DIPARTIMENTO DI INGEGNERIA
CORSO DI DOTTORATO IN INGEGNERIA INDUSTRIALE E DELL'INFORMAZIONE -
PHD COURSE IN INDUSTRIAL AND INFORMATION ENGINEERING - 37TH CYCLE

Title of the research activity:	Experimental analysis and numerical simulation of batteries for automotive application.
State of the Art:	Despite the exponential growth of electric vehicles registered in recent years, the main barriers to their penetration remain still specific energy, specific power, safety, cost (related to cycle life and calendar life), low temperature performance (e.g., cold startup in winter) and charge time, beyond the lack of knowledge in the Battery Management System (BMS). For an efficient vehicle operation, the development of an efficient Battery Management System (BMS) is crucial. In particular, the BMS strategies design requires a detailed knowledge of the battery pack characteristics, either based on simulation (typically according a lumped-parameters approach) or experimental analysis [1-2]. In particular, the battery performance is significantly affected by the temperature, hence the battery thermal analysis is crucial both for the BMS and the battery pack design. it is important to understand how heat is generated inside a cell and how to dissipate heat properly [3-8]. However, the factors influencing the thermal behaviour of cell result quite complex. Multiple mechanisms including electricity, electrochemistry, heat transfer are coupled, and the involved parameters change with time, temperature, State of Charge (SoC), State of Health (SoH), etc…
Short description and objectives of the research activity:	The present research activity aims at developing a comprehensive analysis methodology for the characterization of cells and battery packs for automotive applications, based either on lumped parameters simulation (by Gamma Technology AutoLi-Ion) and experimental analysis (by a ITech 18 kW-500 V battery emulator/tester). The experimental activity will be finalized to the battery model build-up for BMS strategy design and to support the battery pack design by CFD-3D simulation (Ansys Fluent). The simulation CFD tools, supported and validated with experimental tests, constitute one of the most flexible and efficient instruments for the thermal analysis of the single battery, the batteries package and its cooling system. The objective of the thermal management pillar of the proposal consists on understanding the driving parameters of the heat transfer on batteries and the connection with BMS.

Bibliography:	[1] Cittanti D. Ferraris A. Airale A. et al. "Modeling Li-Ion batteries for Automotive Applications: a Trade-Off between Accuracy and Complexity" *2017 International Conference of Electrical and Electronic Technologies for Automotive*, 2017, pp. 1-8, doi: 10.23919/EETA.2017.7993213. [2] Mulder G., Omar N., Pauwels S. et al." Enhanced test methods to characterise automotive battery cells" Journal of Power Sources 196 (2011) 10079– 10087 [3] Q. Wang, B. Jiang, B. Li, et al., "A critical review of thermal management models and solutions of lithium-ion batteries for the development of pure electric vehicles" Renew. Sustain. Energy Rev. 64 (2016). [4] C. Wang, G. Zhang, S. Ge, T. Xu, Y. Ji, X. Yang, et al., "Lithium-ion battery structure that self-heats at low temperatures", Nature 529 (2016). [5] G. Xia, L, Cao, G. Bi, "A review on battery thermal management in electric vehicle" Application Journal of Power Sources 367 (2017). [6] Y. Yang, X. Huang, Z. Cao, et al., "Thermally conductive separator with hierarchical nano/microstructures for improving thermal management of batteries", Nano Energy 22 (2016). [7] D.H. Jeon, "Numerical modeling of lithium ion battery for predicting thermal behavior in a cylindrical cell", Curr. Appl. Phys. 14 (2014) 196e205.. [8] Wen Yang W., Zhou F., Zhou H. et al.. ""Thermal performance of cylindrical lithium-ion battery thermal management system integrated with mini-channel liquid cooling and air cooling" Applied Thermal Engineering 175 (2020) 115331
Scientific coordinator (s)	Prof. Ermanno Cardelli Prof. Lucio Postrioti
Contact (s)	Lucio.postrioti@unipg.it