Master's Thesis Engineering Technology

2022-2023

Testing and validating the lifetime of stretchable electronics

Maarten Budenaers

Master of Electronics and ICT Engineering Technology

Tom Stiers

Master of Electronics and ICT Engineering Technology

Context

Researchers at imo-imomec work with **novel stretchable electronic devices**. These devices consist of the following components:

- silicone (as the enveloping material),
- galinstan (conducting traces),
- flexible PCBs,
- rigid components (e.g. LEDs).

This master's thesis focuses on accelerated lifetime tests to **investigate the expected lifetime** of the novel stretchable devices.

Problems and Objectives

For evaluating the new technology, **reference device designs** with varying attributes must first be established.

Secondly, all relevant **stress factors** expected in the field were identified and, if possible, consequently applied to the reference devices.

Materials and Methods

In the scope of this research, two designs were developed and produced in several batches:

- **Stretchable LED strip**

Figure 1: Stretchable LED strip

→ facilitates functioning LED

- **Stretchable wire**

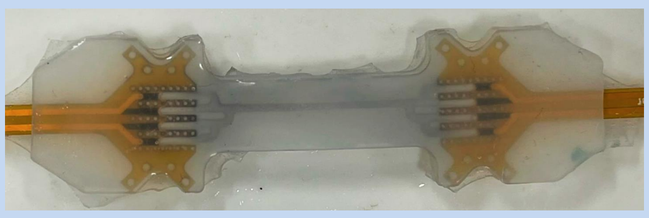

Figure 2: Stretchable wire

→ trace layout designed for four point probe measurement

The influence of the following factors was tested:

- **UV radiation** (QUV test),
- **temperature and humidity** (damp heat test),
- **stretch** (cycle test).

Environmental stress factors were applied to the devices within a damp heat test chamber and QUV test chamber.

Figure 3: QUV test chamber [1]

Mechanical stress in the form of device stretching was applied using cycletesters.

Figure 4: Multiple cycletesters in the measurement setup

Results

During testing resistance measurements were taken on the four point probe devices and LED monitoring was done on the component devices by measuring the current and taking images. The stretchable LED strips were stretched for 50% and the stretchable wire devices for 150%.

Four point probe resistance results:

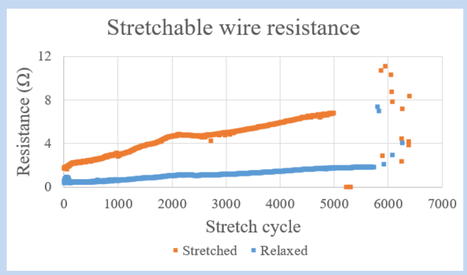

Figure 5: Trace resistance as a function of the number of stretch-cycles

LED results:

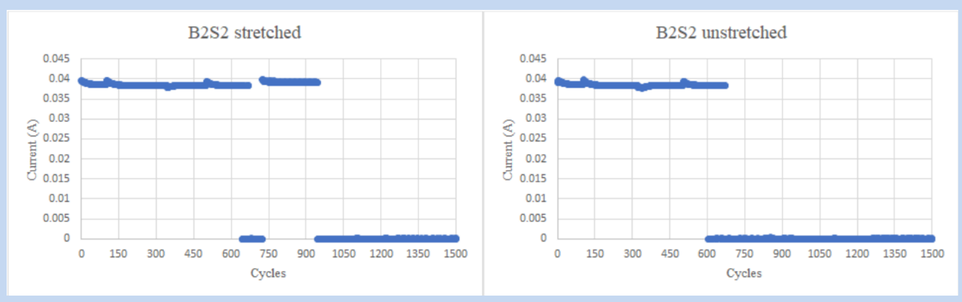

Figure 6: Current in function of the number of stretch-cycles (measured in unstretched and stretched state) for the second device from the second batch

Visual device inspection:

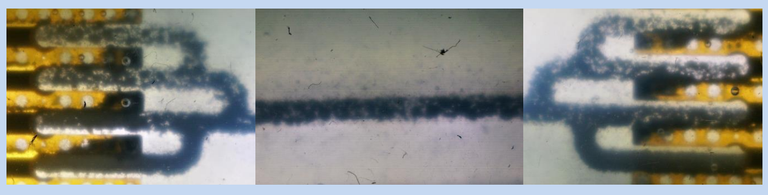

Figure 7: Close-ups of a stretchable wire after stretch testing

The observed **failure mechanisms** are:

- loss of adhesion between the silicone and the rigid components,
- ruptures in the silicone,
- galinstan oxidation.

Conclusions

- **Heat, humidity, UV radiation and stretching** cause a loss of adhesion between rigid components and the encapsulating silicone, which accelerates device failure.
- **UV radiation** can cause the silicone to become stiffer and **rupture more rapidly.**
- The **unexposed stretchable LED strips** permanently **failed** on average after **859 cycles**. Furthermore, the increased stiffness following **UV** exposure **prolonged** device **functionality**.
- **Stretchable wire resistance** increases continuously during **cyclic testing**, until device failure stops conduction completely.

Supervisors / Co-supervisors / Advisors: Prof. dr. ir. Wim Deferme
Prof. dr. ir. Michaël Daenen
dr. Monika Rai
ing. Lennert Purnal
ing. Maximilian Krack

[1] Q-LAB, „QUV Accelerated Weathering Tester," 2023. [Online]. Available: https://www.q-lab.com/products/quv-weathering-tester/quv. [Consulted 07 May 2023].