BIO

Glass-Frit Bonding for Selective Functionalization and Packaging of Biosensors

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Abstract:

In an effort to enhance diagnostic techniques for diseases, the development of microelectromechanical system (MEMS) biosensors offers a novel approach towards mass producing inexpensive reliable sensors. The objective of this project is to effectively package a biosensor through a glass-frit bonding process using a screen printer. In particular, the process outlined here is meant to work with mass sensitive biosensors; these sensors work by inducing a change in resonant frequency based on the change in mass due to analyte attaching to the sensor, i.e. protein binding. Upon completion of the research, packaging wafers have been successfully micromachined and etch rates and etch rate selectivity for the required silicon etching was established. Furthermore the glass-frit material was successfully screen-printed onto a packaging wafer, which was then bonded to a test wafer. Future work will include bonding a packaging wafer to a wafer with actual sensors.

Introduction:

As a means to test our biosensors, we initially resorted to individually assembling them using die-level packaging; the process involved placing a plastic ring onto the resonator chip to form a sample fluid cavity. This however proved to be ineffective for three reasons. To begin with, it was time consuming to place the plastic rings. Second, the resonators and wire bonds could easily break as a result of inserting the plastic rings by hand. Finally, an exact amount of epoxy had to be placed to glue the rings: too much destroyed the resonators and too little resulted in an insufficient seal. The glass-frit bonding process alleviates these problems utilizing wafer-level packaging. The screen-printing process allows to package many resonators dies at once and greatly diminishes the chances of breaking the resonators. Furthermore, the glass-frit bonding is of interest since it is cost effective process, provides a hermetic seal, and can tolerate the surface roughness on the wafer being bonded.

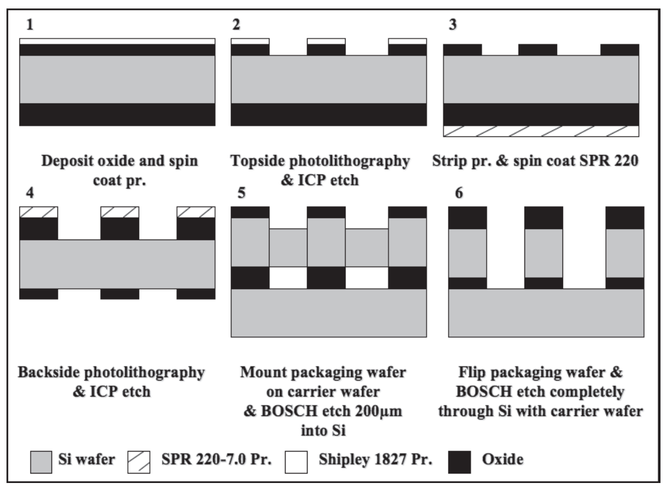

Figure 1: Diagram of fabrication process.

Fabrication:

Fabrication started by depositing 2 μm and 4 μm of oxide on the top and backside of the packaging wafer, respectively. Following standard photolithographic protocols, proximity photolithography and etching in an inductively coupled plasma (ICP) tool were used to pattern the oxide film on the top of the packaging wafer (step 3 in Figure 1). Once we confirmed that the oxide was etched down to the silicon using optical microscopy, we patterned the backside oxide film using a double-side mask aligner (step 4 in Figure 1).

Using the BOSCH process, we then etched 200 μm into the silicon wafer from the topside and then etched completely through the wafer from the backside. This process allowed us to wedge the resonators in the windowed areas on the packaging wafer. Continuing the fabrication, we screen-printed the glass-frit material (DIEMAT, Byfield, MA) onto the packaging wafer (Figure 2). In order to eliminate the organic binder in the glass-frit material, we then went through an organic burnout process. This process step glazed the glass-frit material to the substrate, an initial step towards completing the bonding process. The fabrication was then completed by bonding the packaging wafer to a test wafer.

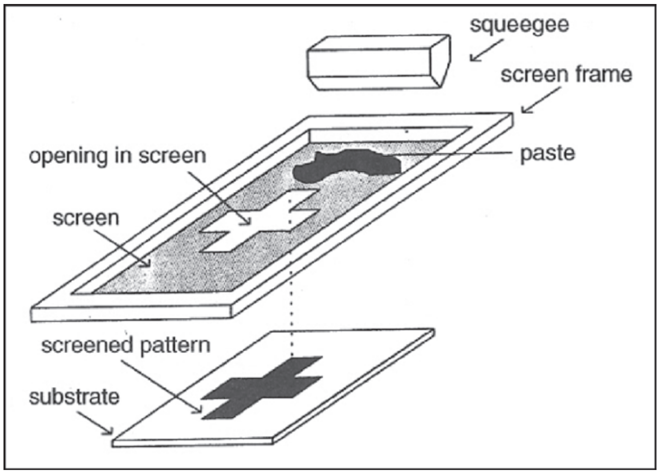

Figure 2: Diagram of screen printer.

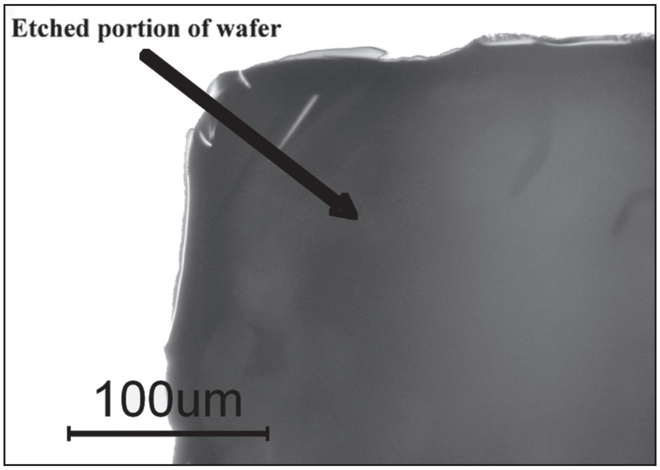

Figure 3: Micrograph of windowed area on packaging wafer after through-wafer etch.

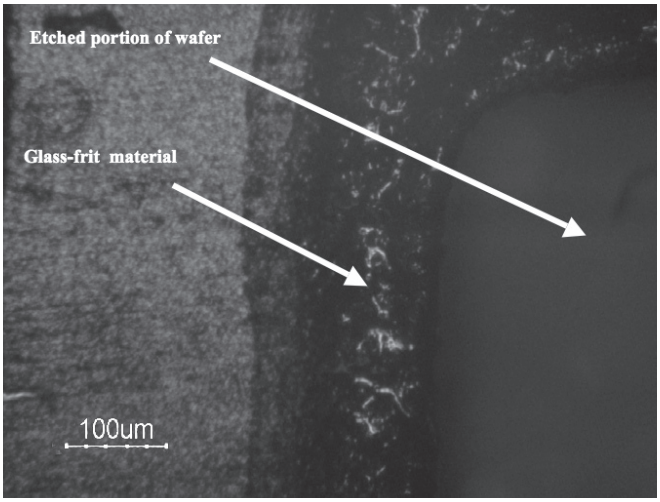

Figure 4: Micrograph of windowed area on packaging wafer after organic burnout and glazing.

Results:

The packaging wafer was successfully fabricated and the fabrication steps were carefully characterized. For the silicon etching with the Bosch process, we acquired an etch rate of 800Å/cycle and an etch rate selectivity to SiO_2 of 178 to 1. Shipley 1827 photoresist was used for the topside photolithography, while Megaposit SPR 220-7.0 photoresist was used for the backside photolithography, due the difference in oxide thickness. The thickness of the screen-printed glass-frit ranged from 30-50 μm. In order to confirm whether this thickness will suffice, the packaging wafer has to be bonded to the device wafer. In the present research, we were able to successfully bond the packing wafer to the rough side of a prime wafer.

Future Work:

We hope to completely characterize the glass-frit bonding process and to bond the packaging wafer to a device wafer with resonant microstructures to acquire fully packaged biosensors.

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