**APPLICANT INFORMATION: Case Study overview**

PVD (Physical Vapor Deposition), and specifically HIPIMS (High Power Impulse Magnetron Sputtering), is an optimal technique to improve the corrosion resistance of a material by coating its surface with a thin layer of a different substance.

Jolt has developed a new coating technology for electrodes manufacturing. The focus is on alkaline water electrolysis (AWE) where Ni is the most common substrate used.

Ni is a scarce metal subjected to big market fluctuations and with an increasing demand for energy transition. Stainless steel is four times cheaper than Ni and abundant enough to assure a regular supply for future electrodes factories building electrolysers to generate green hydrogen.

1. Nano-deposited Ni particles deposited *via* vapor deposition methods bring two benefits to stainless steel substrates. On the one hand the coating can be finely tuned in both thickness and morphology allowing a flat alignment of particles which aggregate in dense and non-porous film layers compared to standard coatings. On the other hand, Ni avoid the corrosion of stainless steel in harsh alkaline conditions.

1. The possibility to further grow a catalytic layer on this multi-interface system (Stainless Steel/Nickel/Catalyst) will open new scenarios in electrode design that bring together enhanced performances with reduced costs of raw materials. However, such approach requires a rigorous validation process to demonstrate the stability of the triple boundary interface during a minimum lifetime of 10+ years. Recently, a new standard protocol test to check the durability for electrodes in AWE has been proposed (*EU harmonized protocols for testing of low temperature water electrolysers (2021)*).

**Company presentation**

Jolt focuses on the development, production and sale of electrodes, stacks and catalyst solutions coating for water electrolysers and hydrogen fuel cells. Our technology can be applied in the future in other electrochemical processes such as chlor-alkali, ammonia and batteries.

Jolt´s technology consists of a new one-step, ultrafast and ultra-safe method to manufacture self-supported industrial electrodes. The process based on an advanced solution combustion method produces metal oxides with significantly improved performance at a reduced cost. It is a competitive catalyst coating treatment (50+ catalysts) which can be applied to electrode supports of any material (stainless steel, nickel, etc).

**Three keywords which describe JOLT’s sector:**

Green hydrogen, Electrodes, Electrolysers.

**DESCRIPTION OF THE CASE STUDY: Excellence**

**S.o.A**:

The material used by the manufacturers of electrodes for alkaline water electrolysis in the substrates of the current collectors is nickel, which is almost the sole metal which can resist to the harsh operative conditions (extremely high concentrations of KOH from 30% to 50%, T > 70°C and pressure between 35-60 bar).

Nickel is used in different formats like flat plates, expanded meshes or foams. There is not a standard among the different electrolysers manufacturers.

The cost in nickel is almost the 70 % of total COGS in electrode production, with enormous fluctuation in the market and subjected to geopolitical risks. This should trigger the exploration of more available alternatives in the perspective of reducing the current costs and ensuring the independency of the supply chain from political concerns. In this regard, stainless steel is more than four times cheaper than nickel and its use in water electrolysis has been largely demonstrated in academic level at least. Nevertheless, long-term stability still rises some major concern in industrial environment.

Jolt’s technology assures robust and durable catalyst layers irrespectively on the metal support may it be nickel but also any other conductive materials such as stainless steel.

**Technology:**

The deposition a nano or sub-micro layers of nickel by HIPIMS on stainless-steel (either flat plates or expanded meshes) is supposed to infer higher chemical stability towards chemical attacks, dramatically reduce the amount of the expensive materials, without sacrificing the electrical conductivity.

In a second and more challenging stage, nickel coatings could be applied over stainless steel foams or fiber felts where 3D structure hinders the full coating of the inner pores.

**Problem to be solved:**

The new range of micro/nano-formulated topcoats of nickel over a stainless-steel substrate will enable the use of cheaper electrodes in electrolysers and contribute to the main goal of having green hydrogen at 1,5 $/Kg before 2050. In fact, the combination of both techniques: PVD and Jolt’s one can accelerate the process and achieve the goal before 2030.

**The following Sustainable Development Goals will be addressed:**

* 7. Affordable and clean energy.
* 9. Industry innovation and infrastructure.
* 13. Climate Action: reduce greenhouse gas emissions (mitigation efforts).

**DESCRIPTION OF THE CASE STUDY: Implementation**

**Work Plan:**

1. Jolt will provide the stainless-steel substrates to University of Uppsala, previously selected with a company supplier of stainless-steel material.
2. The substrates will be coated with nickel and shipped back to Jolt.
3. Jolt will coat the treated substrates with the standard ink for alkaline water electrolysis electrodes.
4. The final stage will be the testing under stressful corrosive conditions comparing current Ni substrates with stainless steel treated ones, all of them with the final coating of Jolt.

The following services are requested:

* HIPIMS Ni active dense and active layer formation on the surface of stainless-steel plates to substitute Ni plates (University of Uppsala).
* Development of active surfaces corresponding to a 1 M/M workload for the development of different thickness and structures to substitute the current Ni plates that currently represents 70% of the component price and which availability it is expected to be a limiting factor for the technology commercialization.
* Corrosion resistance evaluation (TECNALIA)
* Components coating (JOLT)
* Evaluation of material performance (JOLT)

**Own resources:**

Jolt will invest 1000 € as raw materials and delivers while will allocated 1 M/M distributed between a technician and the R&D Manager during the 6 months execution (4000 €). The overall in-kind costs are about 5000 €.

**Contingency Plan:**

R1: In case corrosion resistance is found insufficient (intermediate layer to be developed between stainless steel and catalyst active layer), then it could be necessary to increase the thickness of the PVD treatment.

R2: Low adhesion of the Ni onto Stainless Steel. In this case thermal treatments will be proposed to increase the stability of the Ni film at the interface with stainless steel.

**DESCRIPTION OF THE CASE STUDY: Impact**

Currently electrode cost in AWE is Ni driven, because it is the most common material used as a metallic substrate. Moreover, Ni availability will be subjected to market demand and competition with other energy sectors in the next future.

Ni accounts for 13 Tn of eq CO2 per Tn of Ni and therefore 5 times the carbon footprint of primary steel (the highest carbon footprint sources steel).

The use of Ni-coated stainless-steel instead solid nickel should reduce the price of Jolt’s electrodes to the half part at least. The market reference price in July 2022 is 21,430 $/mT for nickel and 4,700 $/mT for stainless steel.

The case study could be enlarged in the future considering conductive materials cheaper than stainless steel.

The combination of Jolt’s technology and the coating of nickel by PVD will bring robust and durable electrodes to assure a minimum life of 10 years in harsh alkaline conditions. The new electrodes will be in addition easily recycled leading to low carbon footprint Ni and steel in its second like.

IP will be owned by Jolt or jointly owned by UU and Jolt depending on the outcomes achieved. The electrodes supply chain is expected to be created withing the NewSkin Ecosystem by bringing together continuous PVD coaters and stainless-steel manufacturers or directly through stainless steel producers (e.g Consortium partner APERAM).