Miniaturised Hermetic Packages in Glass and Sapphire

Mark Fretz

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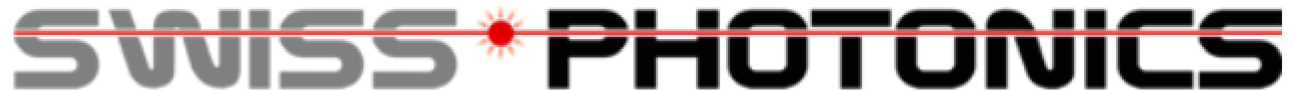


Outline

What's in the package?

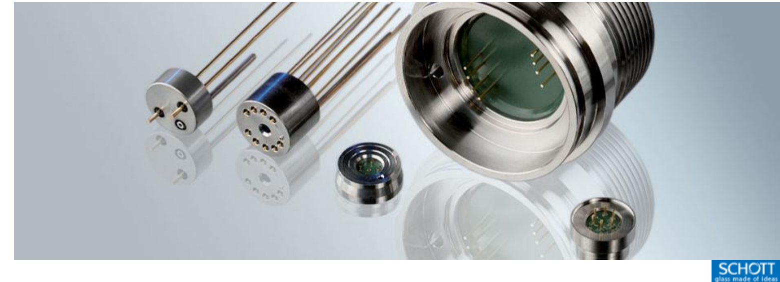
- Challenges in miniaturized packaging
- State-of-the-art package sealing
- CSEM approach
  - Laser assisted bonding
    - Examples
  - Hermeticity testing
  - Volume production

Challenges in Miniaturized Packaging

- **Transparency for RF and visible light and Laser assisted bonding**
  - Limited number of materials which comply with above requirements and are suitable for harsh environments (e.g. space or implants)
- **Solution**
  - Sapphire & glasses
  - → **Laser assisted diffusion bonding**

Challenges in Miniaturized Packaging

- **Bonding of miniaturised packages**
  - New bonding materials for harsh environments and medical applications have high melting points (Pt, Ti, Pd, Au)
  - Lid brazing or soldering of these materials generates excessive heat

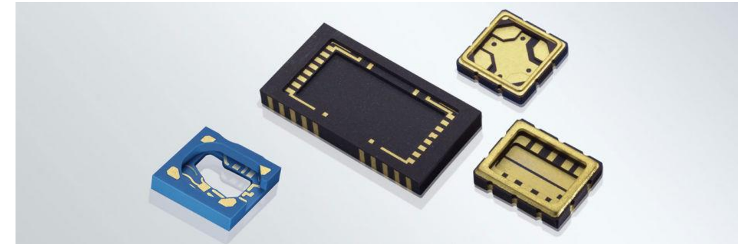


- **Solution**
  - (Localised heat) + (bonding below melting point)
  - → **(Laser assisted) (diffusion bonding)**

Challenges in Miniaturized Packaging

- **Stresses**
  - High temperature brazing or soldering lead to stresses in the package
- **Solution**
  - Localised heat keeps the package cool
  - Diffusion bonding generates lower stresses at the interface)

    → (**Laser assisted**) (**diffusion bonding**)



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Challenges in Miniaturized Packaging

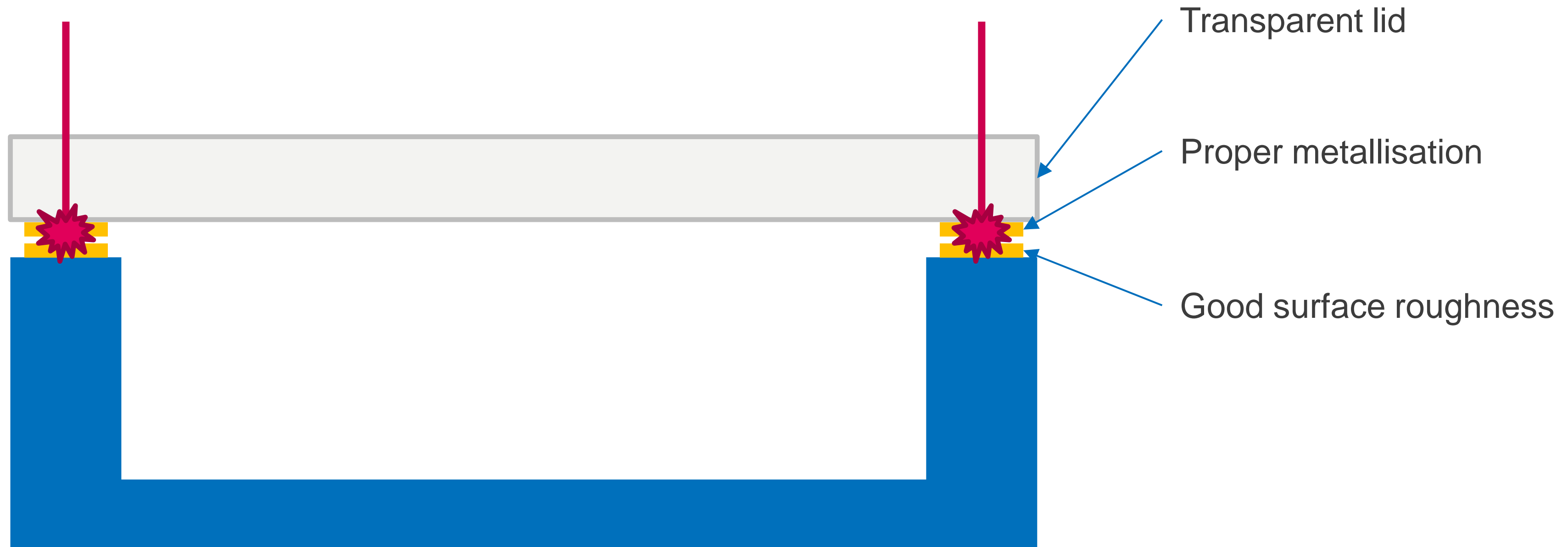
- **Hermeticity Testing**
  - Small packages require lower leak rates down to $6*10^{-15}$ atm.cc/s[1]
  - Current best helium leak rate detection: $5*10^{-12}$ atm.cc/s[1]
- **New Approach**
  - Fourier transform infrared spectroscopy (FTIR)

[1] G. Jiang, D.D. Zhou, Implantable Neural Prostheses 2, Chapter 2: Technology Advances and Challenges in Hermetic Packaging for Implantable Medical Devices, Springer, 1st Edition

State-of-the-Art Package Sealing

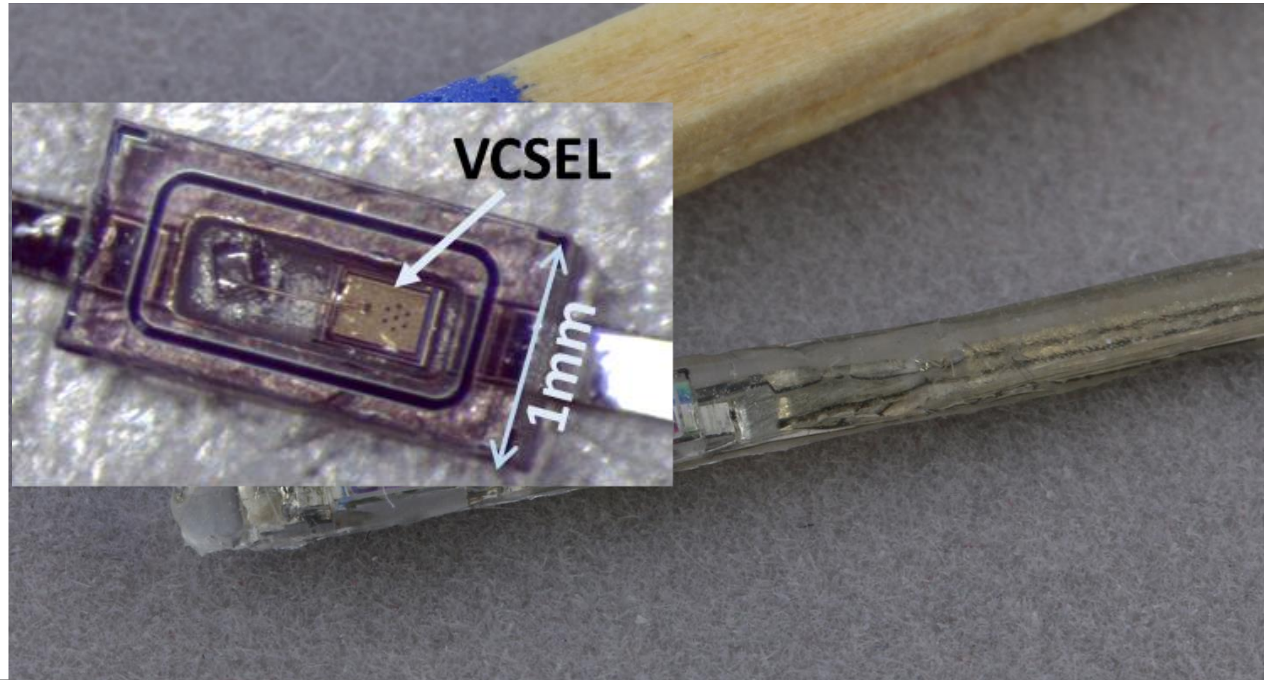
- **Glass frit bonding**
  - High temperature bonding, not biocompatible
- **Laser assisted soldering**
  - High temperature, not biocompatible
- **Laser welding /Resistance welding**
  - Very high temperatures, not biocompatible

CSEM Approach: Laser Assisted Diffusion Bonding

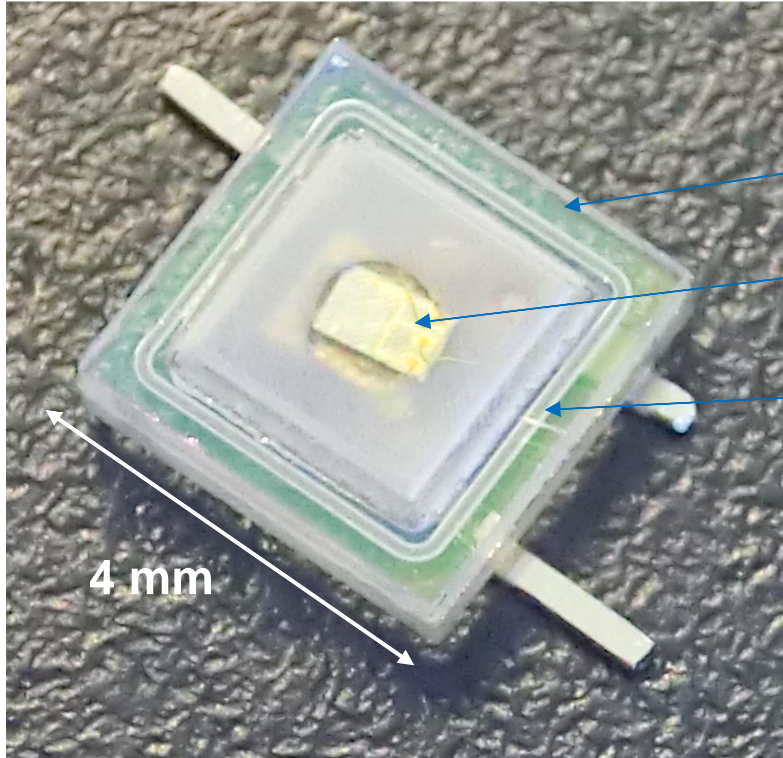


CSEM Approach: Laser Assisted Bonding: Examples

Cochlear Implant



CSEM Approach: Laser Assisted Bonding: Examples



Implantable pressure sensor

Sapphire package

Commercial pressure sensor

LADB seal

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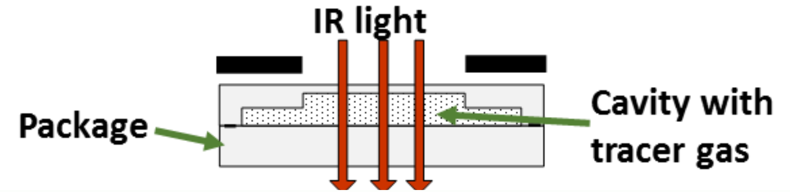
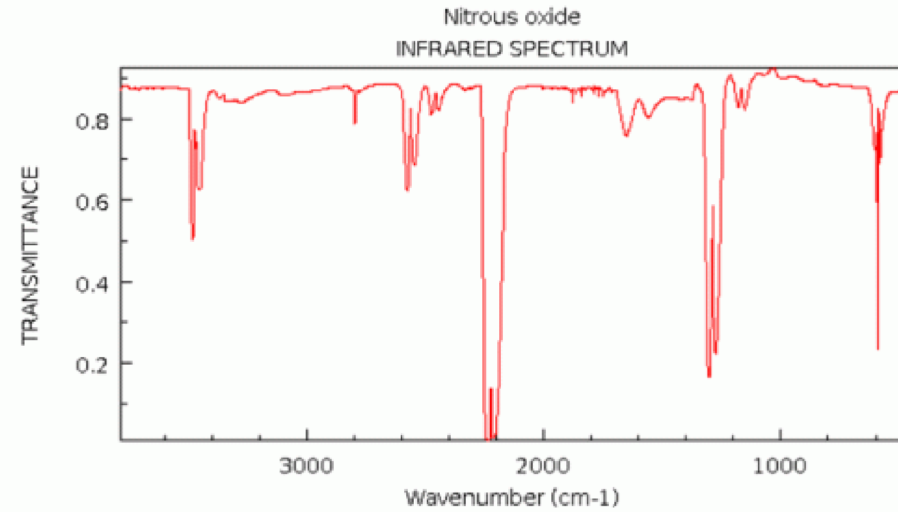
CSEM Approach: Non Destructive FTIR Leak Testing

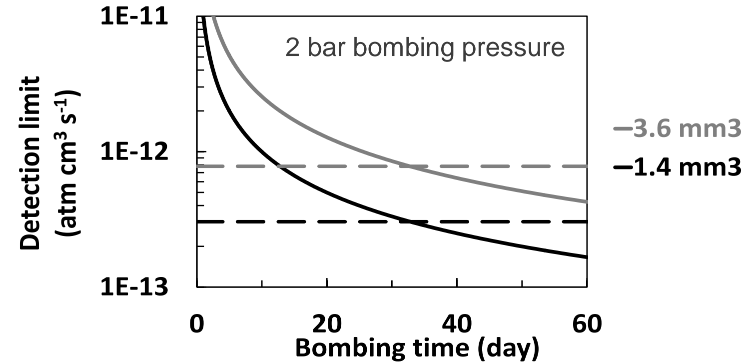
- Bombing with N_2O high pressure
  - 2 to 5 bars
  - Not present in ambient atmosphere (low background)
  - Peaks at wavenumber 2237 & 2212 cm-1

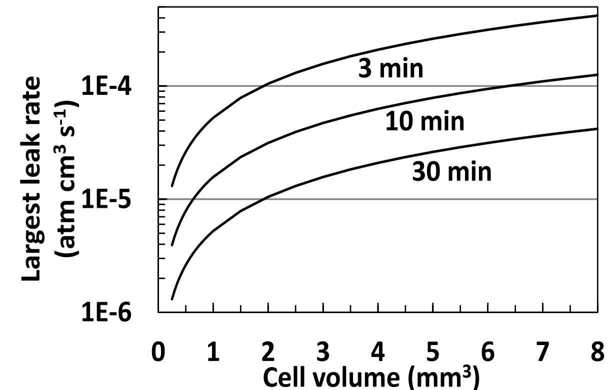




CSEM Approach: Non Destructive FTIR Leak Testing

- Detection depends mainly on
  - Concentration of N_2O
    - **Duration of bombing**
    - **Bombing pressure**
  - Length of light path through the package
  - Detector sensitivity/resolution





CSEM Approach: Volume Production

- Array level tested successfully
  - Glass on silicon
- Chip size: 3.350 x 2.0 mm
- Array size : 13.4mm x 8.0mm
- Overall time for the array is 48 seconds
  - Estimated on 200mm wafer: 75mins (~4’000 parts → 1 sec/part)
  - Estimated for 100mm wafer: 15 minutes (~1’000 parts)
- Further reduction by a factor of 4 seems feasible with further optimisation

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