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Abstract

Fabrication of Wafer-Level Vacuum-Packaged 3C-SiC Resonators with Q-Factor above 250,000 †

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Abstract: In this work, the fabrication of wafer-level vacuum-packaged 3C-SiC on Si double- clamped beam resonators via glass–silicon anodic bonding using Ti-based vacuum gettering is reported. Open-loop resonance measurements are performed on the vacuum-packaged devices, showing Q-factor values up to 290,000, a process yield above 80%, and a maximum vacuum level around 10^{-2} mbar inside the Ti-gettered encapsulations.

Keywords: 3C-SiC; Q-factor; Ti getter

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1. Introduction

Q-factor is an important parameter for the performance of a sensor based on mechanical resonance because it is strictly correlated with the measurement resolution that can be reached by any kind of sensing based on mechanical resonance frequency shifts [1,2]. We present here a technology for fabricating wafer-level vacuum-packaged SiC resonators with a high Q-factor.

2. Materials and Methods

A hetero-epitaxial, non-intentionally doped 0.8 µm thick 3C-SiC thin film was grown on 500 µm thick <100> p-type silicon substrates using chemical vapor deposition, as described in [3]. The process flow adopted to fabricate the wafer-level vacuum-packaged SiC double-clamped beams is shown in Figure 1.

More details about the method used for the micromachining of the SiC structures can be found in [3]. Wet etching using a Cr/Au mask was used to produce 100 µm deep cavities in borosilicate glass for the encapsulation. In some of them, a 1 µm thick Ti layer was inserted for vacuum gettering using either lithography and wet etching or shadow masking in different dies on the wafer. The glass and Si wafers were bonded anodically at 400 °C after a 2 h degassing in vacuum (step 18 in the figure). The double-clamped beams were 900 µm long and 24 µm wide. Q-factor measurements were performed using a laser diode to induce a sinusoidal vibration of the beam, while a Doppler vibrometer was employed to measure the beam vibration at resonance.

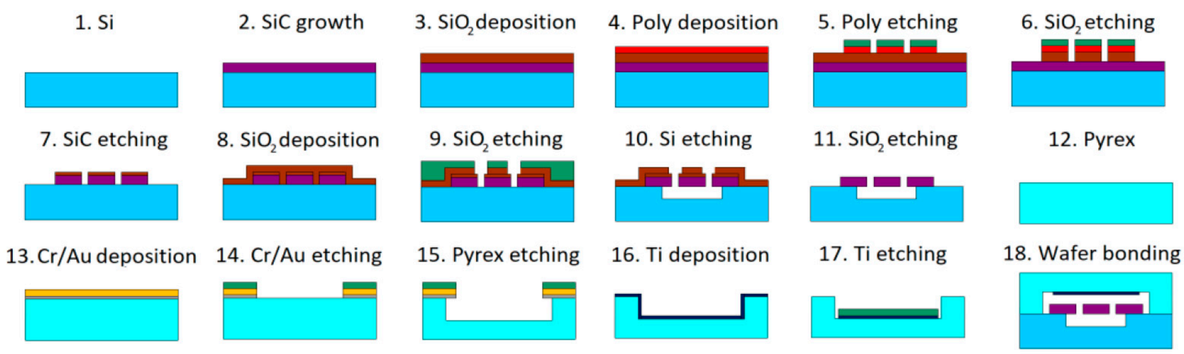

Figure 1. Process flow for the fabrication of the wafer-level vacuum-packaged SiC resonators.

3. Discussion

The results of the Q-factor measurements performed within encapsulations of different geometries are shown in Figure 2. Evidently, the presence of Ti greatly increases the vacuum level and the Q-factor, both when using shadow masking and the lithographic patterning of it. A very high yield of the vacuum encapsulation is also observed, with a vacuum level, estimated through the resonators' Q-factor, around 10^{-2} mbar.

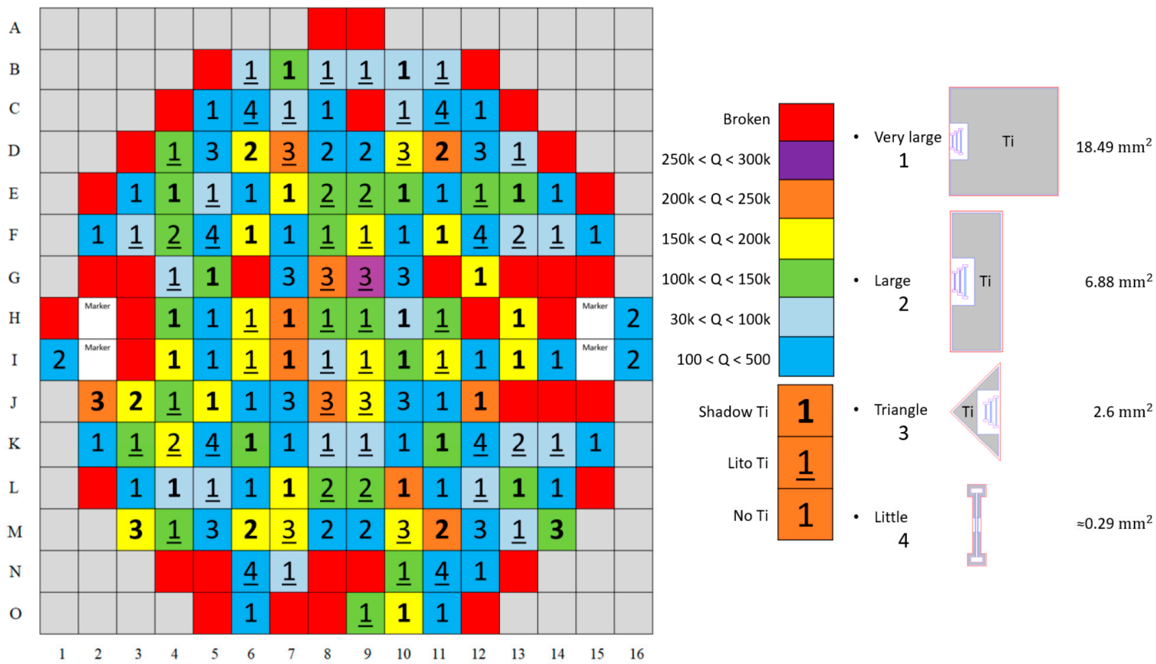

Figure 2. Q-factor measurements performed on double-clamped beams inside capsules with different geometries and areas.

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