# Integration of mode localized coupled resonators with ZnO nanowires for ammonia gas detection

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With the rapid societal development, there is increasing environmental air pollution, affecting people's health and the natural environment. Ammonia gas as one of prominent air pollutants is frequently found in the chemical and agricultural industries[1]. Although various types of ammonia gas sensors have been developed today[2], most of which are relatively unportable, costly or low sensitivity. Most recently, mode localized coupled resonators (MLCRs) have been employed for a wide range of micro-electromechanical system (MEMS) applications. Due to their ultra-high sensitivity and inherent common-mode rejection, MLCRs are an excellent candidate as microsensor systems that can benefit from improved sensitivity. Moreover, the possibility of integrating functional materials into MEMS devices has attracted attention in the sensing field, with emerging applications such as gas and biological mass sensing.

We report the fabrication and integration processes of MLCRs with zinc oxide nanowires (ZnO NWs). The ZnO NWs are grown on MLCRs by hydrothermal method for absorption of ammonia gas. Because of high surface area/volume ratio of ZnO NWs, the response speed, gas absorption and dissipation rate are expected to be increased. The process begins with a silicon-on-insulator (SOI) wafer with a low resistivity device layer. Therefore, the resonators can be coupled and actuated electrically. Aluminum electrodes are used for actuation and sensing. Fig. 1 shows the device fabrication process flow. Fig. 2 shows scanning electron micrograph (SEM) of one of the fabricated devices. finite element method (FEM) simulations have been performed in order to characterize the devices' actuation mechanism and resonant frequency. Fig. 3 shows FEM simulation result of in-phase resonant frequency and out-of-phase resonant frequency when the resonators are coupled with 30 volts DC voltage. Details of the design, fabrication and testing of the coupled resonators integrated with ZnO NWs will be reported.

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[1] Hongbin Cheng et al. "Ammonia Sensing Characteristics of Quartz Resonator Coated with ZnO Nanowires Sensitive Layer." 2008 IEEE International Frequency Control Symposium. IEEE, 2008. 535–537. Web.

[2] Kwak, Dongwook, Yu Lei, and Radenka Maric. "Ammonia Gas Sensors: A Comprehensive Review." Talanta (Oxford) 204.C (2019): 713–730. Web.

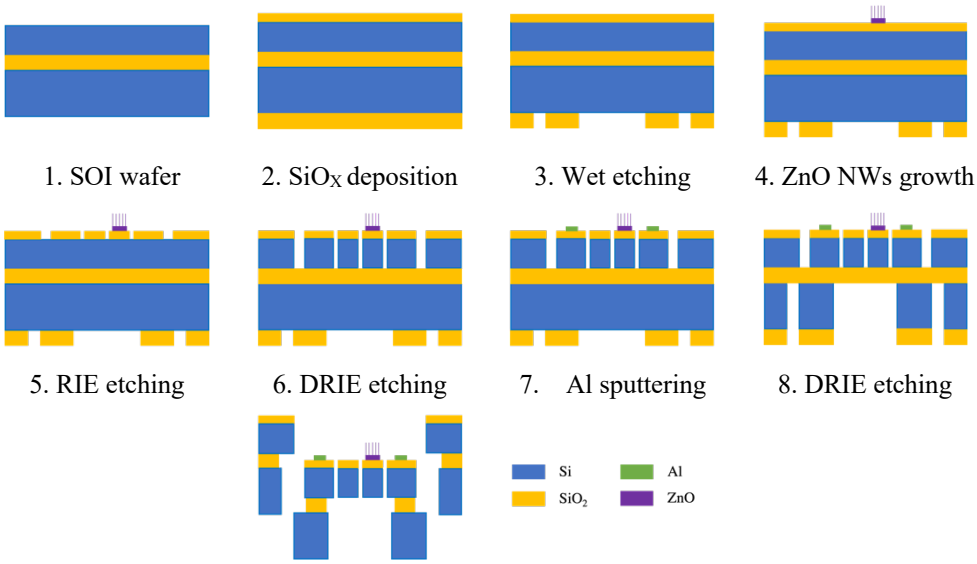



**Figure 1.** Process flow for the fabrication of coupled resonators with ZnO NWs.

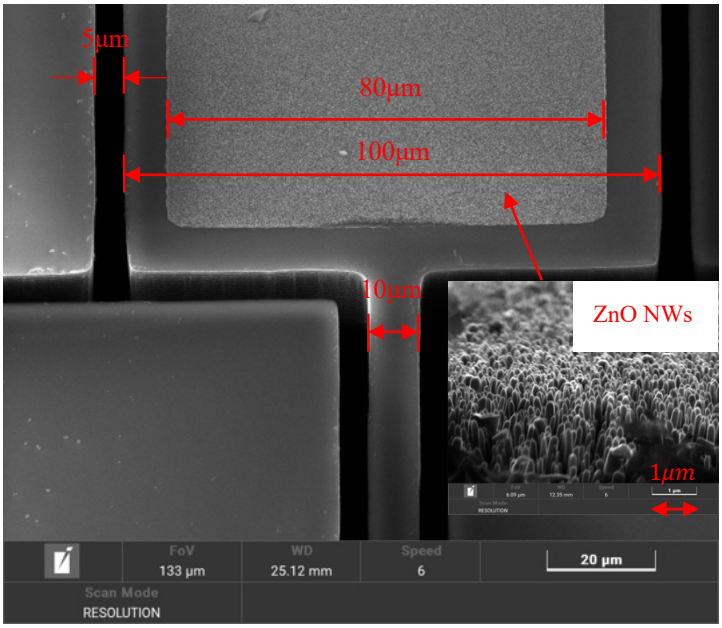
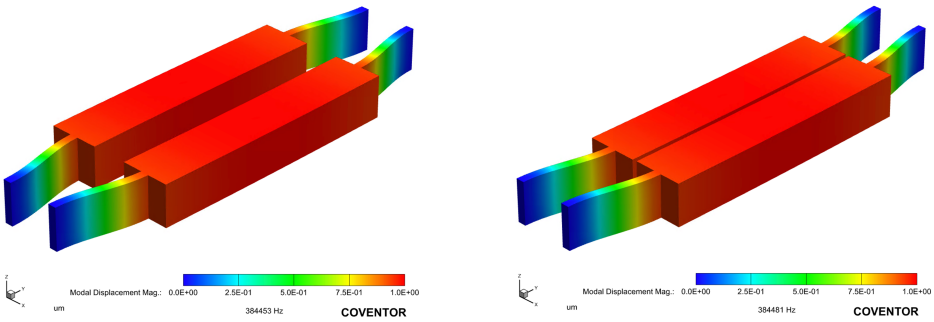



**Figure 2.** SEM of one of the fabricated devices. The high magnification SEM of ZnO NWs is shown in the inset.




(a) Out-of-phase mode frequency (b) In-phase mode frequency

**Figure 3.** Simulation snapshots of a coupled resonators actuated electrically.