0. Abstract

A new process for the fabrication of piezoelectric quartz thin films on silicon is investigated. With this process, new silicon-implemented acoustic wave delay lines for sensor applications can be realized. The process consists of low temperature fusion bonding of a piezoelectric quartz wafer to a silicon wafer followed by a back-lap of the quartz to a thickness of between 10 and 50 μm. In this contribution we report on the first step: the fusion bond process. An annealing temperature of 140°C was found to be sufficient for further micromachining of the wafer stack.

Keywords: micro acoustic wave detector, quartz-to-silicon bonding, low temperature bonding

1. Introduction

In situ monitoring of the concentration of compounds in a chemical solution receives increasing attention in medical science and in the production of foods and chemicals. It opens up the way for automatic process control. The use of detectors based on physical principles avoids typical problems encountered with biochemical sensors using chemical sensitive layers such as ageing, clogging and the fabrication of a reproducible and stable biochemical interface. Micro acoustic-wave sensors are often used for the determination of liquid properties such as density and viscosity [1,2,3,4]. An acoustic-wave delay-line consists of two interdigital thin film metal transducers (IDTs) fabricated on a piezoelectric crystal. In order to realize acoustic-wave devices on (non-piezoelectric) silicon, the use of...
piezoelectric thin films such as zinc oxide, aluminum nitride or PZT has been reported [5,6,7,8]. However, these films often exhibit stress, aging, pinholes, or poor reproducibility which affects the performance of the device. Piezoelectric quartz crystal wafers are known for their high stability and reproducibility of piezoelectric and mechanical properties. Therefore, the realization of piezoelectric quartz thin films on silicon would be very attractive for silicon-implemented micro acoustic-wave detectors. Lamb wave sensors are an example of devices which could benefit from this technique, as will be discussed in the following section.

2. Thin-film piezoelectric-quartz on silicon for Lamb-wave sensors

Lamb-wave delay-lines consist of a membrane in which interdigital transducers are realized. The membrane is typically made of silicon or silicon nitride by using silicon bulk etching techniques. For the generation and detection of the acoustic Lamb waves, a piezoelectric film is required. The fabrication sequence of the Lamb-wave device proposed in this paper is shown in Fig.1.

![Fig. 1 Fabrication sequence of the lamb wave device: Quartz and silicon are fusion bonded after which the quartz is lapped back to a thickness of 10 to 50 \( \mu \text{m} \). The metal IDTs are fabricated by a metal deposition followed by an etch step. The last step consists of silicon bulk etch process from the back.](image)

Starting materials of the Lamb-wave device are a piezoelectric ST-cut quartz wafer and a silicon wafer which are bonded together at low temperatures. In the following section this