Low-temperature Laser-assisted Sealing of Glass Lid on Silicon

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This new low-temperature sealing technology enables hermetic packages of environmentally sensitive components like VCSEL, CCD eventually combined with ASICs. The advantage of a high shear strength (~150 MPa) and fast laser-assisted sealing makes this technology suitable for a wide range of applications.

The low temperature bonding and hermetic sealing of different materials like glass, ceramics, and single crystals is still challenging. Many applications use high temperature sealing techniques (e.g. soft soldering and thermo-compression bonding at >250°C) to realize a robust hermetic seal. Many electronic components are not compatible to such high temperatures.

Developments in MOEMS and optoelectronics technology during recent years for smaller integrated low-power sensors and optical components opened up new fields of applications. In domains where exposure to harsh environments or long term stability is required (e.g. implants) or where electrical components (e.g. VCSEL) prone to degradation with moisture are used, hermetic sealing into a package is needed using materials with very low water permeability. Moreover temperature sensitive components like VCSEL, CCD eventually combined with ASICs would need to be encapsulated at a temperature of less than 150°C to ensure proper functionality without any degradation.

A novel laser based hermetic sealing method was developed (Figure 1). This hermetic sealing technology which was proven for sapphire in earlier developments [1] and has been extended to bonding of silicon onto glass. The sealing process is very fast and takes only a few seconds to provide a strong bond. The temperature inside the sealed chamber will be less than 150°C [1] . The sealed packages were also tested to be helium leak tight to better then 10^{-10} mbar·L/s, which is the detection limit of the measurement method.

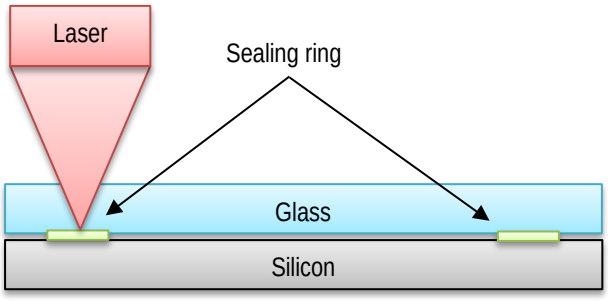

Figure 1: Laser-assisted sealing of glass lid on silicon with sealing ring.

In Figure 2, a hermetically sealed and perfectly aligned package is displayed. The color (red, green) of the interference fringes implies the flatness of the sealed package.

Accelerated tests were carried out to verify that the bonded chip can withstand harsh environmental conditions. Therefore two tests methods based on MIL-STD-750 where used to ensure that the right test condition is used. The tests used were moisture resistance test based on "Method 1021.3 moisture resistance" and thermal cycling tests based on "Method 1051.7 temperature cycling (air to air)" [2].

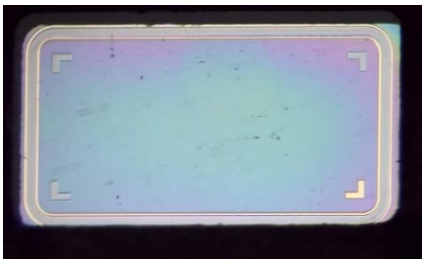

Figure 2: Hermetically sealed glass on silicon package.

To test the bond strength of the sealed chip a shear tester was used. It could be shown, that the shear strength did not change significantly after environmental stress testing. A comparison of the shear test values between reference samples (which were not submitted to accelerated testing) and samples which went through accelerated tests is given in Figure 3. On average very good shear strength values of about 150 MPa were achieved. After environmental testing 94% of the packages were still helium leak tight to better then 10^{-10} mbar·L/s.

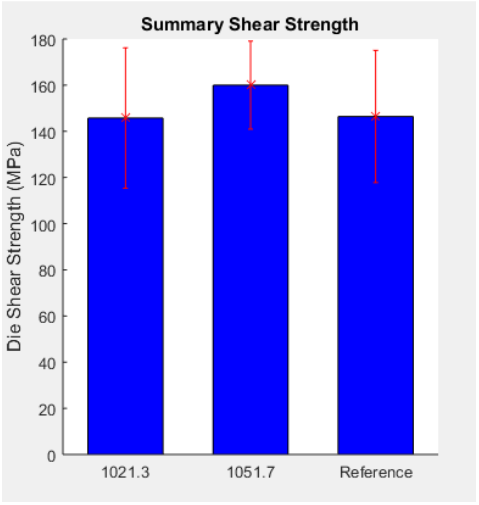

Figure 3: Summary of shear strength, with reference without MIL-STD-750 tests.

Further process development will be elaborated to explore new material combinations for chip material and sealing ring. This allows even more technology applications to be covered with this unique laser sealing technology taking advantage of low temperature hermetic sealing concept with high throughput.

[1] R. Jose James, *et al.*, "Low Temperature Hermetic Sealing of Sapphire Substrates", CSEM Scientific and Technical Report (2014), 41.

[2] Test Method Standard, Environmental Test Methods for Semiconductor Devices Part1: Test Methods 1000 through 1999, Department of Defense, MIL-STD-750 (2012).