

Figure S1. The peripheral circuit connected to DAC output pin.

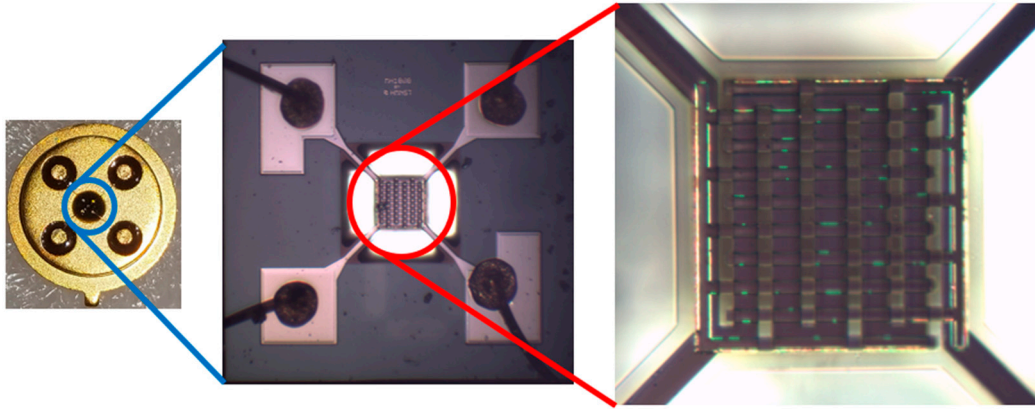


Figure S2. The photo under camera and microscope (x50 and x100).

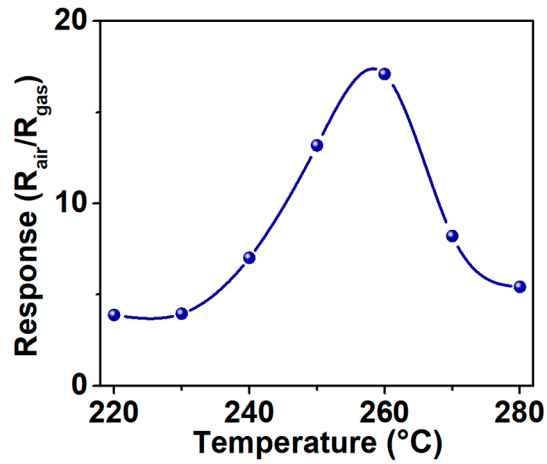


Figure S3. The response – temperature curve to 500 ppm ethanol of the synthesized Pd-Doped  $\text{SnO}_2$ .

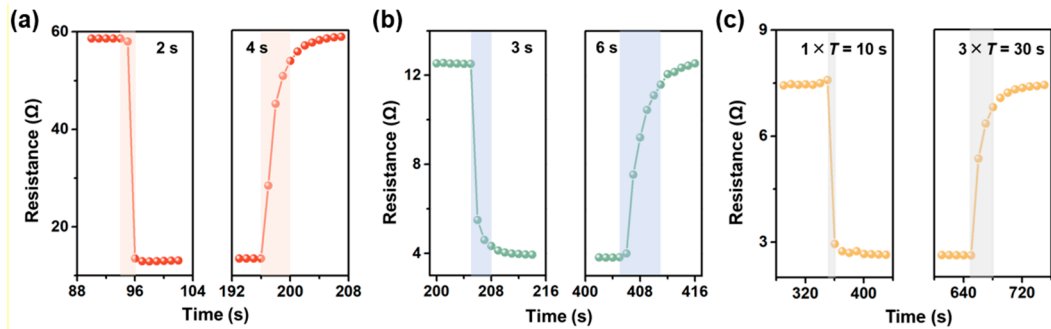


Figure S4. Response and recovery time under (a) DC heating on ceramic substrate (b) DC heating on MHP and (c) PWM heating on MHP.

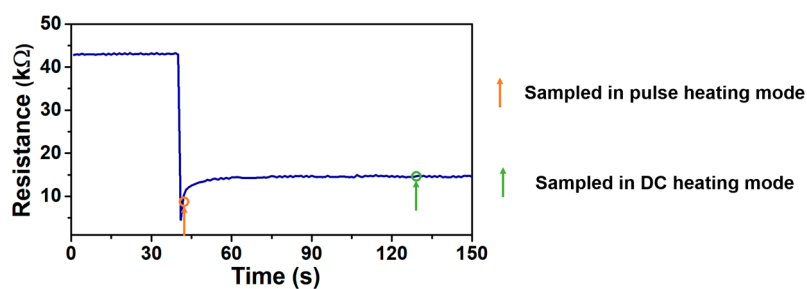


Figure S5. The resistance variation of the MHP sensor after the applied of heating voltage.

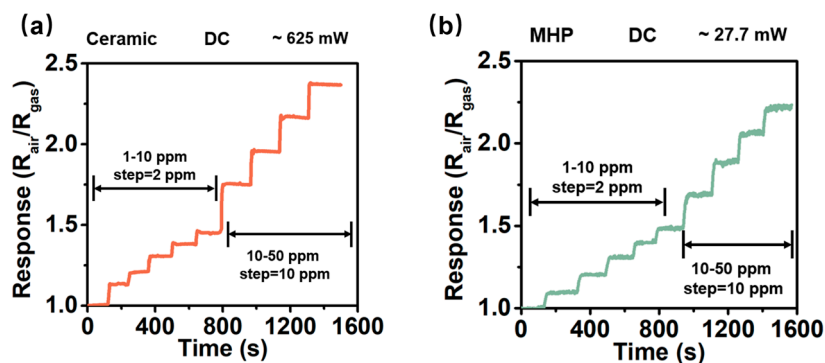


Figure S6. Response to 0-50ppm ethanol under (a) DC heating on ceramic substrate (b) DC heating on MHP.

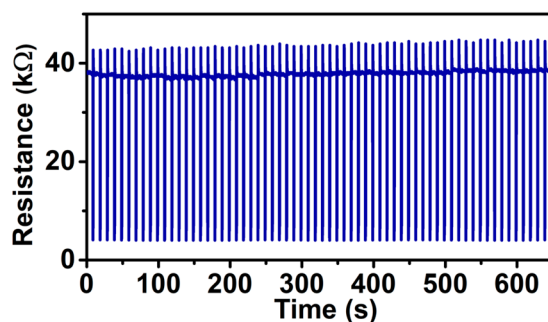


Figure S7. The MHP sensor's baseline resistance value under the PWM signal.

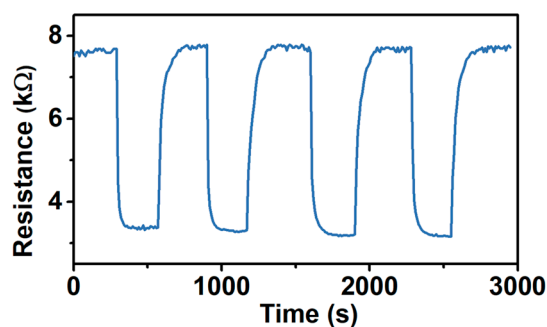
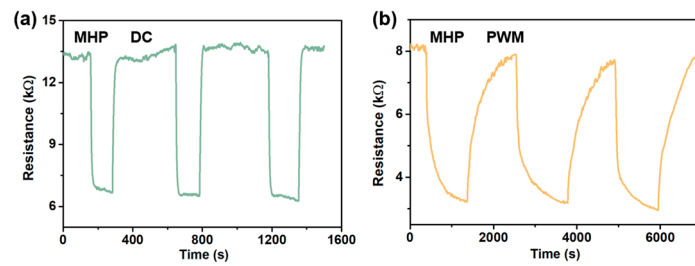


Figure S8. The dynamic response variation of four cycles of the MHP sensor exposed to 50 ppm ethanol (under PWM signal).



**Figure S9.** The dynamic response variation of three cycles of the MHP sensor exposed to 100 ppm formaldehyde using (a) DC (b) PWM signal.