Electronic Supplementary Information

Single-Mode Lasing of Nanowire Self-Coupled Resonator

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1. The process of the R6G-PNWs drawing.

The process of the drawing is shown in Figure S1.

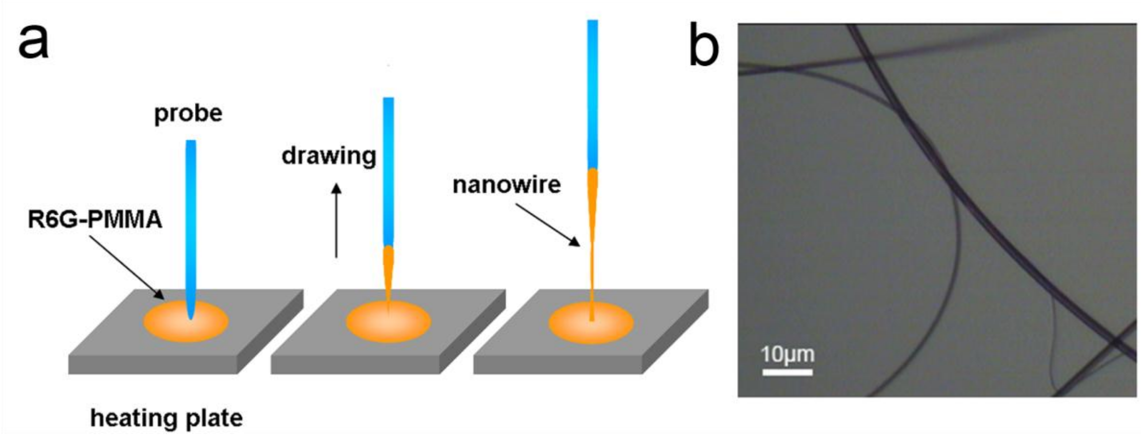

Figure S1. (a) Schematic of R6G-PNWs fabrication by direct drawing process from molten R6G-PMMA. (b) Optical microscopy image of the as-drawing R6G-PNWs with various diameters.

2. Micromanipulation process of R6G-PNWs into a self-coupled resonator.

The self-coupled resonator is bent by two micromanipulators (Figure S2). The probe is stabilized on a resolution of 0.1 μm XYZ translation stage with a fiber holder on its side mount Z-bracket.

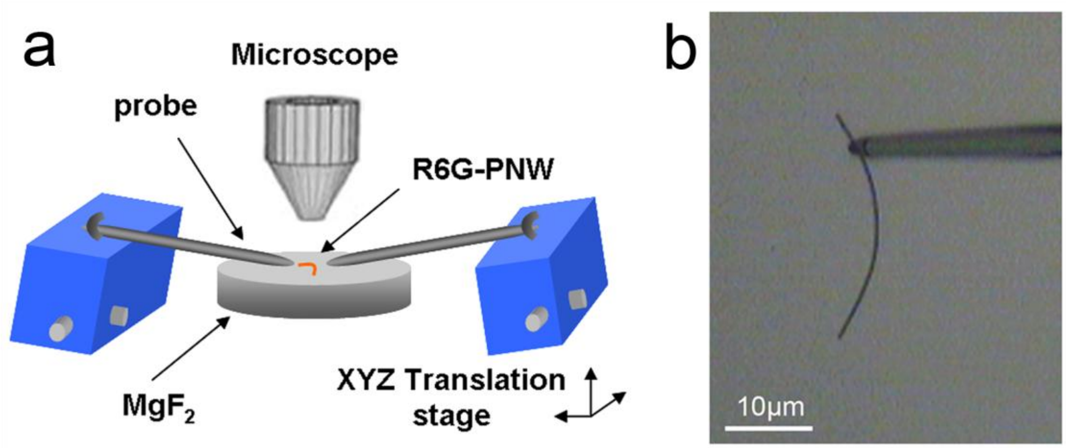

Figure S2. (a) Schematic of R6G-PNWs manipulation. (b) Optical microscopy image of a single R6G-PNW manipulated by a fiber probe.

3. R6G-PNW waveguiding measurement.

A continuous wave 532 nm laser is coupled into a fiber probe by a 40× objective. A single bent R6G-PNW with diameter of 480 nm length of 40 μm is excited by the probe tip, then we keep the laser power at 0.2 mW and locate the excited spot along the R6G-PNW by adjusting the XYZ translation stage, as shown in Figure S3.

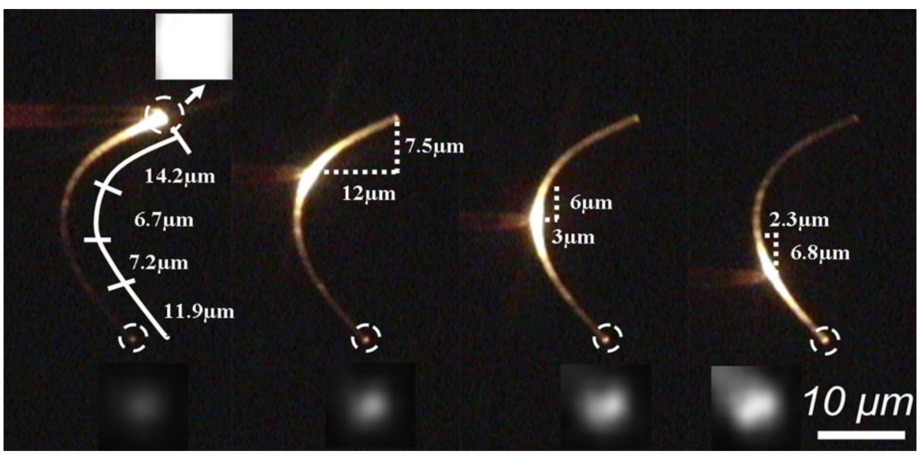

Figure S3. Dark-filed PL microscope images of a 480 nm diameter 40 μm length R6G-PNW excited by the probe tip at different spot along the R6G-PNW. The insets are the gray images of the excited and output spots.

To quantitatively analyze the waveguide efficiency of the R6G-PNW, we calculate the normalized PL intensity of the excited spot and the output spot by studying the image brightness, as used in references

[S1,S2] . The spot images are converted from RGB to gray styles in Adobe Photoshop, whose gray values are calculated by Matlab to characterize the corresponding intensity. The PL intensity of the output spot is normalized against the excited spot, then the decay of the guided normalized PL intensity dependent propagation distance (d) is obtained, as shown in Figure 2d. Upon increasing d, the PL intensity decreases as ≈ exp(-αd), with a loss coefficient $\alpha = 605\ cm^{-1}$. The loss coefficient is comparable to those reported for electrospun polymer nanofibers [S3].

4. FDTD simulations of the field distribution in the coupling microcavity.

The field distribution in SCRs and ring-like microcavity are investigated with the three dimensional−finite difference time domain (3D-FDTD) simulations as shown in Figure S4. (a) a NW with diameter of 350 nm length of 60 µm. (b) a NW with diameter of 350 nm length of 80 µm. (c) a NW with diameter of 350 nm length of 90 µm. (d) a NW with diameter of 500 nm length of 120 µm.

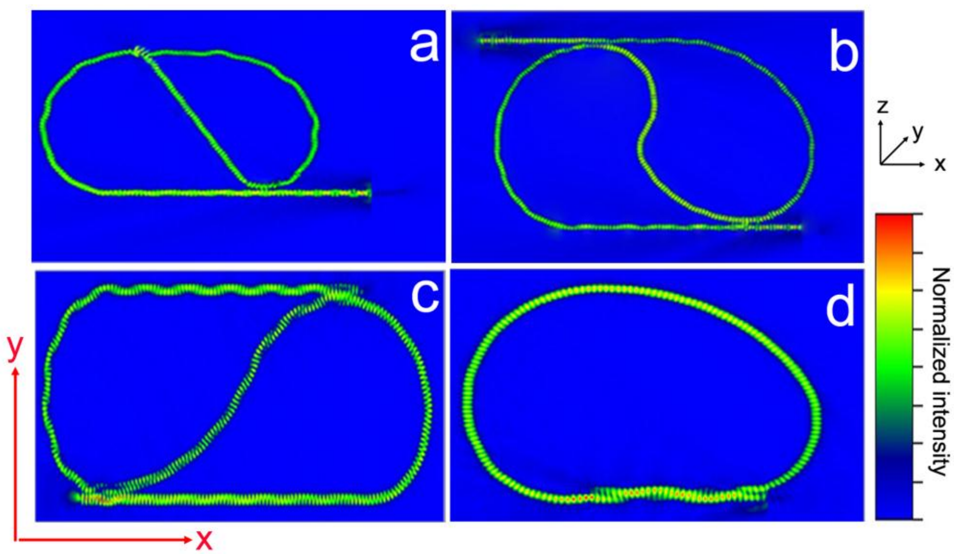

Figure S4. (a), (b) ,(c) The FDTD simulation of the electric field intensity distribution in the SCR1, SCR2 and SCR3, (d) The FDTD simulation for the ring-like coupling microcavity.

We select a cw 532 nm laser with power of 0.1 mW as the light source. The NWs of the microcavities (n = 1.5) are located on a MgF_2 substrate (n = 1.38). One can see that the energy of the electric field is well confined in the NW, and the scattering into the air is quite limited. The mode profiles along the nanowire clearly show the

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efficient light guiding. The increases of the electric field intensity at the top and bottom junctions proved the NW's high coupling efficiency. Therefore, we estimated it is possible to generate laser by exciting the microcavities.

5. Lasing action in a single U-shaped R6G-PNW.

An U-like shape geometry will be formed before a single R6G-PNW was manipulated to the SCR by a fiber probe. We had measured the emission of the single U-shaped R6G-PNW (Figure 1b) at different pump energy density. The spectra with the multiple peaks were recorded and the result is shown in Figure S5. As the pumping intensity increases (from 43.3μJ/cm^2 to 102.1μJ/cm^2), the lasing energy tends to concentrate on fewer modes. However, it is difficult to realize single-mode operation by solely increasing the pumping intensity in the U-like NW without SCR.

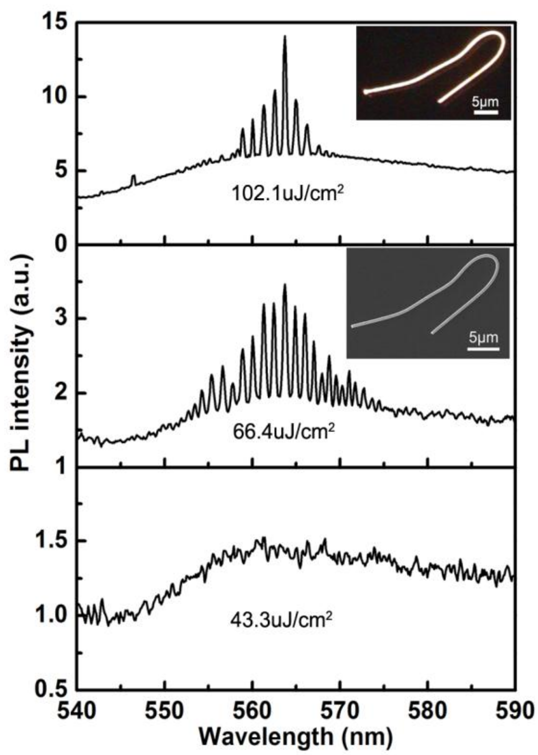

Figure S5. The emission spectra of a single U-shaped R6G-PNW with diameter of 200 nm and length of 30 μm at different pump energy density. Inset: Dark-filed PL microscope image and SEM image of the NW.

6. Photobleaching of fluorescent dye in PNWs.

In order to investigate the photobleaching process of the R6G-PNW, we fold a single R6G-PNW with diameter of 500 nm and length of 340 μm into several circles structure, a frequency-doubled pulses of a Q-switched Nd:YAG laser (λ = 532 nm, pulse duration is 10 ns, 10Hz) is employed to pump the R6G-PNW (Figure S3b).We measure the pump energy density is 216.6 μJ/cm^2, and keep in this density to 2 hours. There are obviously photobleaching and reduction in emission brightness of the R6G-PNW after 2 hours (about 90000 pulses).

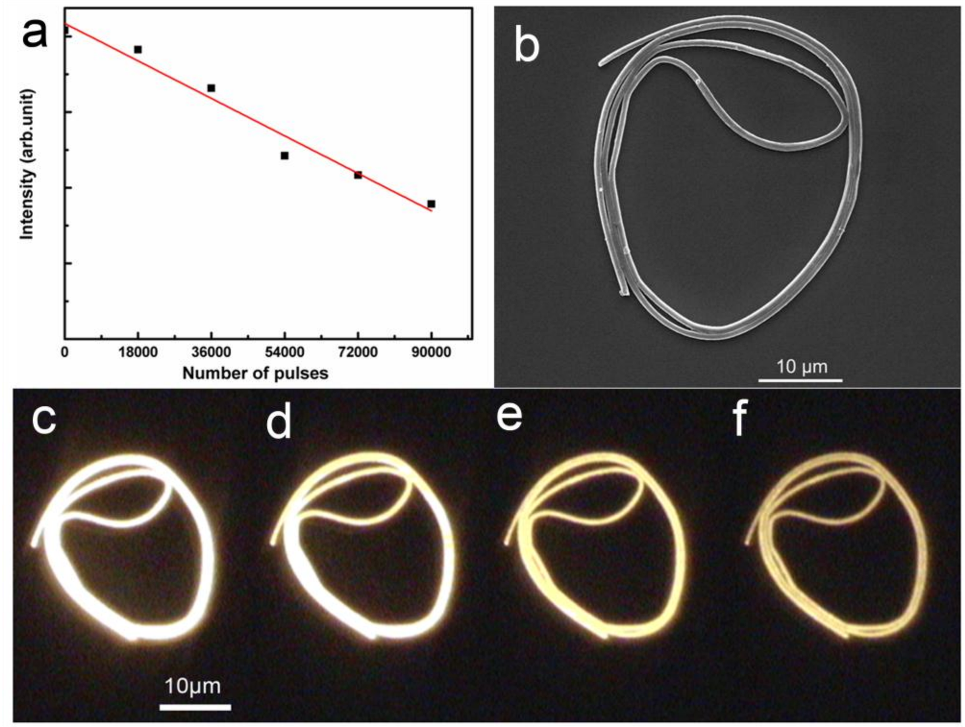

Figure S6. (a) Normalized pumping emission intensity as a function of the number of pump pulses for Rh6G-PNW in (b). (b) SEM image of a single R6G-PNW with diameter of 500 nm and length of 340 μm which is manipulated into several circles. (c) Dark-filed PL microscope image the R6G-PNW in (b), the pump energy density is 216.6 μJ/cm^2. The R6G-PNW was pumped by the same energy density after 30 minutes (d), 60 minutes (e) and 90 minutes (f).

References

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