Development of Physics-informed Deep Learning methods for Remaining Useful Life prediction of Metal-Oxide Semiconductor Field-Effect Transistors (MOSFETs)

Context of the research

Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs) are fundamental components in power module converters across numerous industrial applications, including electric vehicles and wind turbines. The European Project Safer and More Reliable WBG/UWBG-Based MVDC Power Converters (SAFEPOWER, https://www.safepowerproject.eu/) focuses on enhancing their efficiency, thermal performance, and reliability. Within this project, the present thesis work addresses the challenge of predicting the Remaining Useful Life (RUL) of MOSFETs. Accurate RUL prediction enables proactive maintenance, thereby minimizing unplanned downtime, optimizing utilization, and increasing system reliability, safety, and cost-effectiveness. Leveraging recent advancements in Artificial Intelligence, Deep Learning (DL) models have emerged as powerful tools for predicting the RUL of industrial components. However, DL models act as "black boxes", lacking an inherent structure based on physics-based correlations. This can hinder interpretability and generalizability, impacting their practical application and trustworthiness. Physics-Informed Deep Learning (PIDL) offers a solution by integrating fundamental physical principles and domain expertise into DL architectures.

Objective of the research

This research aims to develop a method for RUL prediction of MOSFETs based on PIDL. The thesis project consists of the following steps:

- Literature reviews on RUL prediction methods of MOSFETs and PIDL methods for RUL prediction;
- Development of the method;
- Implementation of the method in Python;
- Application and validation of the methodology on case studies based on benchmark and experimental data. Potential case studies will include the NASA benchmark dataset containing electrical signal values collected performing accelerated aging tests of MOSFETs (https://www.nasa.gov/intelligent-systems-division/discovery-and-systems-health/pcoe/pcoe-data-set-repository/) and other experimental datasets collected by project partners by performing run-to-failure aging tests of MOSFETS.

The thesis work will be performed within the SAFEPOWER project funded by the European Union under the Horizon Programme. During the thesis work, periodic meetings with the project partners will be organized to discuss the work progress.

Collaborations

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Power Electronics España, S.L., Spain.

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