Supplementary information

A super flexible and custom-shaped graphene heater

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1. The surface morphologies of the GO film and the LRGO lines prepared at different laser energy densities.

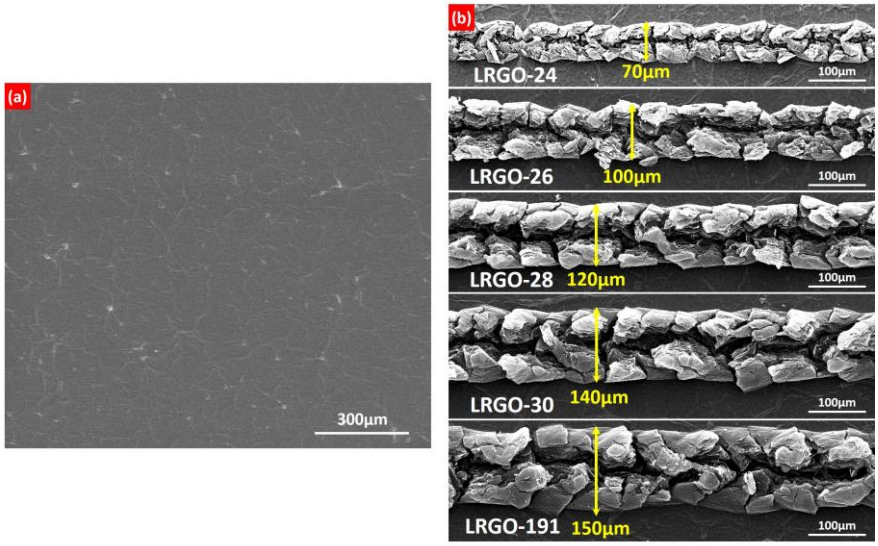

Figure S1. SEM images of (a) the GO film and (b) the LRGO lines prepared at different laser energy densities.

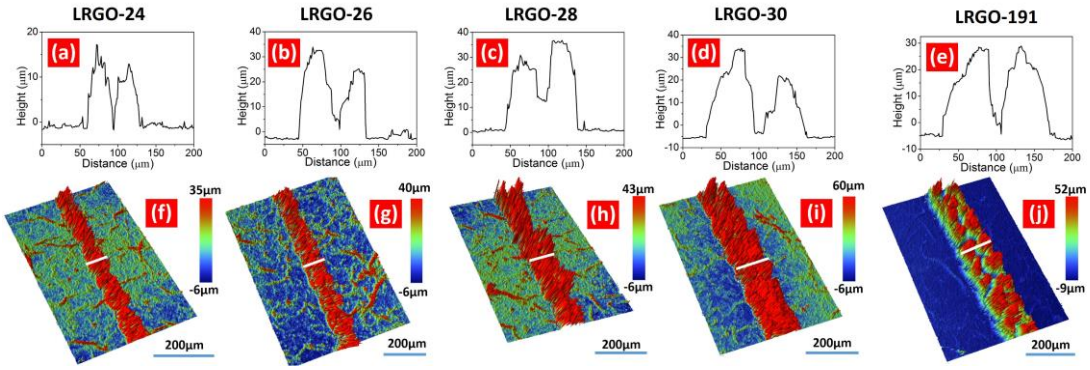

Figure S2. (a)-(e) The sectional views of the LRGO lines along the white line in the bottom corresponding 3D profiles. (f)-(j) The 3D profiles of the LRGO lines prepared

at different laser energy densities, which are captured through white-light interferometer.

2. The detail information for testing the electrical properties of the GO film and the LRGO films prepared at different laser energy densities.

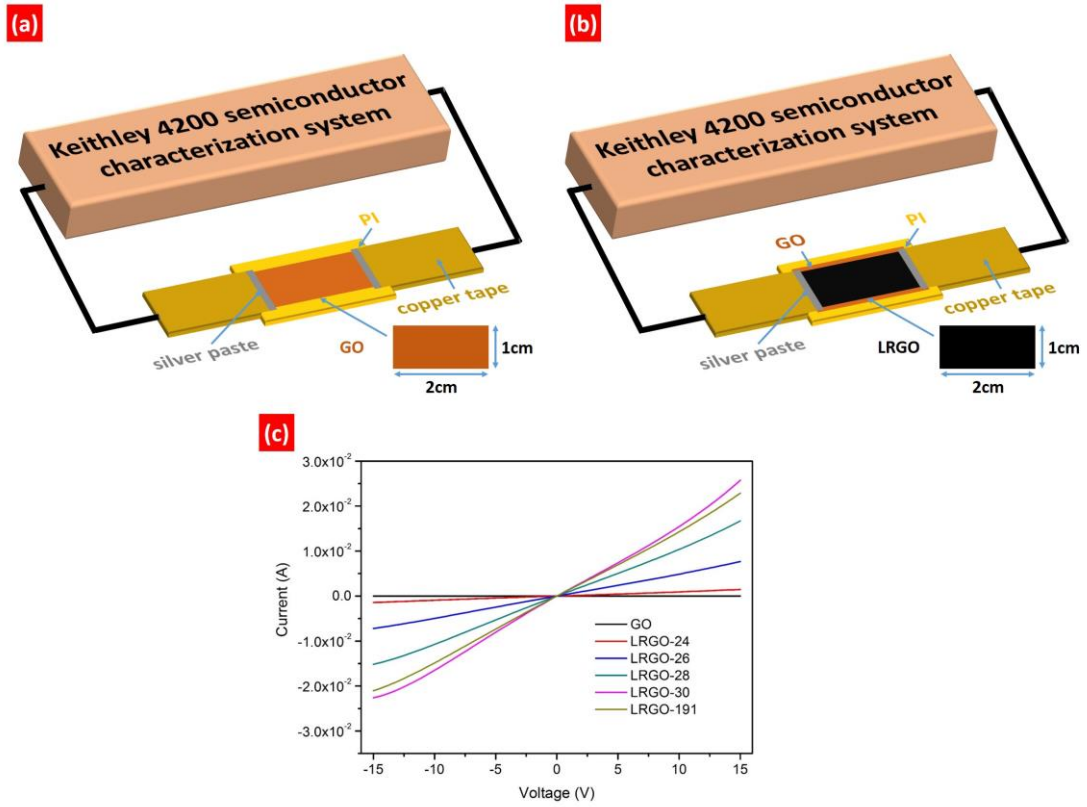

Figure S3. Experimental setups for testing the electrical properties of (a) the GO film and (b) the LRGO films prepared at different laser energy densities. (c) The IV curves of the GO film and the LRGO films prepared at different laser energy densities.

The size of the GO film and the LRGO films is 2cm in length and 1cm in width. The copper tapes are used as the electrodes. In order to reduce the contact resistance, the junctions between the copper tapes and GO and the junctions between the copper tapes and LRGO are coated with the silver paste. The contact resistance between the copper tapes and GO and the contact resistances between the copper tapes and LRGO are negligible.

The electrical properties of the GO film and the LRGO films are tested by Keithley 4200 semiconductor characterization system. Through the IV curves of Fig. S3c, we obtain the resistances of the GO film and the LRGO films prepared at different laser energy densities. The GO film is nearly insulated ($\sim 3.6 \times 10^7\ \Omega$). After laser reduction, the resistances of the LRGO films decreases dramatically (below $1.2\times10^4\Omega$).

3. The detail information about the structure of the LRGO film heater and the method for testing its electrothermal performance.

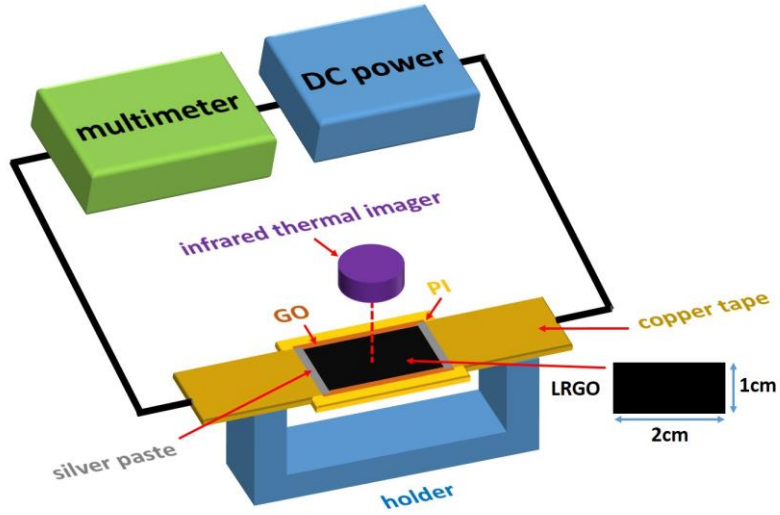

Figure S4. Measurement equipment for testing the electrothermal performance of the LRGO film heater.

The LRGO film heater consists of the LRGO film and the polyimide (PI) film. The thicknesses of the LRGO films prepared at different laser energy densities are shown in Fig. S2. The thickness of the PI film is 25μm. The size of the LRGO film is 2cm in length and 1cm in width. The copper tapes are used for electrodes. In order to reduce the contact resistance, the joints between the copper tapes and the LRGO film are coated with the silver paste. The contact resistances between the copper tapes and the LRGO films are negligible. When the driving voltage is applied on the LRGO film heater, the heat generated by the contact resistance can be ignored.

The LRGO film heater is suspended in air and supported by a holder. The thermal conductivity of the holder is poor and the heat transfer from the LRGO heater to the holder is negligible. In the testing environment, the airflow is little. The applied voltage on the LRGO film heater is supplied by a DC power source and a digital multimeter is used to monitor the current. An infrared thermal imager is hung over the LRGO film heater to record its surface temperature in real time.

5. The detail information for testing the flexibility of the LRGO film heater and the ITO film heater.

The LRGO film is prepared at the laser energy density of 30mJ/cm^2 and has a length of 2cm and a width of 2.5cm. The thickness of LRGO is about 25μm. The substrate of the LRGO film is the PI film with thickness of 25μm. The copper tapes are connected with the width of the LRGO film as the electrodes. The silver paste is used for reducing the contact resistance between the LRGO film and the copper tapes. The contact resistance can be ignored. When the driving voltage is applied on the LRGO

film heater, the heat generated by the contact resistance is negligible.

The LRGO film heater is fixed on the holder and the width of the holder can be adjusted. Through changing the width of the holder, the LRGO film heater can be curved with different bending angles. The bending angle is measured via a protractor. The driving voltage is provided by a DC power, and the current is measured by a digital multimeter. The infrared thermal imager is hung over the LRGO film heater to record its temperature in time.

The commercial ITO film is provided by HUANAN XIANGCHENG Tech Co., Ltd. (Shenzhen, China). The ITO film has a length of 2cm and a width of 2.5cm. The thickness of ITO is about 185nm. The substrate of the ITO film is the PET film with thickness of 175μm. The copper tapes are connected with the width of the ITO film as the electrodes. The silver paste is used for reducing the contact resistance between the ITO film and the copper tapes. The contact resistance can be ignored. When the driving voltage is applied on the ITO film heater, the heat generated by the contact resistance is negligible. The method for testing the flexibility of the ITO film heater is same with the method for testing the flexibility of the LRGO film heater.

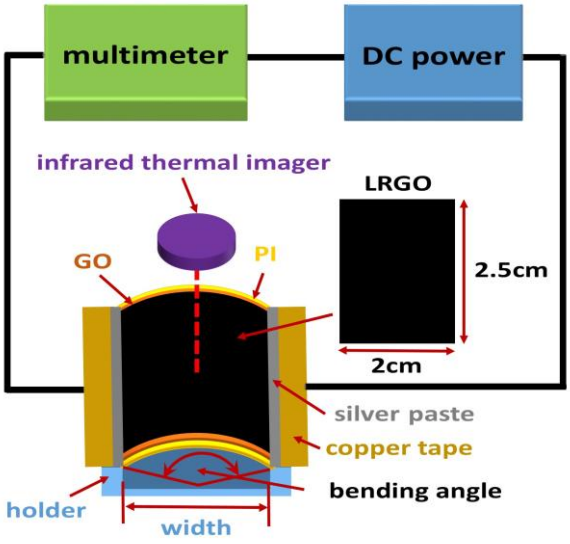

Figure S5. Schematic illustration for testing the flexibility of the LRGO film heater prepared at the laser energy density of 30mJ/cm^2.