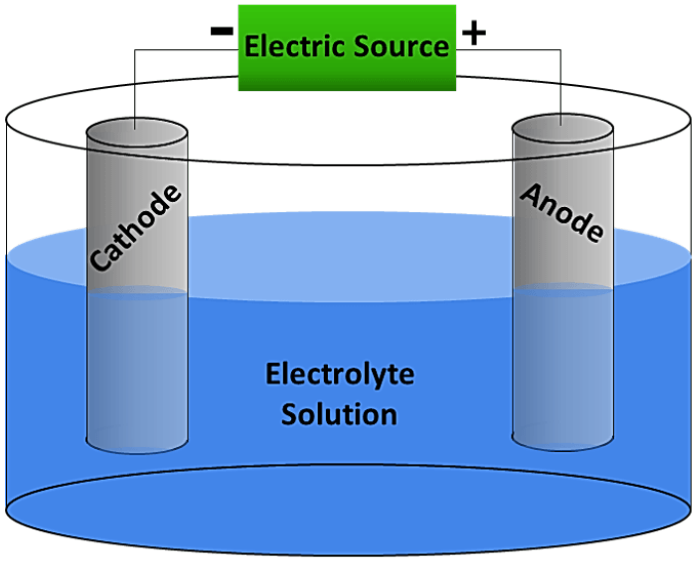
Electrochemical Cell

- **Electrochemical cell** is a device that either generates electrical energy from a chemical reaction or uses electrical energy to drive a chemical reaction.
- It is based on redox (reduction-oxidation) reactions occurring at two electrodes, which are connected through an external circuit and an electrolyte medium.

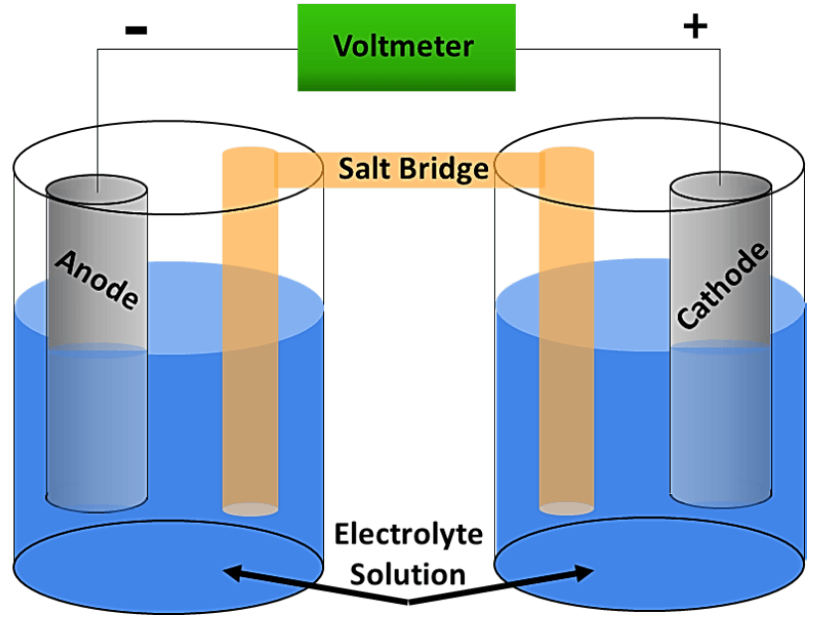
Types of Electrochemical Cell

Electrolytic Cell



Converts **electrical energy** to **chemical energy** (non-spontaneous).

Galvanic Cell



Converts **chemical energy to electrical energy** spontaneously.

Introduction to Electrochemistry

Electrochemistry is concerned with the effect of electrical voltages and currents on chemical reactions (**ionics**) and chemical changes which produce the voltages and currents (**electrodics**).

Ionics	Electrodics
Faraday's law	Nernst equation
Current flow causes reaction to occur	Reactions cause voltage to develop and current to flow
Electrolysis	Batteries
Electrodeposition	Fuel cells
Electrochemical machining	Corrosion protection
Battery charging	

Ionics is the study of ions (charged atoms or molecules) and their behavior.

Electrodics is the study of electrode processes, what happens at the interface of an electrode and an electrolyte.

Faraday's laws of electrolysis are:

Faraday's First Law: The mass of substance deposited (or dissolved) at an electrode is directly proportional to the amount of electricity (charge) passed through the solution.

Faraday's Second Law: If the same amount of electricity is passed through different electrolytes, the masses of substances deposited are proportional to their equivalent weights.

$$Equivalent\ weight = \frac{Atomic\ mass}{Z}$$

where Z = valency (number of electrons transferred).

Ionics: What is Faraday?

Charge on an Electron:

Charge of one electron = 1.602×10^{-19} C

One mole of electrons (Avogadro's number, 6.022×10^{23})

$= 1.602 \times 10^{-19} \times 6.022 \times 10^{23}$

$\approx 9.648 \times 10^{4}$ C/mol

This is called 1 Faraday ($\mathcal{F}$).

Rounded value: **$1\ \mathcal{F} \approx 96{,}500$ C.**

Relation of Charge with Current and Time:

$$Q = I \times t$$

where Q = charge in coulombs,
I = current in amperes,
t = time in seconds.

- **1 Coulomb = 1 ampere × 1 second.**
- **1 Faraday = 26.8 ampere-hours.**

Ionics: Question

Q. How much silver would be electrodeposited by a current of 6.0 amperes for 3h from a solution of $AgNO_3$? (The atomic mass of silver is 107.87 g/mol)

Ans. 72.43 g of silver would be deposited.

Exp. The charge on silver is +1 (Z=1), and this means that 1F would deposit 107.87g. We must now determine the number of coulombs (Q) that were passed through the solution.

$Q = It$ = 6.0 amp × 3h × 60 min/h × 60 s/min = 64,800 amp.s

96,500 C would deposit 107.87 g of Ag.

Hence, 64,800 C would deposit 64,800 × (107.87/96,500) g of Ag,

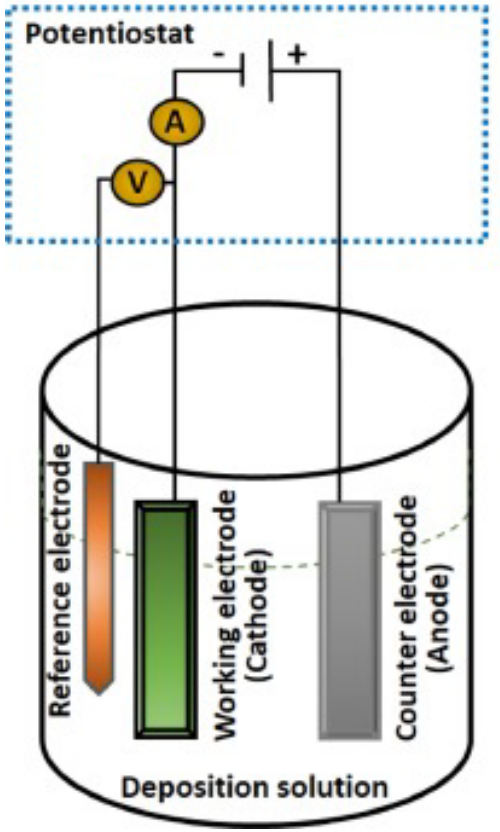
or **72.43 g of silver would be deposited.**

Electrolysis and Electrodeposition of Metals

When an increasing DC voltage is applied to a solution of metal ions, the metal, in some cases, will begin to deposit the deposition material at a **minimum voltage (D)**

Chromium plating on iron

https://www.zbbhot.store/?path=page/ggitem&ggpid=2334119



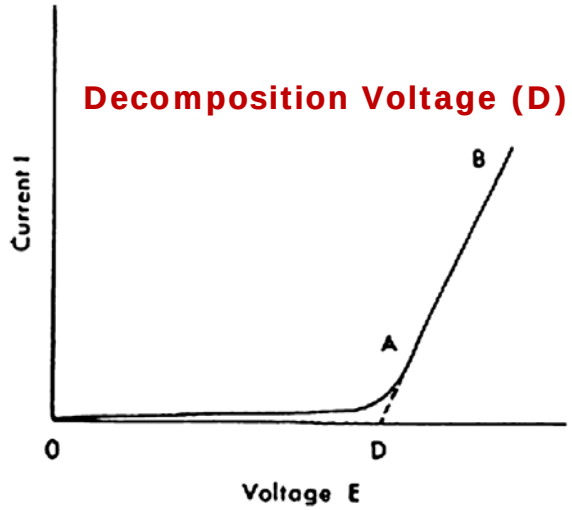
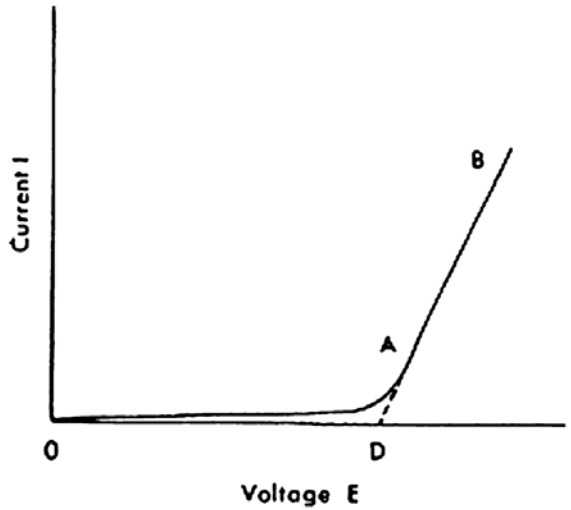


Fig. Typical current–voltage plot for an electrolyte solution. A start of deposition, A–B linear segment of plot, D extrapolated deposition potential

Electrolysis and Electrodeposition of Metals

Electrodeposition

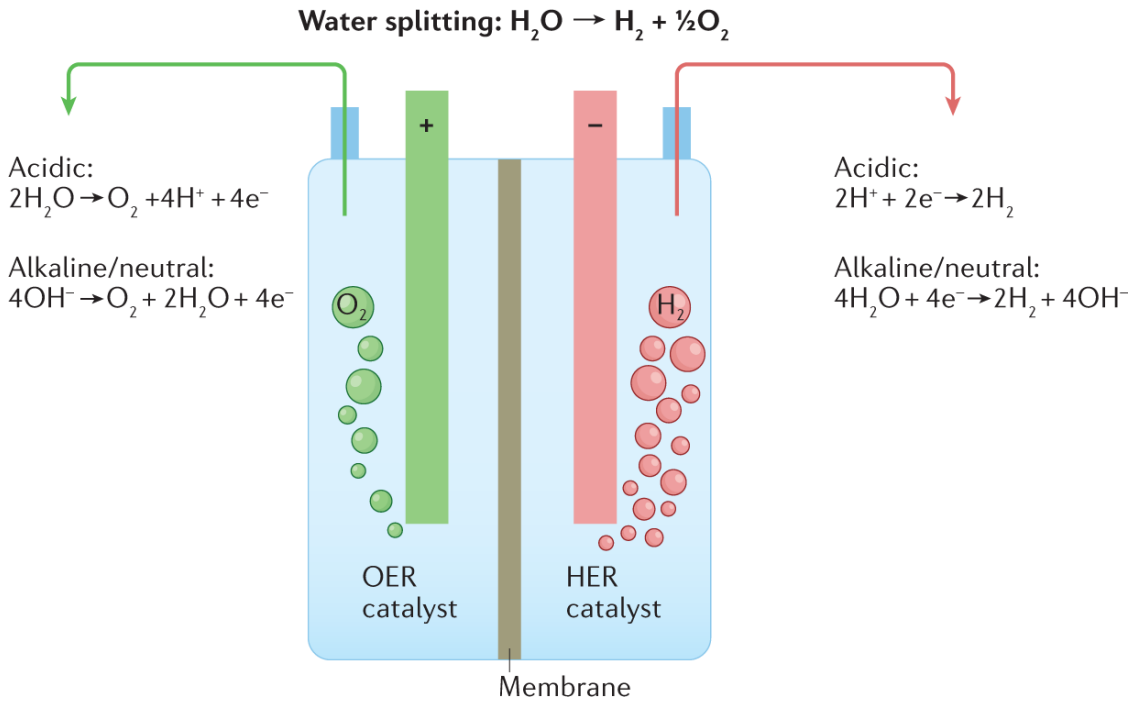
The electrodeposition or electroplating reaction: $M^{+n} + ne^- \rightarrow M$



If the voltage (D) is too high, then hydrogen will be evolved (**HER**): $2H^+ + 2e^- \rightarrow H_2$

Water-Splitting

The theoretical minimum voltage required for the electrolysis of water is 1.23 V at 25 °C.

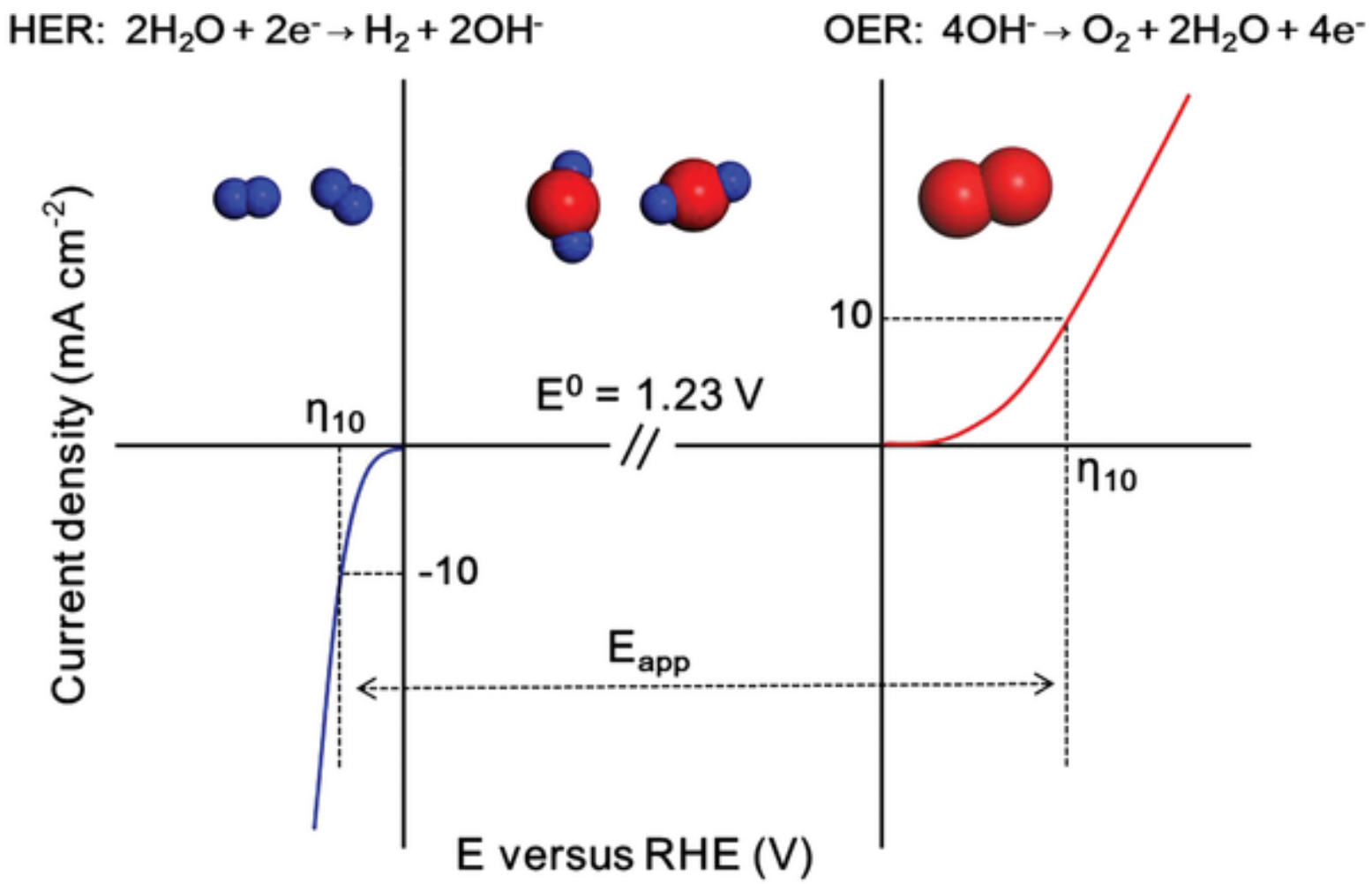


Nat Rev Methods Primers. **2022**, *84*, 2

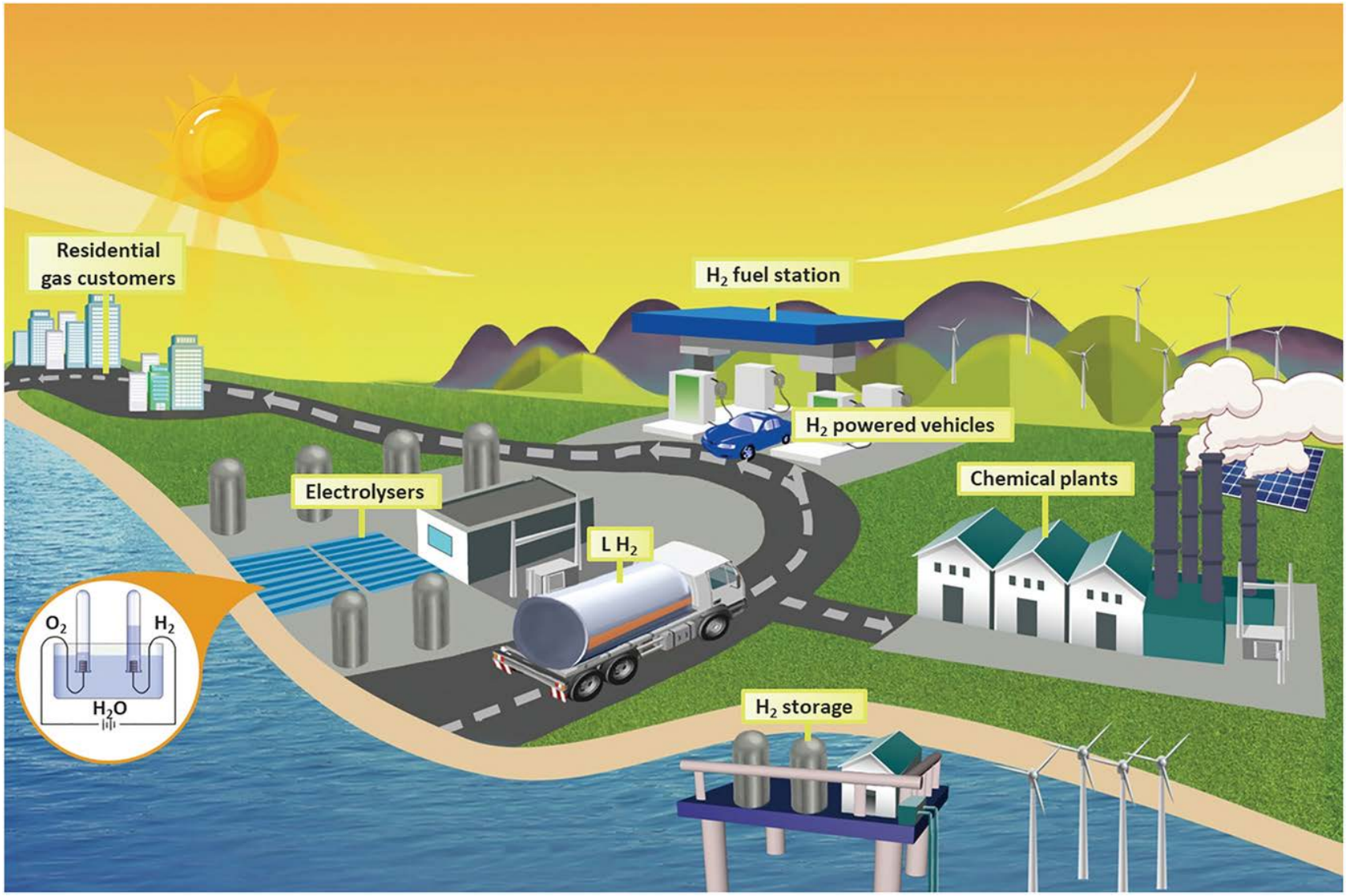
HER and OER

Hydrogen Evolution Reaction (HER)

Oxygen Evolution Reaction (OER)

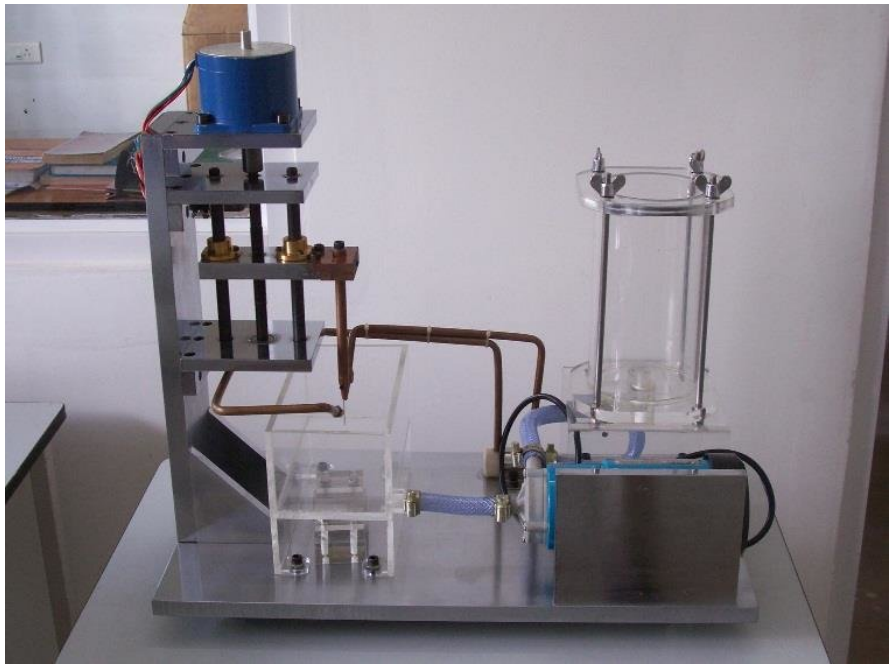


Blueprint of the future hydrogen economy society



Electrochemical Machining (ECM)

Electrolysis, with an anode that dissolves under controlled conditions, is the basis of electrochemical machining (ECM).



Micro electrochemical machining

Int. J. Pure App. Math., **2018,** *119*, 869-877

VS: Manufacturing IE-Purdue | How Electrochemical Machining Works | https://youtu.be/Ej-GWNPYFVM