Fraunhofer

IISB

FRAUNHOFER INSTITUTE FOR INTEGRATED SYSTEMS AND DEVICE TECHNOLOGY

AI-AUGMENTED SIMULATION

RESEARCH GROUP AT FRAUNHOFER IISB

Within the research group *AI-augmented Simulation* numerical methods and simulation tools for solving engineering problems are enhanced by artificial intelligence (AI) approaches and machine learning techniques.

Simulation

- Coupled electrical, thermal and mechanical simulations in the domain of micro- and power electronic devices and energy systems based on various open source and commercial simulation software packages
- Implementation of customized software packages to increase efficiency, performance and functionality of standard software products
- Simulation and optimization of electrical components based on CAD data from 3D CT scans

Artificial Intelligence

- Clustering unknown data sets using unsupervised learning algorithms
- Recurrent neural networks for analyzing and predicting time series
- Convolutional neural networks for signal and image processing

Optimization

- Optimization of electrical networks and systems with genetic algorithms
- Topology optimization of inductive components using gradient-based methods such as SIMP
- Sensitivity analysis and visualization of big data

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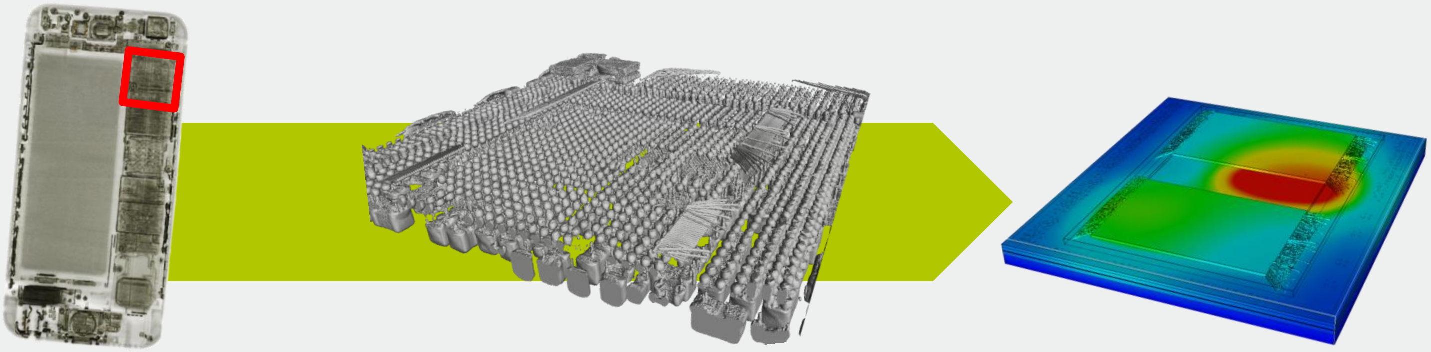


1a *3D CT Scan of a smartphone with chip package highlighted in red*

1b *Extracted CAD geometry of the smartphone with ball grid array of the chip package*

1c *3D FEM simulation of the temperature distribution of the chip*

Simulation workflows and optimization with *Pyflow*

The in-house developed Python package *PyFlow* enables an efficient implementation of complex workflows, large parameter studies and holistic optimization approaches in the domain of power electronic simulations and beyond.

The key features include:

- Parallel execution of parameter variations and workflows
- Efficient sampling and scheduling strategies
- Consideration of hardware and license load
- Direct linkage to the most advanced genetic optimization technics

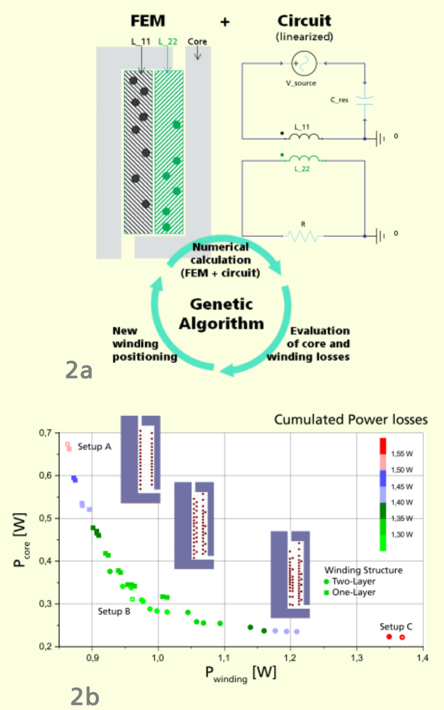
Based on *PyFlow*, the execution of millions of circuit simulations or complex nested couplings of multiphysics simulations can be performed on multiple cores and cluster nodes in parallel.

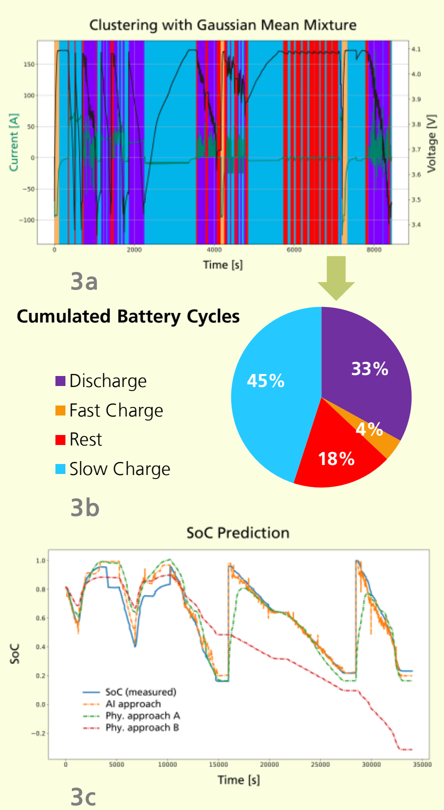
Artificial Intelligence in the domain of power electronics and physics

Increasing real word engineering problems can hardly be solved by physical based approaches or numerical simulations, due to high calculation efforts or inaccurate material properties and physical boundary conditions. By using data driven techniques and artificial intelligence on measured or simulated data precise predictions of complex physical processes can be provided:

- State of charge (SoC) prediction of lithium-ion battery cells and modules using long short-term memory (LSTM) and WaveNet approaches
- Electric circuit metamodeling via fully connected neural networks
- Defect detection on measured and simulated images of power electronic devices, lithography masks and wafer.

The research group **AI-augmented Simulation** combines a wide range of physical based simulation approaches und software tools with both mathematically advanced and efficient algorithms and AI frameworks to model and optimize power electronic devices and systems.





2 *Coupling of electric circuit simulations and finite element simulations of an inductive power transfer system (a), iteratively optimized considering the best trade-off (Pareto front) between the generation of power losses in the ferrite cores or windings (b).*

3 *Automotive driving profile of a lithium-ion battery clustered in 4 different classes: discharge, slow charge, fast charge and rest (a). Based on that, the cumulated distribution of different lithium-ion battery working conditions can be evaluated (b). SoC prediction using physical based and AI based models (c).*