Disconnections analysis with HF Magnetic Microscopy

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(thanks to K. Berglind and A. Kabakow
for sample preparation)

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EUFANET workshop

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Never stop thinking

Purpose

Failure types in microelectronic devices:

(a) increased current consumption (shorts, leakages)

(b) electrically open current paths (cracks, lifted bonds, isolating interface layers, ...)

(c) functional failure states

Variety of analysis methods for (a) and (c).

Failure type (c): Only one established method: Time Domain Reflectometry (TDR).

Aim of this study:
Development of a new method to visualize electrically open current paths with magnetic microscopy and get a hint to the failure location.

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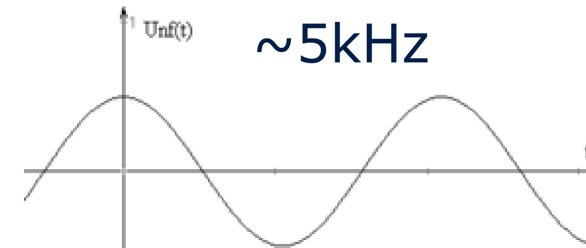
Experimental

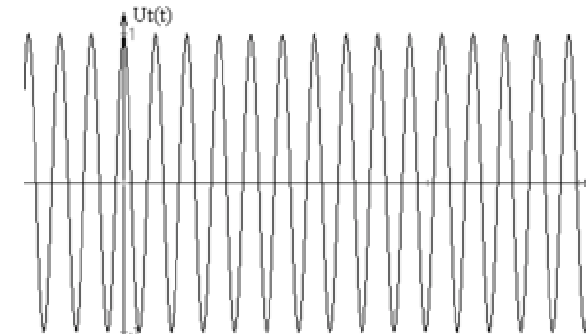
Principle:
Amplitude modulation

Modulating signal from Magma C30 generator

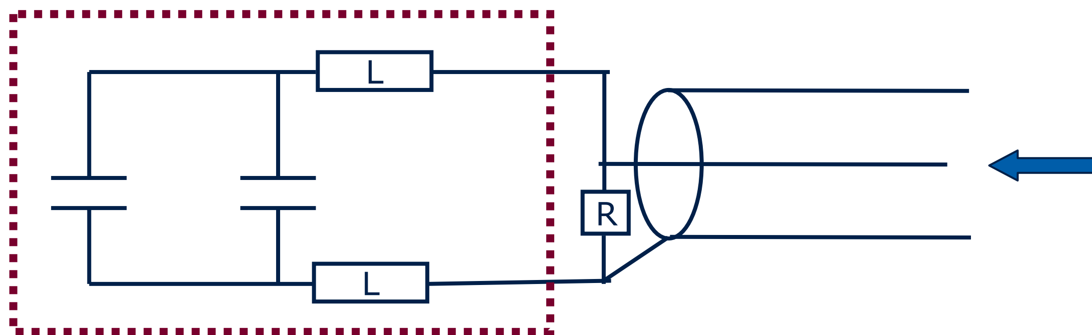
~5kHz



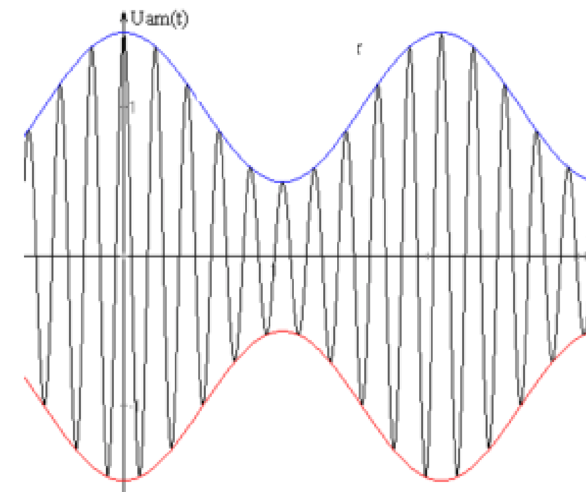
Carrier signal from HF generator (30-300MHz)



Sample with idealized inductive and capacitive elements



$J_D \sim dE/dt$



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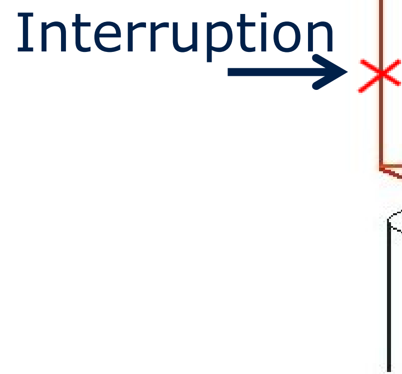
Wire test structure : Influence of the carrier frequency

Test sample
(100µm copper
wire)



Frequency dependant results of the measured magnetic signal

➔ *Failure feature (broken current path) visible for all frequencies.*

60 MHz
17 dBm

83 MHz
17 dBm

72 MHz
17 dBm

136 MHz
17 dBm

102,5 MHz
17 dBm

195 MHz
17 dBm

176 MHz
17 dBm

205 MHz
17 dBm

187 MHz
17 dBm

218 MHz
17 dBm

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Wire test structure : Current Image

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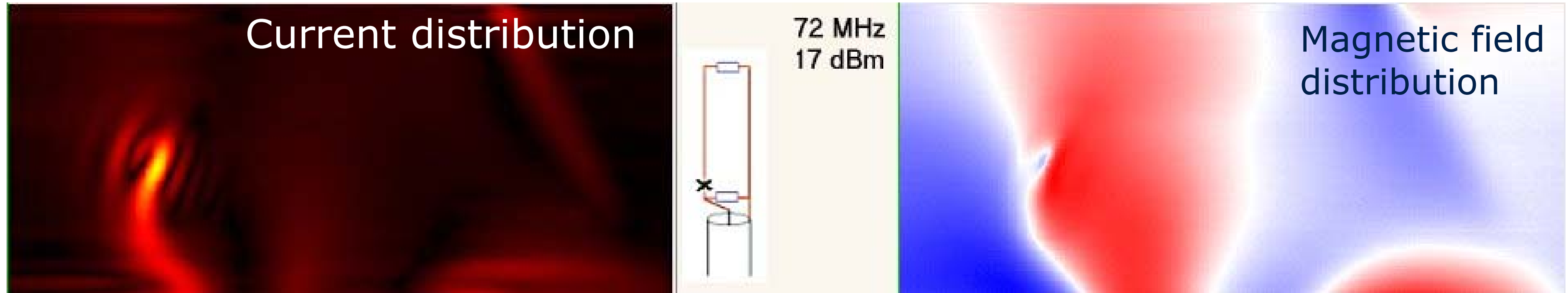
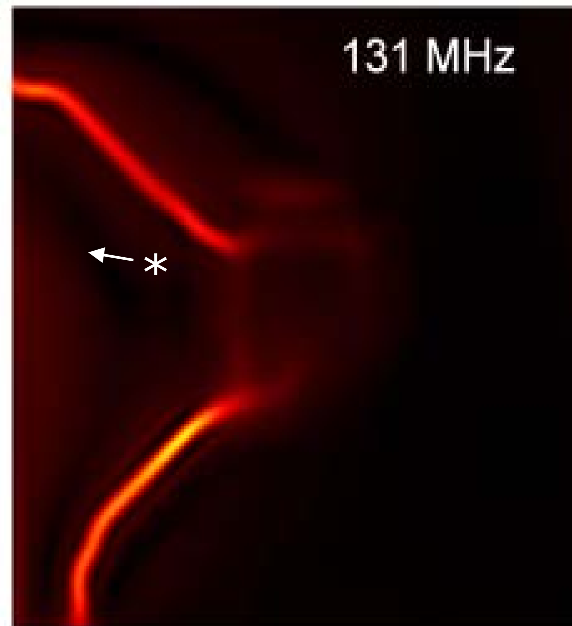


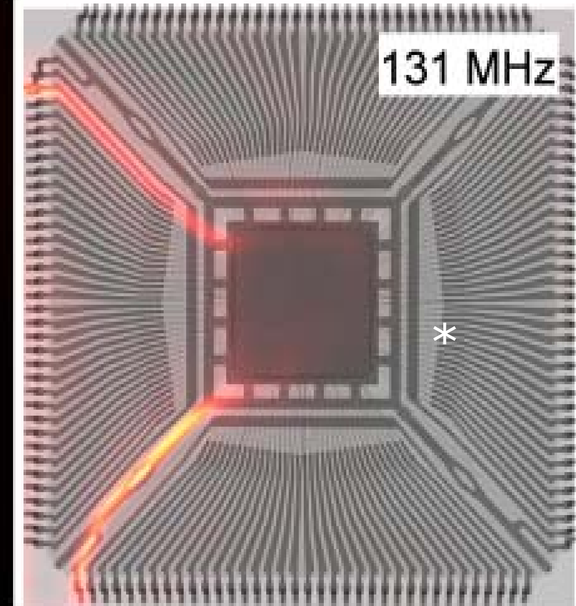
Wire open

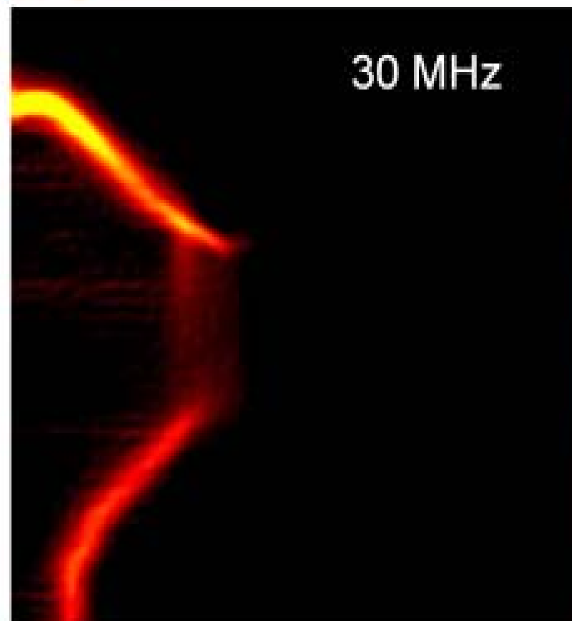
Test Device : HF frequency dependent signal strength

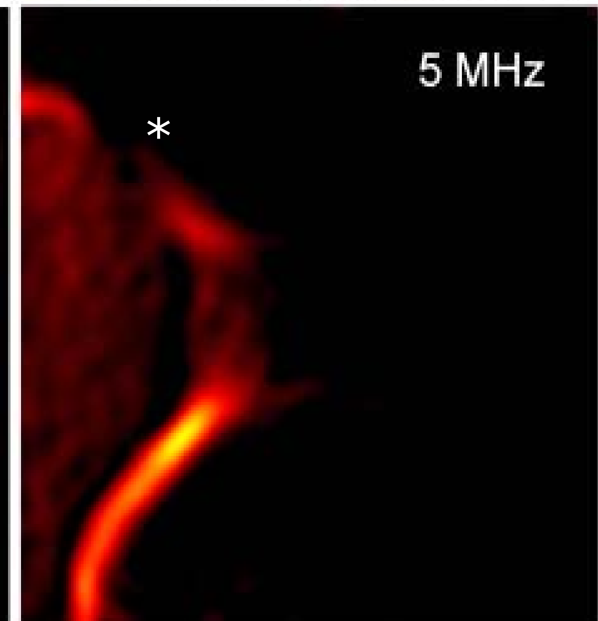
- Modulated HF input to a signal line and GND.
- Defect : The wire bond of the signal line was lifted → with conventional magnetic microscopy in the kHz range, no signal could be detected.

Result:
- For frequency above ~30MHz the connected signal lines become clearly visible
- below ~10MHz only metal lines connected to high capacitance may be detected









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Case Study : Open I/O Pin

- Failure: No signals at a device
- Sample set-up:

- Magma Setup: Open sample pin connected to the HF signal (~100MHz), which is modulated with the 5kHz signal of the Magma generator. A reference pin of the sample is connected to the outer coaxial signal line of the HF generator.

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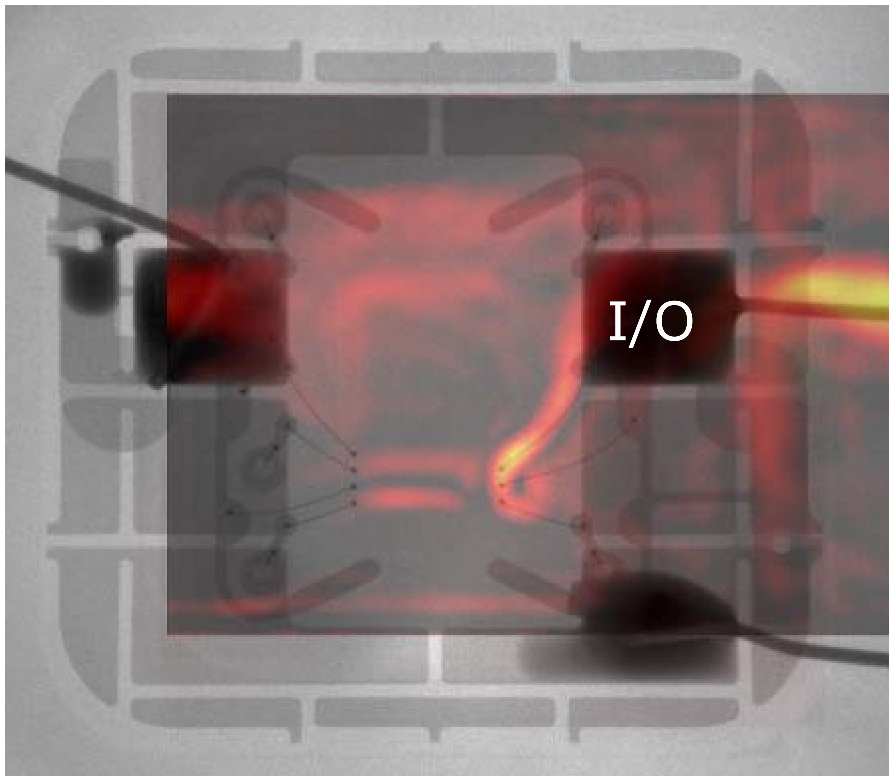
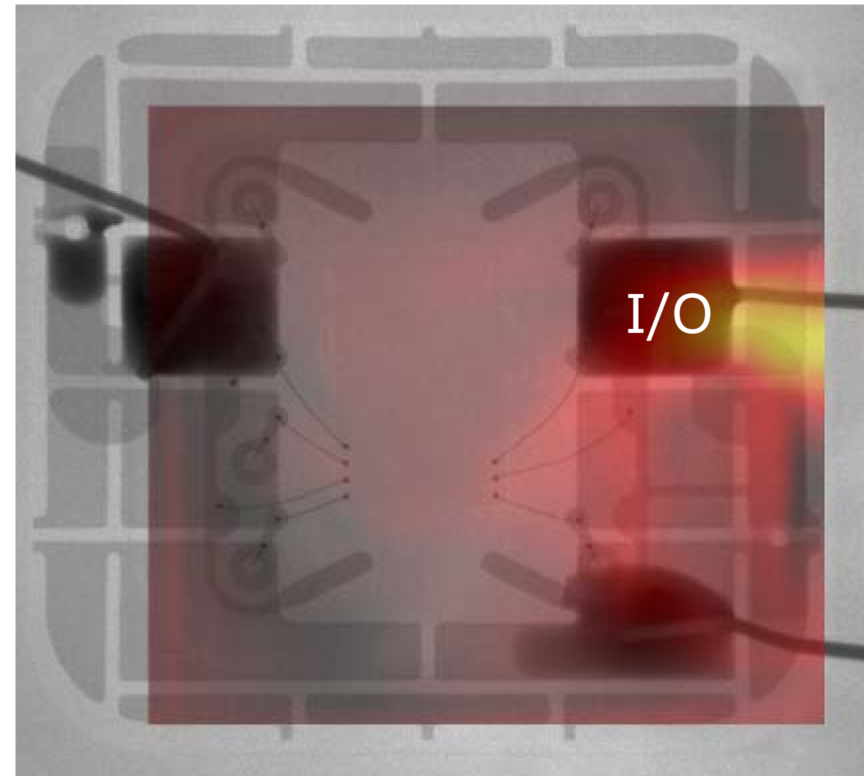
Case Study : Open I/O Pin

I/O pin powered with modulated HF signal



Pass device



Fail device

➔ *no clear localization …*

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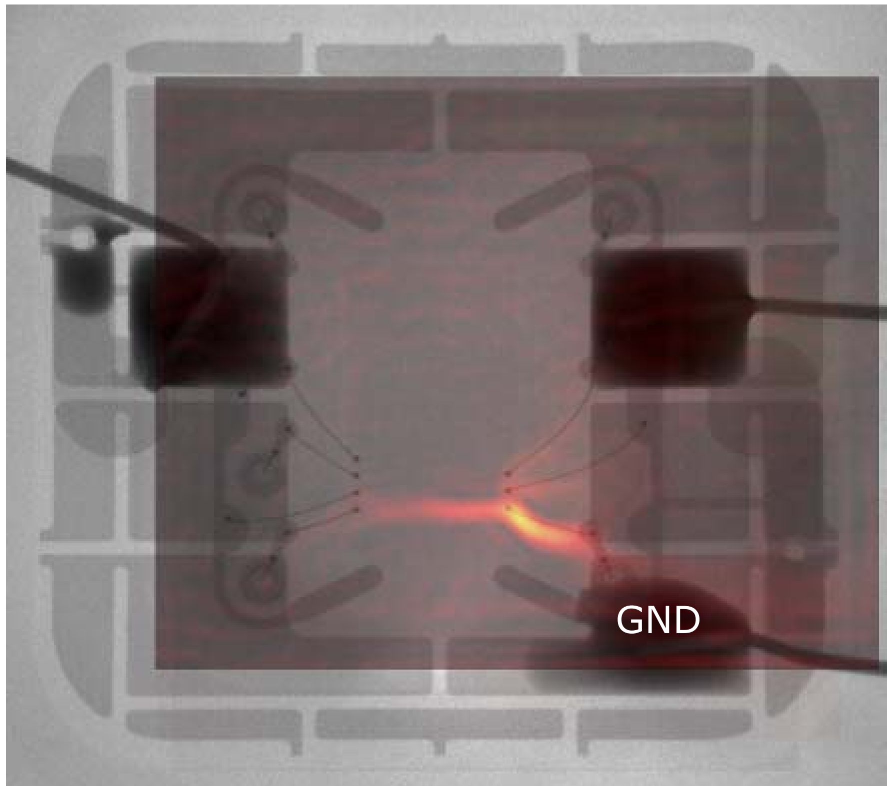
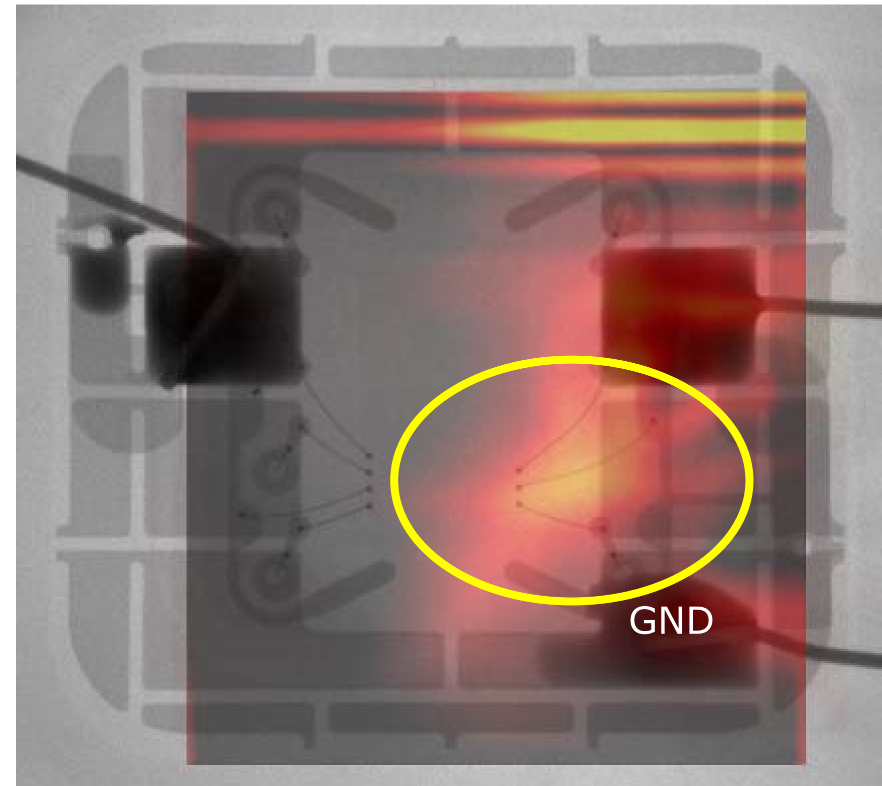
Case Study : Open GND Pin

GND pin powered with modulated HF signal



Pass device



Fail device

➔ *no clear localization but a strong hint for the location of the fail*

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Broken wirebonds

Physical failure

I/O

GND

KB

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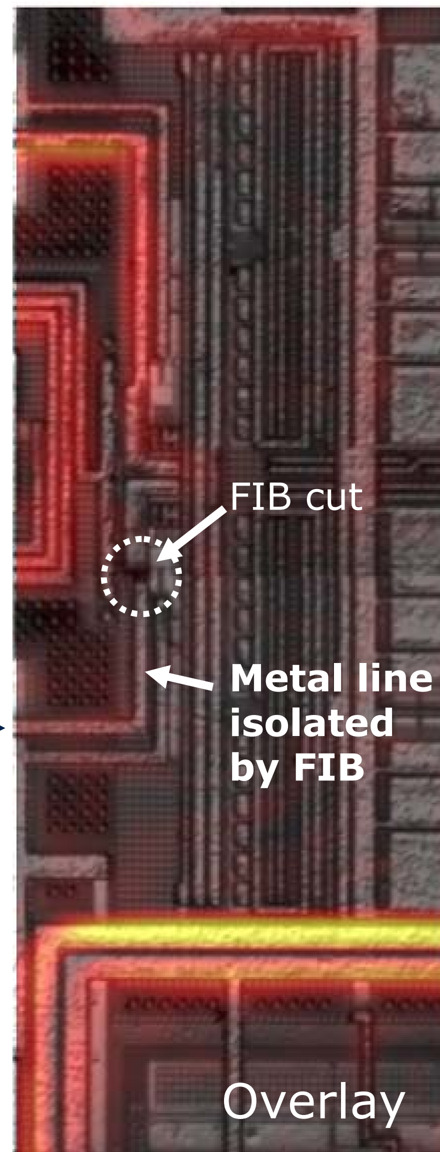
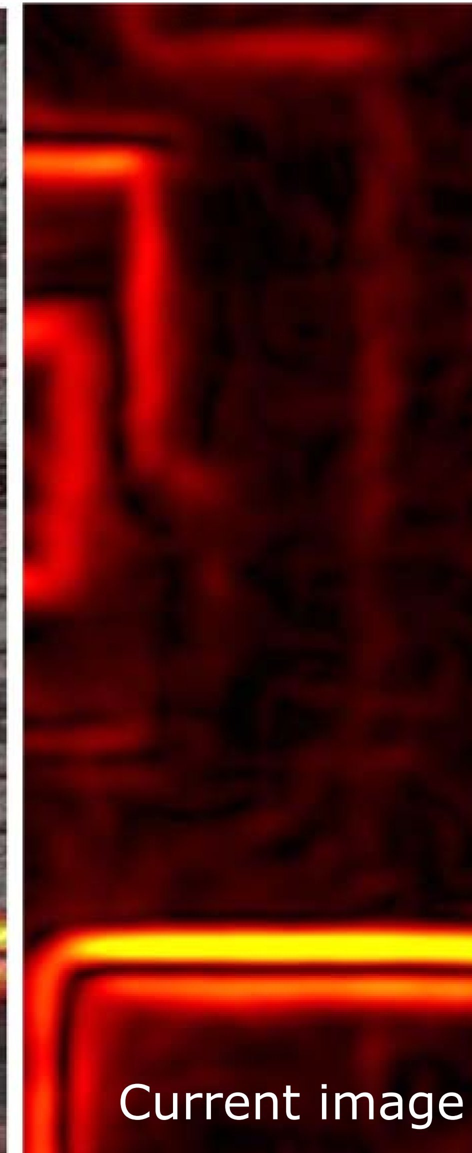
HF magnetic microscopy with GMR sensor

Result:
GMR sensor detects signals from metal lines, which are not powered
--> Input HF signal couples between neighboring wires in the package

Powered with modulated HF





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Outlook

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- Electrically open current paths may be visualized by magnetic microscopy, both with SQUID and GMR sensor.
- for a certain test structure, the magnetic field distribution gave a clear hint to the location of a wire interruption.
- for complex layout structures in microelectronic devices, the determination of the exact failure location was not successful up to now, probably due to inductive effects between neighboring metal lines, GND plates, etc. (Hints for strong frequency dependent effects in the MagmaC30 electronics were also found.)

➔ More fundamental studies with specially designed test structures needed.

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