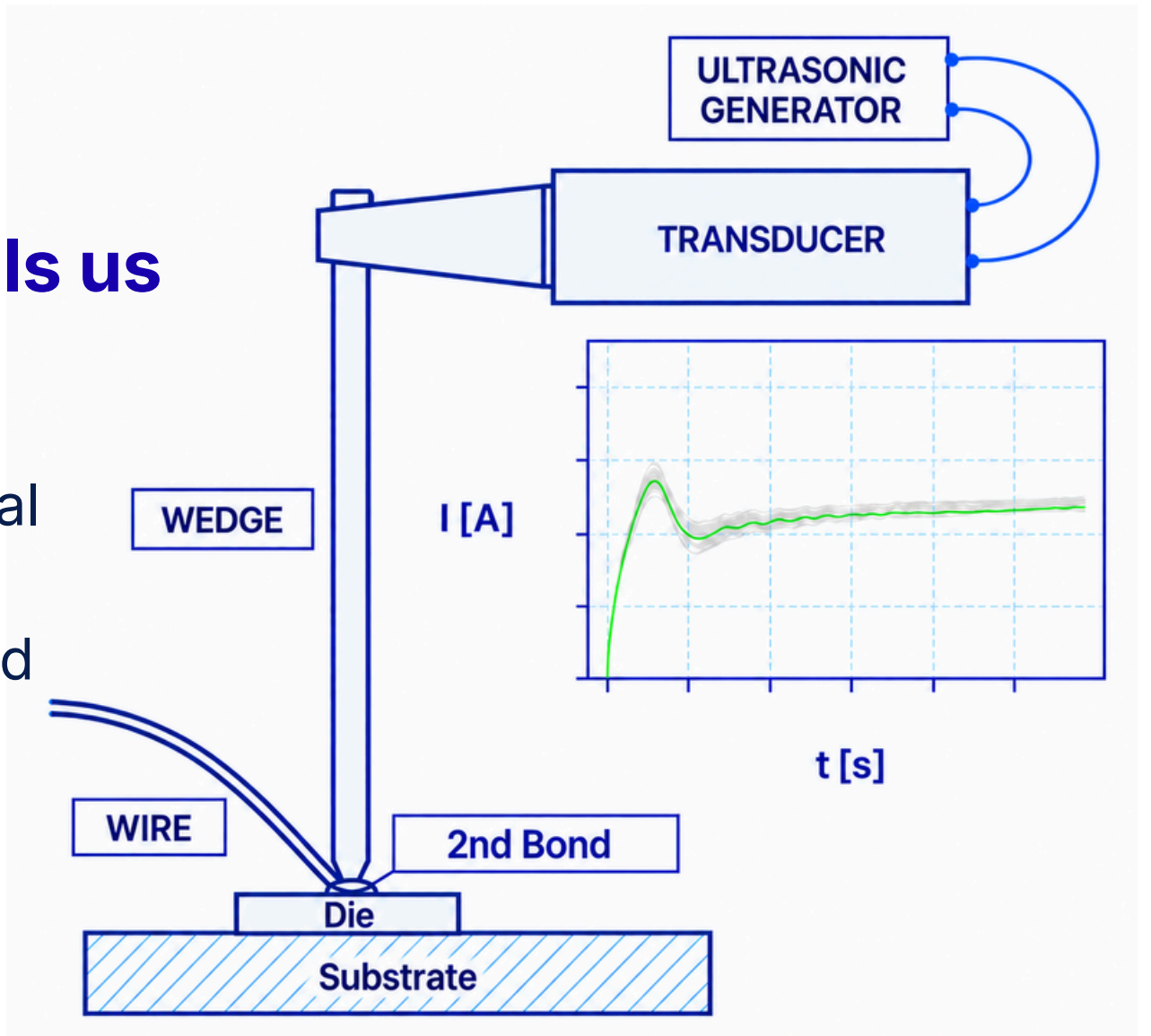
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Can the Ultrasonic Current Signature Reveal Bond Quality?

What the electrical signal during bond formation tells us

A study investigated whether the ultrasonic generator current signal can indicate bond quality by linking signal behavior to attached area and thermal-cycling reliability.



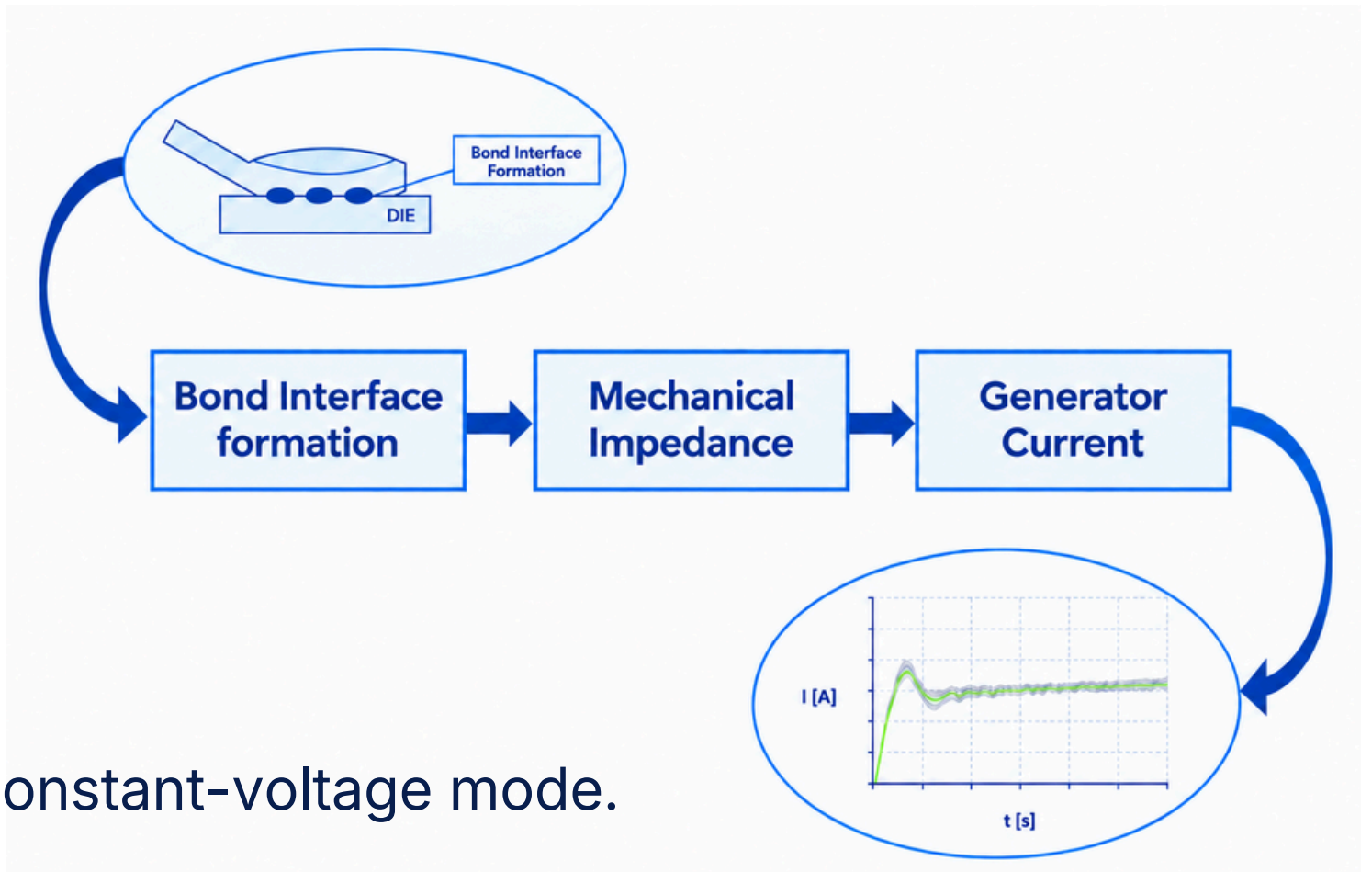
The electrical signal during bonding may already contain useful bond-quality information.

Note: *Visuals are schematic representations based on the study, not 1:1 reproductions of the original figures or data.*

What Is the Current Signature?

The bond interface influences the electrical signal

During bond formation, changes at the wire-bond interface affect the mechanical impedance and resonance frequency of the ultrasonic system.



The generator operates in constant-voltage mode.

Changes in mechanical conditions are therefore reflected in the measured ultrasonic generator current.

Current Signature = electrical response to changing mechanical conditions at the bond interface.

Study setup:

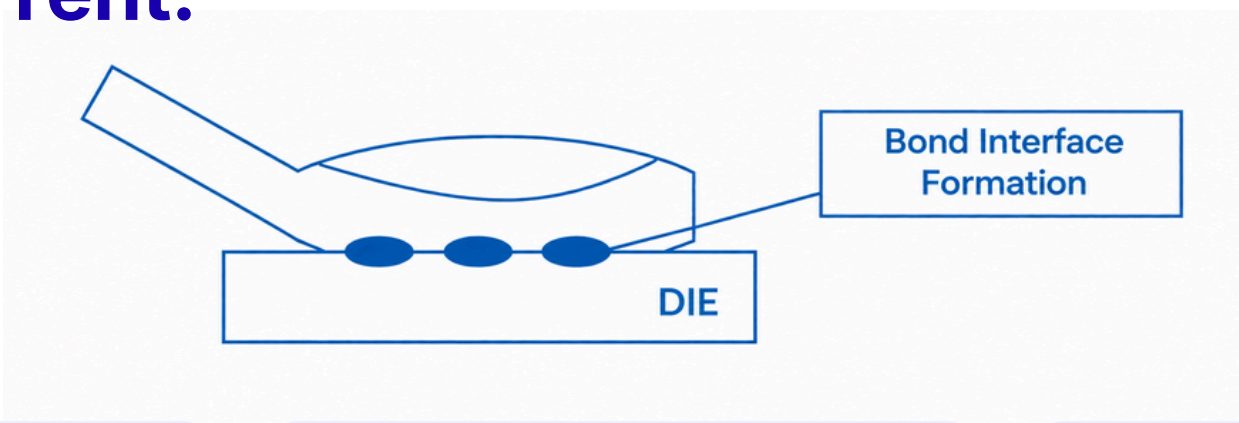
375 µm 5N Al wire | F&K Delvotec wedge bonder | ultrasonic operating frequency ~58 kHz

Signal acquisition: generator current sampled at 12.5 MHz via oscilloscope-based data acquisition.

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From Bond Interface to Generator Current

Changes at the bond interface affect the mechanical impedance and are reflected in the ultrasonic generator current.



Bond Interface

Condition of the wire-bond interface

Mechanical Impedance

Mechanical impedance presented to the transducer

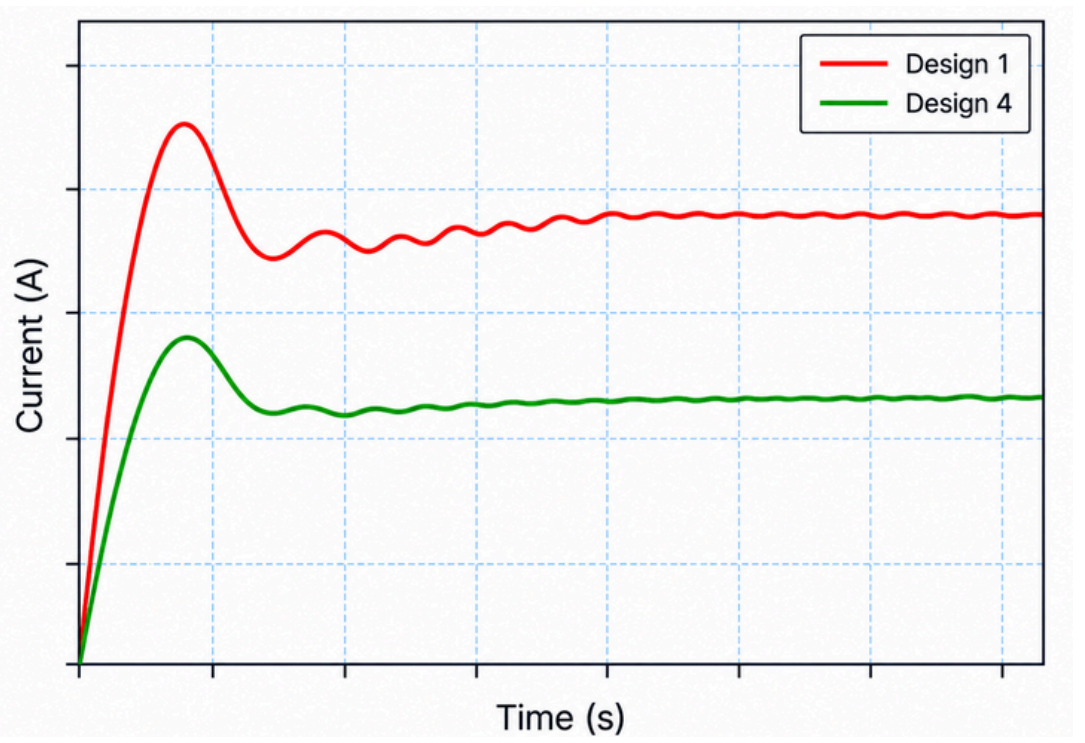
Generator Current

Current varies according to the mechanical impedance in constant-voltage mode.

Changes in mechanical conditions at the bond foot are directly reflected in the current envelope.

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Different Parameter Sets, Different Current Signatures



From 25 bonding-parameter designs, the paper directly compares Design 1 and Design 4, as the weakest and strongest designs.

Design 1 - weakest design

T100 | **US**115 | **BF**200 | **EF**200 | **TDS**70

Compared with Design 4:

- Lower ultrasonic power
- Lower begin- and end-force
- Fewer touch-down steps

According to the paper, insufficient begin-force and touch-down steps resulted in poor attached area and less reliable bonds.

Observed for Design 1:

- Higher steady-state current
- Less uniform signal shape
- Smaller attached area
- **140** cycles average lifetime

Design 4 - strongest design

T100 | **US**145 | **BF**800 | **EF**800 | **TDS**100

Compared with Design 1:

- Higher ultrasonic power
- Higher begin- and end-force
- More touch-down steps

The paper states that sufficient US power and force produced a more uniform attached area and more reliable bonds.

Observed for Design 4:

- More uniform current signal
- Larger attached area
- **1740** cycles average lifetime

***T:** Bonding time | **US:** Ultrasonic power | **BF:** Begin-force | **EF:** End-force | **TDS:** Touch-down steps*

The comparison links different bonding-parameter settings to differences in current signature, attached area and average lifetime.

Engineering Insight

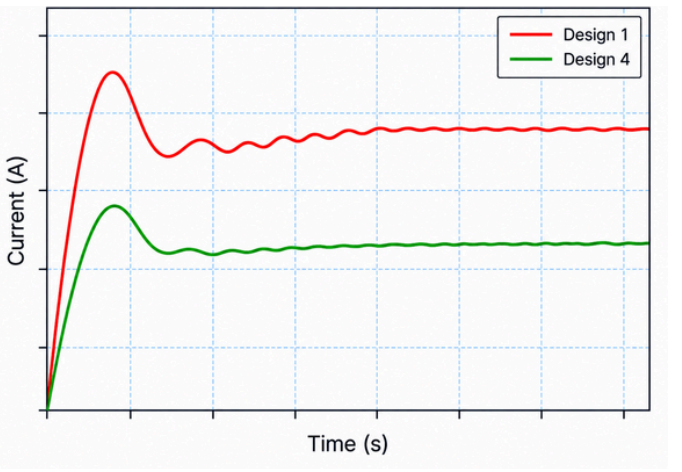
The Electrical Signature Is Consistent with Bond Quality and Reliability

The study shows that the ultrasonic-generator current signature reflects bond quality and is consistent with independent measurements of attached area and thermal-cycling lifetime.

1 Generator Current Signature

Design 1 showed a higher steady-state current and a less uniform signal shape compared with Design 4.

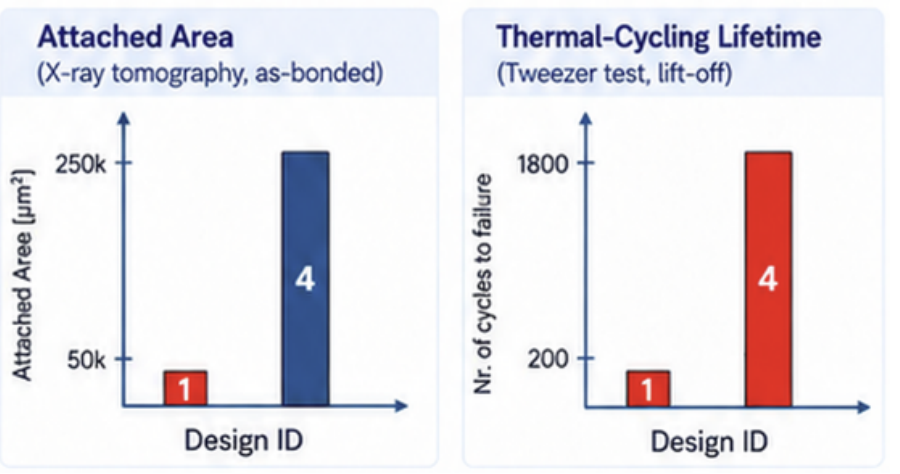
Design 4 showed a more uniform current signal and was identified as the stronger, more reliable design.



2 Independent test results support the signal-based interpretation

- Attached Area — X-ray tomography, as-bonded
- Thermal-Cycling Lifetime — Tweezer test / lift-off

X-ray tomography and thermal-cycling results showed clear differences between Design 1 and Design 4, consistent with the current-signal comparison.



3 Why this matters for manufacturing

The method is described as:

- Non-destructive
- Fast
- Cheap
- Suitable for online use in manufacturing

The paper concludes that bond-signal analysis can facilitate non-destructive evaluation of the effect of bonding-process parameters on bond quality.

The electrical signature was consistent with both attached area and thermal-cycling lifetime.

Engineering synthesis based on the investigated test conditions.

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Research Behind This Engineering Insight

E. Arjmand • P.A. Agyakwa • C.M. Johnson

Reliability of thick Al wire: A study of the effects of wire bonding parameters on thermal cycling degradation rate using non-destructive methods

Microelectronics Reliability, Volume 54 (2014), 2006–2012

Elsevier, 2014
DOI: 10.1016/j.microrel.2014.07.119

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