# Multilayer coating based on parylene-C and $TiO_2$ deposited by ALD for the packaging of medical devices

D. Grange, N. Chatelain, S. Farine-Brunner, L. Jeandupeux, T. Journot

*Haute Ecole Arc Ingénierie (HES-SO), La Chaux-de-Fonds, CH*

**INTRODUCTION:** Implantable electronic devices intended to stay over long periods of time in the human body must be protected from the physiological environment by means of an encapsulation to avoid their failure during the use and achieve the highest longevity.

This encapsulation must be mechanically stable (to avoid damage due to, e.g. liquid infiltration that causes corrosion of the device), biocompatible, and have a high corrosion resistance. Our new multilayer coating showed promising results as a conformal packaging layer.

**METHODS:** This study aims to develop a thin encapsulation coating combining poly(chloro-p-xylylene) (commercial name parylene-C) layers with a thickness of 500 nm deposited by LPCVD, and 15 nm $TiO_2$ layers deposited by Atomic Layer Deposition (ALD) using tetrakis(dimethylamido)titanium ($Ti[N(CH_3)_2]_4$) and water as precursors with a process time of 8 hours maximum and a process temperature as low as possible.

The barrier performance of the layers has been tested by three different means: helium leak test, immersion of coated magnesium samples in Ringer's solution and immersion of coated Nd-Fe-B magnets in Ringer's solution.

The layers have been tested individually and combined by changing the order of the two layers and the number of alternation.

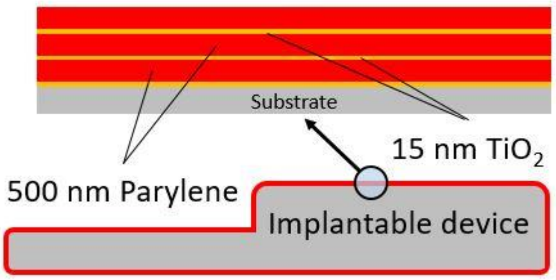


*Fig. 1: Architecture of the multilayer coating composed of $TiO_2$ deposited by ALD and parylene-C deposited by LPCVD.*

The optimized multilayer coating consists of 3 $TiO_2$ layers (15 nm-thick) alternating with 3 parylene-C layers (500 nm-thick) all deposited at a low temperature (50 °C) (Fig. 1). It exhibited a protection comparable to a 3 times thicker state of the art commercial barrier coating.

**RESULTS:** We noticed that parylene-C was damaged by an ALD process above 50 °C. Indeed, the permeability of a multilayer with $TiO_2$ deposited at 150 °C is higher than that of parylene alone or multilayer with $TiO_2$ deposited at 80 °C or 50 °C.

Moreover, barrier properties of $TiO_2$ deposited at 50 °C are as good as those of $TiO_2$ deposited at 80 °C or even at 150 °C (for the same layer thickness).

Finally, the optimized multilayer coating with a total thickness of 1.6 µm showed better or equivalent results in most of the tests than the commercial state of the art multilayer coating with a total thickness of 5 µm (Fig. 2).

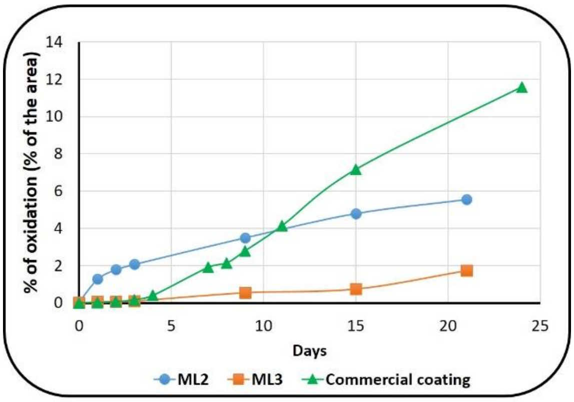


*Fig. 2: Evolution of the oxidized area of coated Mg samples immersed in Ringer's solution : a multilayer made of 2 alternations (ML2), 3 alternations (ML3) and the commercial barrier coating.*

**DISCUSSION & CONCLUSIONS:** The optimized multilayer coating showed excellent barrier properties with a thickness less than 2 µm. Nevertheless, progress has to be made in term of reproductively. Changing of reactor for every layer is detrimental. Therefore replacement of parylene-C by another material deposited by ALD is envisaged.

**ACKNOWLEDGEMENTS:** We would like to thank the HES-SO for its financial support in the frame of project "PolyPackAL".