Micro Igniters based on WSi_x thin films

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1 Introduction

Thin film based ignition elements for airbag systems have faster ignition times and require a lower ignition energy compared to commercially available wire-based igniters. Thus, WSi_x based igniters on a silicon substrate were developed and investigated. Their properties were then adjusted to fit certain fire and no-fire conditions.

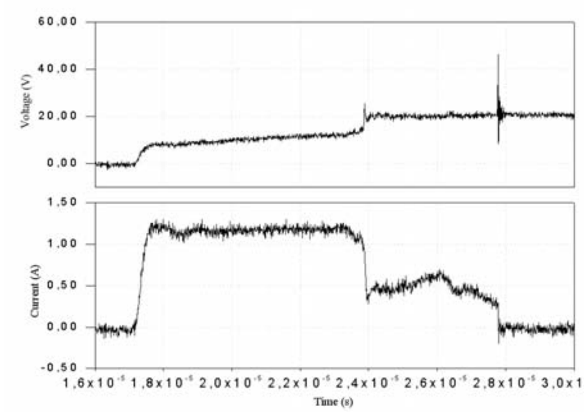
2 Design and Fabrication

Ignition chips of different geometries were designed and fabricated on 4 inch silicon wafer substrates. A SiO_2 layer was grown on the silicon to provide electrical insulation to the substrate. Subsequently, WSi_x was sputtered and tempered. For the electrical contact pads an aluminium layer was sputtered on the WSi_x film.

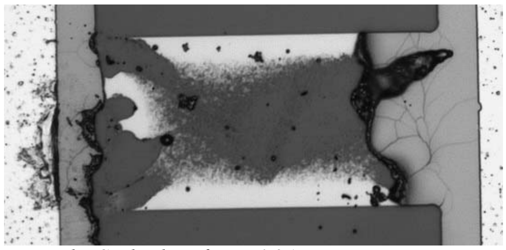
3 Packaging and Characterization

3.1. Resistance and fire conditions

The fabricated ignition elements were electrically characterized. After resistance measurements, some of the structures were ignited by a constant current of 1,2A or 1,75A. Fig. 3.1.a shows an example of the measured current and voltage during the ignition process. The destruction of the bridge starts where the current drops to a significant lower value, and ends, when the current drops to zero. A destroyed igniter bridge is shown in Fig. 3.1.b.



a) Voltage and Current during the ignition process as function of time



b) Destroyed WSix bridge after I=1,2A

Fig. 3.1: Ignition of a WSix Bridge (L=100µm, W=50µm) with a constant current of I=1,2A

3.2. Heating and destruction process

For better understanding of the working principle of the ignition process, different currents were applied to WSi_x bridges with dimensions of L=200µm, W=100µm (Fig. 3.2). These relatively large dimensions were chosen to slow down the heating process and therefore getting better time and current resolution.

Until a certain current $I_{nofire1}$, the temperature due to the current density in the structure is not sufficient to destroy the WSi_x bridge even after a time of more than 1,5ms. The resistance increase, which is correlated to the temperature of the structure, was found to be reversible and no damage could be seen or measured at the bridge afterwards. Since the resistance increase for currents below $I_{nofire1}$ follows an asymptotic behaviour, reversibility can also be assumed after a much longer time than shown in Fig 3.2.
The temperature inside the bridge mainly depends on the current density and the heat dissipation to the substrate, which also has been verified by FEM simulations. Both, current density and heat dissipation were adjusted by changing bridge geometry and process

technology to fulfil certain all-fire and no-fire conditions.

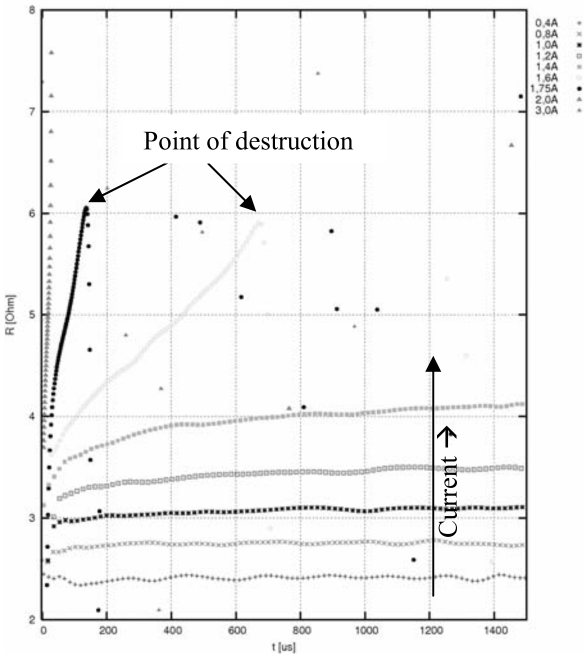
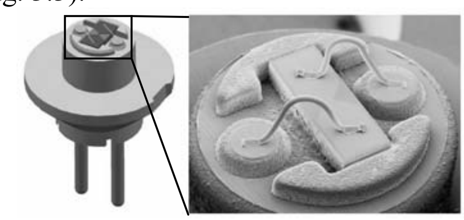


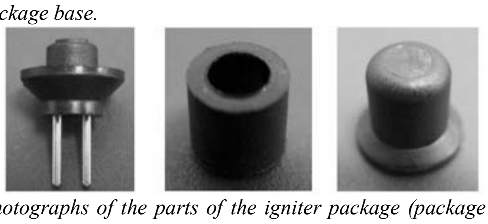
Fig. 3.2: Resistance of a large WSi_x bridge (L=200µm, W=100µm) as function of time for different currents. A higher current leads to a faster increasing of temperature. If the temperature is sufficient to destroy the structure (ignition point), the current defines the ignition speed.

3.3 Packaging and Pyrotechnics

A full-plastic igniter package was developed by the company Fahrzeugelektrik Pirna GmbH. For ESD protection an additional capacitor was integrated into the package.
The igniter chips fabricated at the Center for Microtechnologies were mounted and wire-bonded to the contact pins of the package base (Fig. 3.3).



a) CAD drawing of the package base and SEM picture of igniter chip which has been wire-bonded to the contact pins of the package base.



b) Photographs of the parts of the igniter package (package base with contact pins, charge holder, cap)

Fig. 3.3: Full-plastic igniter package

Subsequently, a charge holder was ultrasonically welded on the package base.
The cavity inside the charge holder was then filled with liquid pyrotechnics provided by the company NICO Pyrotechnik GmbH and successfully ignited. Fig. 3.4 shows voltage, current and light emission of the full ignition process.

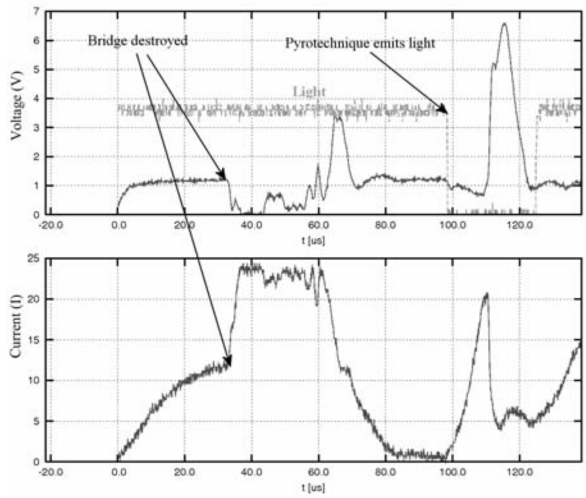


Fig. 3.4: Voltage and current as function of time during ignition of a igniter filled with pyrotechnics. The delay between destruction of the bridge and ignition of the pyrotechnics (indicated by the light emission) is about 40..50µs

4 Conclusion

Micro igniters based of a WSi_x thin film bridge were successfully developed and integrated into a full-plastic package. The ignition parameters of these WSi_x bridges are adjustable in a wide range according to the desired application. The Micro igniter chips together with the package showed good and reliable ignition behaviour both with and without pyrotechnics. First tests showed good ESD stability, but additional ESD, EMD and climatic tests have to be performed.

5 Acknowledgments

We would like to thank the company NICO Pyrotechnik GmbH for providing the liquid pyrotechnics and the test environment.
The project was a joint research project with the companies Fahrzeugelektrik Pirna GmbH (FEP) and FLEXIVA automation & Robotik GmbH and supported by SMWA (Sächsisches Staatsministerium für Wirtschaft und Arbeit).