Sensitive detection of cardiac troponin T based on superparamagnetic bead-labels using a flexible micro-fluxgate sensor

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Fabrication process of the micro-fluxgate sensor

The fabrication of the micro-fluxgate sensor was performed on a circular glass wafer. Fig S1 shows the MEMS-based fabrication process of the micro sensor. The fabrication process is as follows: (a) Cr/Cu seed layer was sputtered on the glass substrate for electroplating, and positive photoresist was spun on the seed layer which was patterned by ultraviolet lithography with the templet of bottom coil. Then, 30 um Cu film was electroplated in the photoresist mold to act as the bottom coil. (b) After the bottom coil was completed, positive photoresist was spun and patterned with the templet of vias. Vertical Cu cylinder was electroplated in the photoresist mold to act as the Cu vias to connect the top coil. (c) Then the seed layer was removed by reactive ion etching after the photoresist was eliminated with acetone. (d) Polyimide was spun on the wafer and baked at 250 °C in vacuum for 2 h for solidification, here polyimide was used for electrical insulation in order to isolate the sensing elements from the bottom Cu coil. Then the polyimide was etched by reactive ion etching to expose the Cu vias. (e) Then, another Cr/Cu seed layer was deposited on the surface and Co-based magnetic cores, with a thickness of 10 um, were stuck onto the wafer. (f) Positive photoresist was spun and patterned with the templet of vias. The Cu vias was then electroplated to reach a height over the magnetic core. Afterwards the Cr/Cu seed layer was removed by reactive ion etching after eliminating the photoresist. (g) Polyimide was spun on the wafer again, and baked at 250°C in vacuum for 2 h for the purpose of isolating the sensor core from the top coils. Then the polyimide was etched by reactive ion etching to expose the Cu vias. (h) A second layer of magnetic core and vertical vias were fabricated using the same sequence of lithography, electroplating and polyimide discussed above in (e)-(g). (i) After coating the Cr/Cu seed layer on the wafer again, the positive photoresist was spun on the seed layer and patterned with the templet of top Cu coil, afterwards top Cu film with thickness of 30 um was electroplated in the photoresist mold to form the top Cu coil, finally the whole sensor was obtained after removing the photoresist and seed layer.

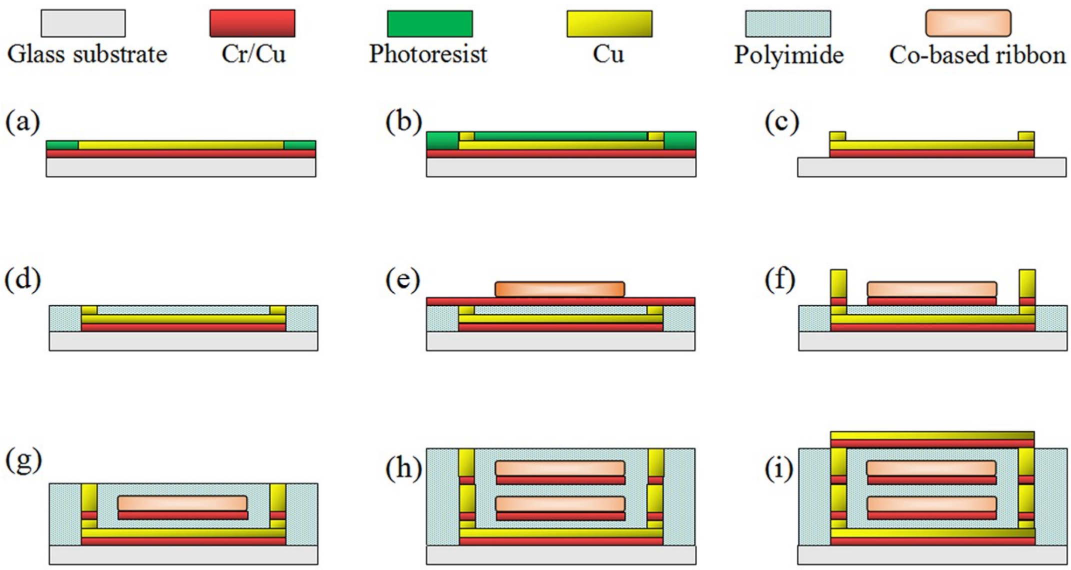

Fig. S1 Fabrication process of the micro-fluxgate sensor. (a-i) The detail fabrication procedure of the fluxgate sensor.

Fabrication process of the Au film substrate

The entire fabrication process comprises the following steps (Fig S2): (a) An Au layer of 300 nm was deposited on a glass wafer. (b) A photoresist layer was spun on the Au layer and patterned to several rectangles with sizes of 5 mm x 3 mm by thick photoresist-based lithography. (c) The uncovered part of the Au layer was removed by chemical wet etching. (d) The whole sample was obtained after the photoresist was removed by acetone.

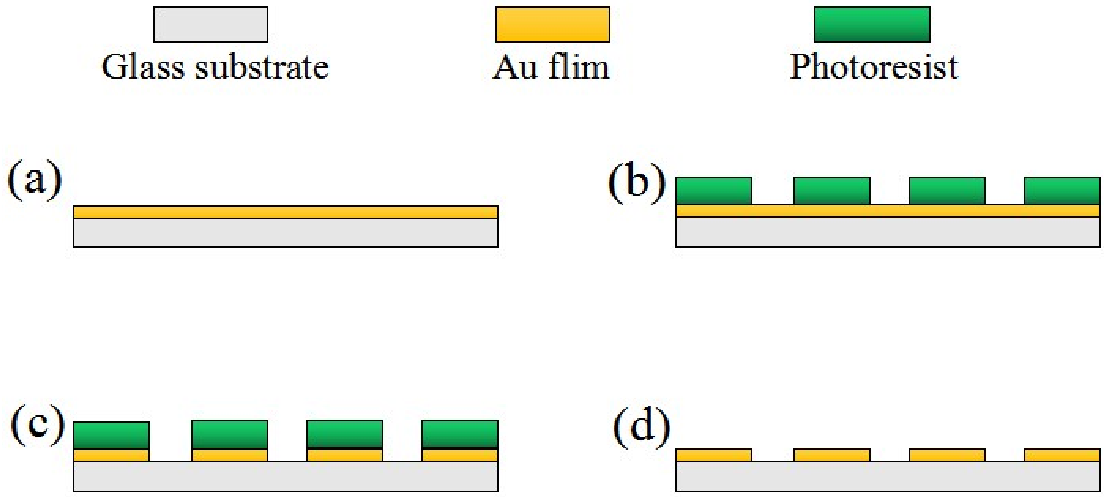

Fig. S2 Fabrication process of the Au film substrate. (a-d) The detail fabrication procedure of the Au film substrate.

SEM characterizations of the superparamagnetic beads

SEM images and EDS analysis was utilized to characterize the structure of the superparamagnetic beads with and without antibody-conjugation. As can be seen from the Fig S3 (a) to (d), no clear difference can be found in the superparamagnetic beads before and after antibody-conjugation, since the huge size difference between the magnetic beads (2.8 um) and the antibodies (several nanometers). And a similar result can also be found in the EDS analysis due to the antibodies is too small to be distinguished from the SEM characterizations.

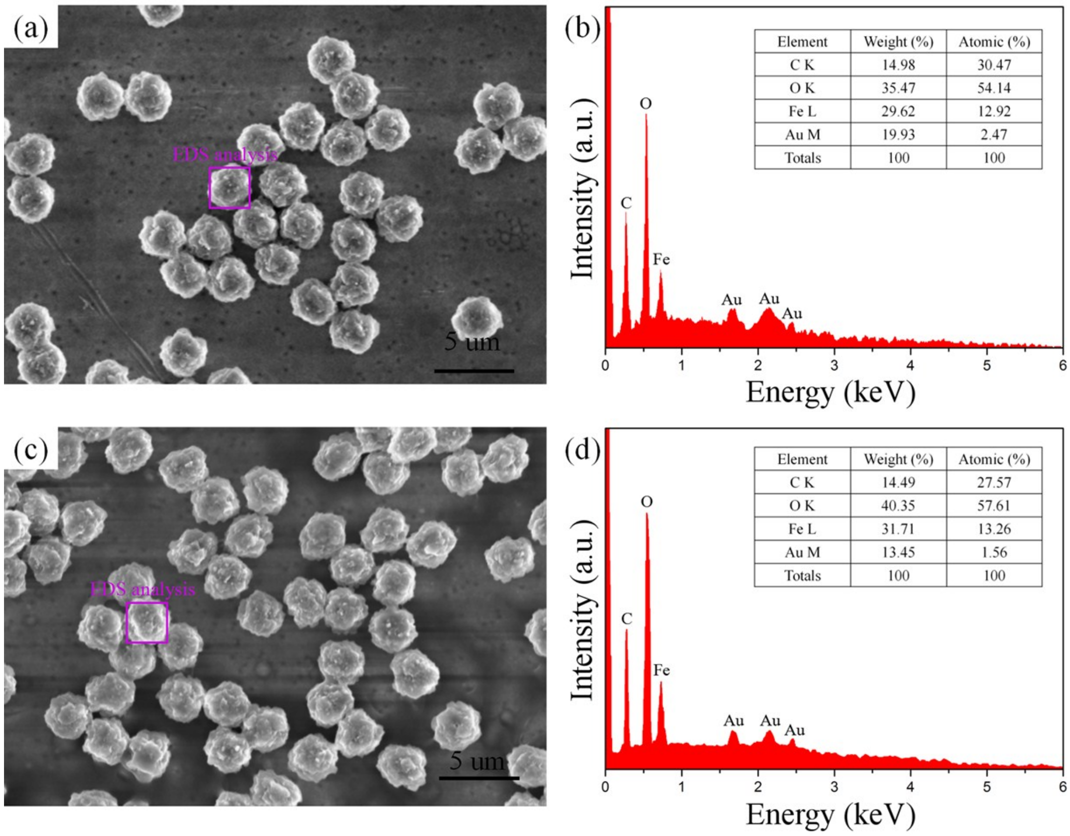

Fig. S3 SEM characterizations of the superparamagnetic beads. (a) SEM image of the superparamagnetic beads before antibody-conjugation, (b) EDS analysis of superparamagnetic beads before antibody-conjugation, (c) SEM image of the superparamagnetic beads after antibody-conjugation, (d) EDS analysis of superparamagnetic beads after antibody-conjugation.