



HAL
open science

Electrochemically induced breakdown of integrated microsupercapacitors based on LiPON

Sneka Prabhakaran, Sami Oukassi, Charles Leroux, Frédéric Voiron

► **To cite this version:**

Sneka Prabhakaran, Sami Oukassi, Charles Leroux, Frédéric Voiron. Electrochemically induced breakdown of integrated microsupercapacitors based on LiPON. 244th ECS Meeting, Oct 2023, Gothenberg, Sweden. cea-04665739

HAL Id: cea-04665739

<https://cea.hal.science/cea-04665739v1>

Submitted on 31 Jul 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Electrochemically induced breakdown of integrated microsupercapacitors based on LiPON

Sneka Prabhakaran^a, Sami Oukassi^b, Charles Leroux^b, Frédéric Voiron^a

^a *Murata Integrated Passive Solutions, Caen, France*

^b *CEA Leti, Grenoble, France*

Lithium Phosphorous Oxynitride (LiPON) solid electrolyte has gathered a lot of attention due to its favorable ionic conductivity (10^{-6} Scm^{-1}), good electronic insulation ($10^{-14} \text{ Scm}^{-1}$) and electrochemical stability[1]. Solid state microsupercapacitors based on LiPON have been demonstrated to meet demanding performances required for novel on-chip technologies[2,3]. The electric double layer (EDL) formation at the electrode interface results in the high capacitance and energy density of these devices. The EDL and to an extent the bulk of the electrolyte layer will be affected by the electric potential/field present during the operation. In this work, the electrochemical breakdown of microsupercapacitors were studied under different bias conditions. The influence of device geometry and test conditions on failure of LiPON based devices will provide the scope for potential applications as well.

PVD depositions of thin LiPON films in MIM structure (20nm,50nm,100nm) were fabricated for the study with Pt bottom electrode and Ti/TiN top electrodes. The devices were electrically characterised by Impedance spectroscopy and subjected to a voltage sweep from 0 to $\pm 19\text{V}$ at various scan rates. LiPON was found to undergo electrochemical degradation followed by electrical breakdown as previously reported elsewhere[1]. Increasing the scan rate and thickness of LiPON, increased the breakdown voltage of LiPON. The electrode material influenced the degradation and the interface was found to evolve with successive voltage levels. The interface was found to drive the degradation using equivalent circuit analysis of Impedance spectroscopy results. Charge densities extracted for breakdown indicate possible electronic conduction and Li depletion, which were further verified with physico-chemical characterisation. A model of capacitive and resistive elements will be discussed to capture the individual contributions for electrochemically driven failure and thereby identify the parameters to tune or delay such mechanisms.

This work identifies various factors which could modify electrochemical breakdown behaviour of LiPON. The modification of electrochemical breakdown voltage/strength and variation in charge density with scan rate has been newly identified. Further, resolving various contributions to different circuit elements will provide a way to understand and decorrelate their role in electrochemical breakdown.

References:

- [1] B. Put, P. M. Vereecken, et A. Stesmans, « On the chemistry and electrochemistry of LiPON breakdown », *J. Mater. Chem. A*, vol. 6, n° 11, p. 4848-4859, 2018, doi: 10.1039/C7TA07928A.
- [2] V. Sallaz, S. Oukassi, F. Voiron, R. Salot, et D. Berardan, « Assessing the potential of LiPON-based electrical double layer microsupercapacitors for on-chip power storage », *J. Power Sources*, vol. 451, p. 227786, mars 2020, doi: 10.1016/j.jpowsour.2020.227786.
- [3] V. Sallaz *et al.*, « Hybrid All-Solid-State Thin-Film Micro-supercapacitor Based on a Pseudocapacitive Amorphous TiO₂ Electrode », *ACS Appl. Energy Mater.*, 2022.

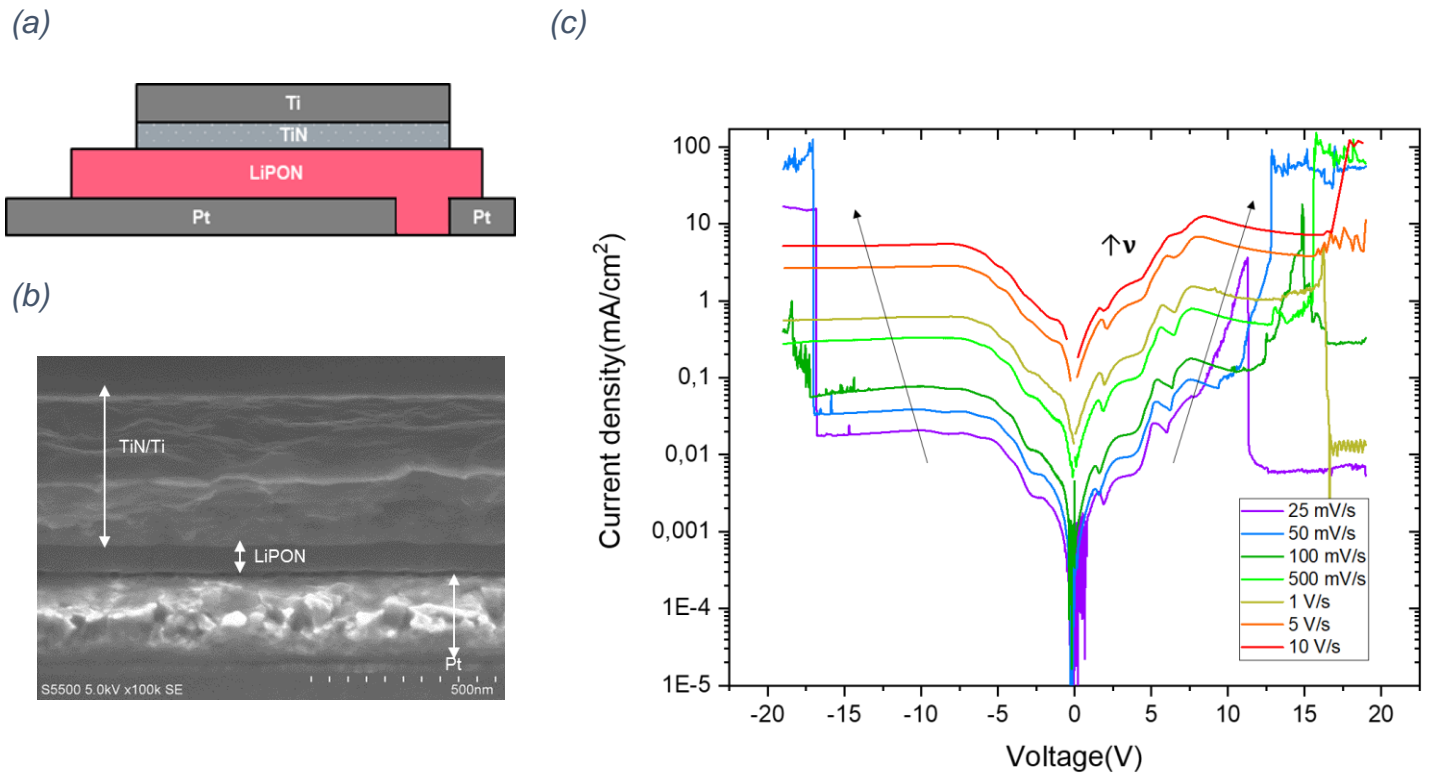


Figure 1 (a) Cross-sectional layout for Pt/LiPON/TiN/Ti microsupercapacitor used for the study, (b) SEM image of LiPON MIM structure, (c) Current density versus voltage for Pt/LiPON/TiN stack of 100nm thick LiPON for scan rates from 25mV/s to 10V/s taken at ambient temperature ; the arrows indicate the trend of increase in current density and breakdown voltage with scan rate