Optimization of the mass sensitivity of wafer bonded resonant gravimetric CMUTs is presented. Gas phase sensors based on resonant gravimetric CMUTs have previously been demonstrated. An important figure of merit of these sensors is the sensitivity which, for typical CMUT geometries, is increased by decreasing the radius of the CMUT cell. This paper investigates how to minimize the radius of CMUT cells fabricated using the wafer bonding process. The design and process parameters affecting the radius of the CMUT and hereby the sensitivity are studied through numerical simulations and atomic force microscopy measurements. An excellent fit was obtained between the simulations and measured profiles with a low relative error of ≤ 5%, thus validating the simulation model. Two types of CMUTs are designed and fabricated using the design and process rules determined herein, with experimentally determined mass sensitivities of 0.46 Hz/ag and 0.44 Hz/ag, respectively. The two CMUT devices have cavities made using the local oxidation of silicon (LOCOS) and reactive ion etching (RIE) process. For the LOCOS process, it was found that the smallest radius can be obtained by choosing a Si₃N₄ oxidation mask and lowering the pad SiO₂ thickness, vacuum gap height, and Si bump height. For the RIE process, the vertical dimensions do not influence the horizontal dimensions and consequently, equivalent rules do not exist.