Supplementary Information for Photothermal healing of glass fiber reinforced composites interface by gold nanoparticles

Zhenxing Cao[a], Rongguo Wang*[a], Fan Yang [a], Lifeng Hao*[a], Weicheng Jiao[a], Wenbo Liu[b], Qi Wang[a], Boyu Zhang[a]

The Au NPs for self-assembly are sphere or slightly oblate sphere as shown in the Fig. S1a. In addition, Fig. S1b demonstrates that their diameters are about 16 nm. The extinction spectrum of these Au NPs was measured to identify the location of the surface plasmon resonance as shown in Fig. S1c, which has a single narrow plasmon resonance peak at 533 nm. Thus the laser with 532 nm wavelength is selected to excite the photothermal effect.

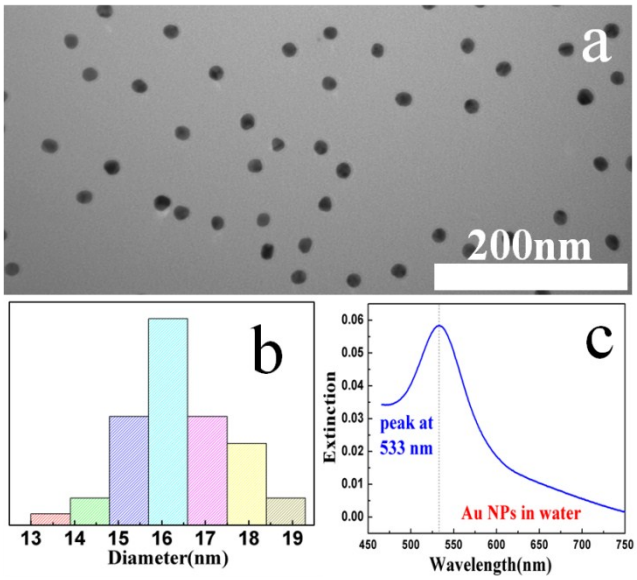

Fig. S1. (a) TEM image of Au NPs (b) A representative histogram of Au NPs size distribution (over 100 Au NPs were analyzed). (c) Extinction measurements of Au NPs dispersed in water. The Au NPs dispersed in water displays a peak at 533 nm indicated by a vertical dashed line.

The sketch of micro bond test sample is showed in Fig. S2. The glass fiber reinforced PMMA composite was prepared for micro bond test. A single filament of glass fiber coated with Au NPs was fastened to a thin paper holder (30×70 mm) with double sided adhesive tape. The free fiber length was approximately 30 mm. Some

PMMA micro-droplet sample made by applying PMMA/chloroform at a weight ratio of 1:10 was adhered on the fiber filament with an embedded length of 40–120 μm using a fine point applicator.

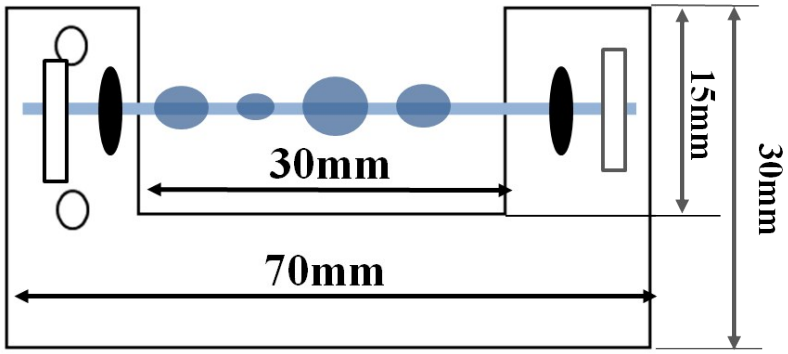

Fig. S2. Sketch of micro bond test sample.

Fig. S3 shows the sketch of micro bond test. Samples were tested at room temperature at a cross-head speed 0.5 μm/min. The knives came in contact with the solid resin droplet and the force required to debond the microdroplet from the fiber was recorded. The load displacement curve from each test was recorded to obtain the maximum force (Fmax).

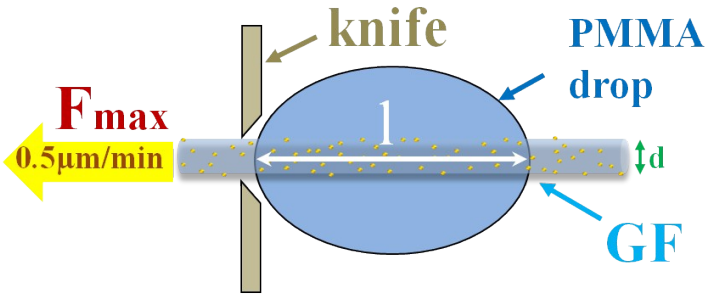

Fig. S3. Sketch of micro bond test

The Au NPs coating on the surface of glass fiber was proved by using EDX analysis as shown in Fig. S4. The Si-peak confirmed the basic substrate of glass fiber as shown in Fig. S4a. The signals of Au metal were demonstrated at the peaks between 2.0 and 2.3 keV in the spectrum as shown in Fig. S4b. The result also confirmed Au NPs successfully adhered on the fiber surface.

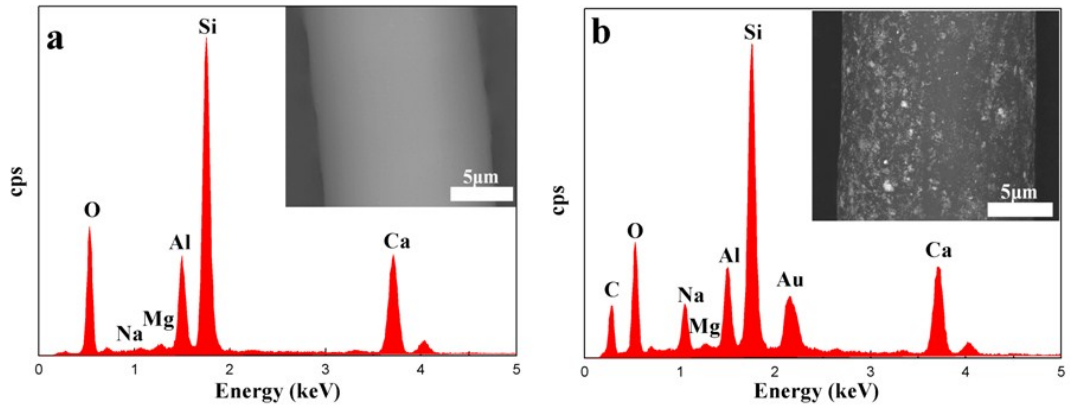

Fig. S4. EDX analysis of (a) blank GF and (b) GF coated with Au NPs.

Fig. S5 shows FTIR spectra results of the samples before and after healing. The peaks at 2950, 1724, 1447 and 1145 cm^{-1} are assigned to CH stretching, C=O stretching, CH_3 stretching and $–O-CH_3$ stretching vibrations, which are derived from the PMMA[2]. There is no significant change observed in the spectra before and after healing. It indicates that the most of chemical groups are not changed and the interfacial healing can be considered as a physical process. This is consistent with our analysis about the healing process that the heat generated by photothermal effect melts the PMMA resin to heal the interface.

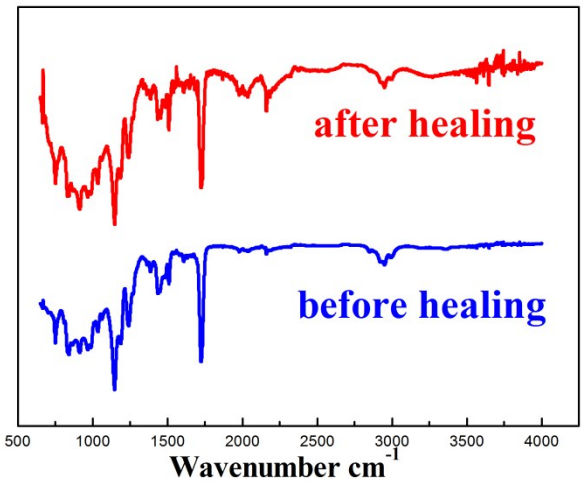

Fig. S5. FTIR spectra of the samples before (blue) and after healing (red).