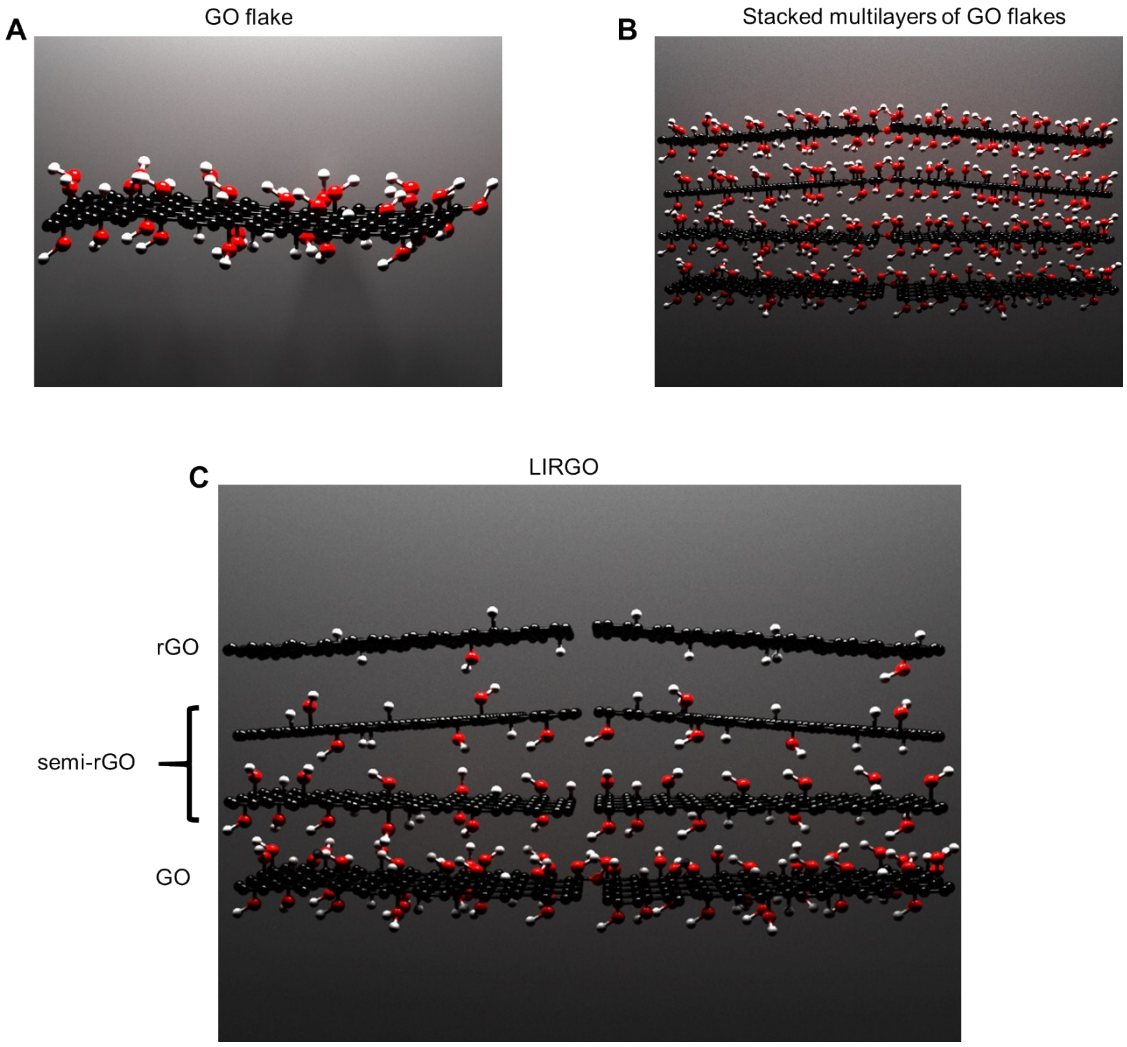

Fig. S8 Schematic diagram of GO flake, stacked GO flakes, and LIRGO. (A) Schematic diagram of a GO flake with many functional groups. (B) Schematic diagram of GO film with many layers of GO flakes inside. (C) Schematic diagram of LIRGO. The rGO layers, semi-rGO layers, and the unreduced GO layers are stacked from top to bottom inside LIRGO.

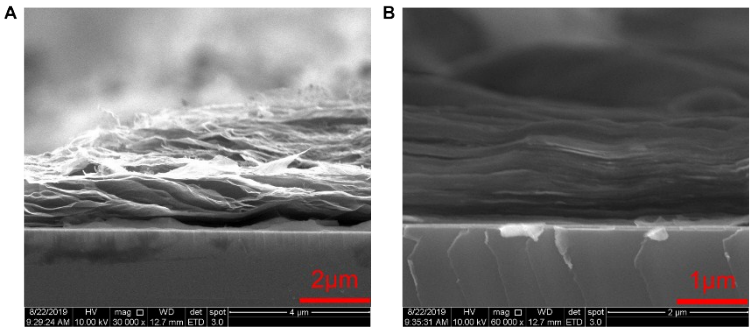

Fig. S9 Cross-sectional SEM of different positions from the same LIRGO. There are irregular stacks in both (A) and (B).

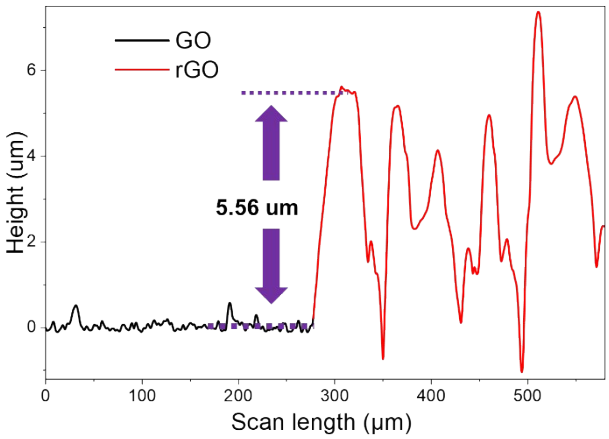

Fig. S10 Thickness scanning result of LIRGO by step profiler. The surface of LIRGO is undulating and about 5.56 μm higher than GO.

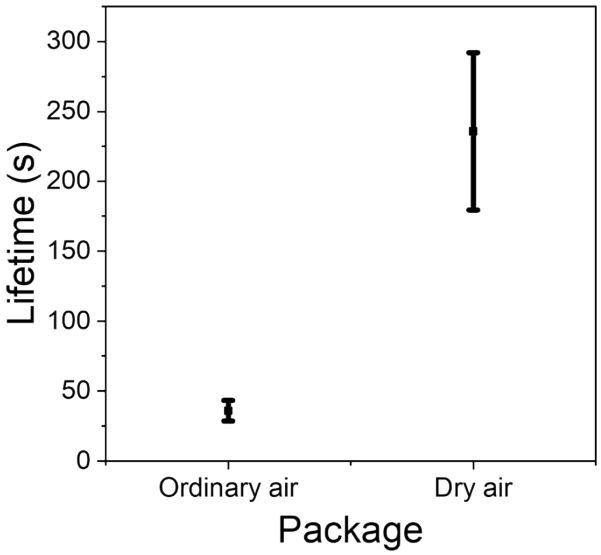

Fig. S11 Luminous lifetime of LIRGO devices in air. The average lifetime is 36 seconds in ordinary air, and 236 seconds in dry air.

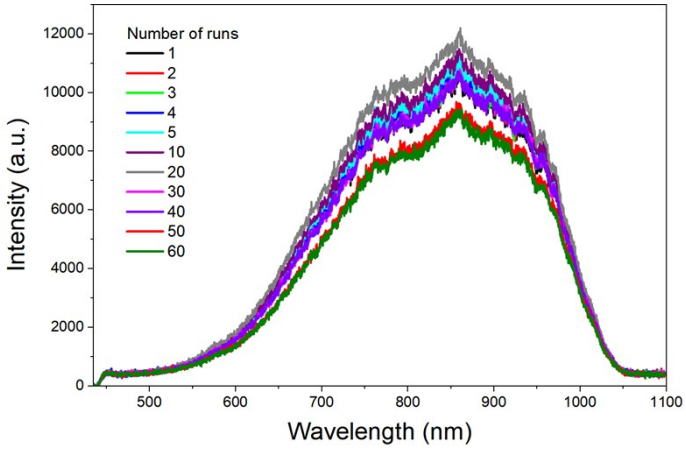

Fig. S12 LIRGO's spectra vs. repowering in different runs (after stabilization of the current). The overall distribution of the spectrum is unchanged. Some fluctuations in luminous intensity may be due to fluctuations in thermal effects and oxidation of residual oxygen in the vacuum.