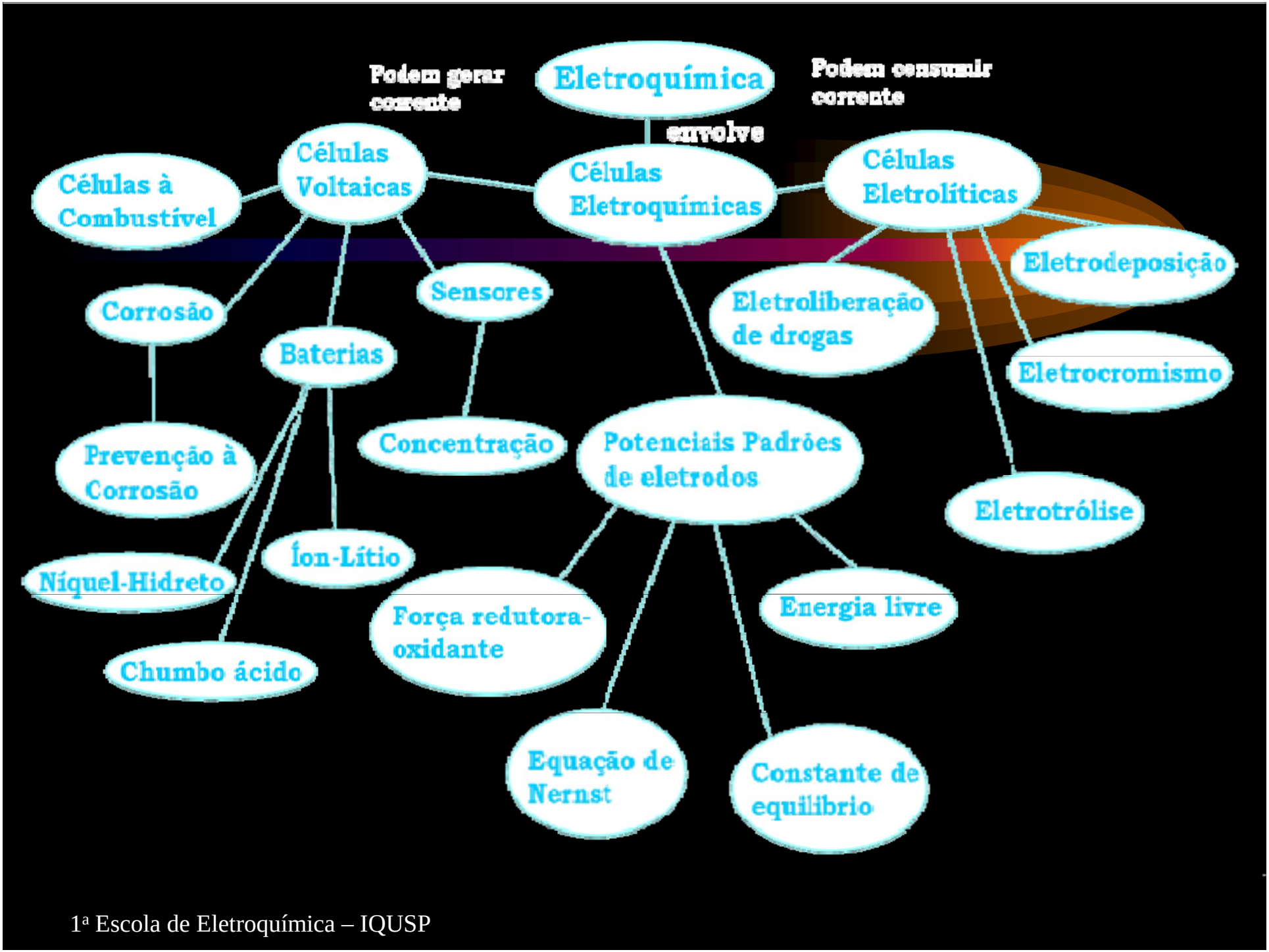
Instituto de Química
Universidade de São Paulo

QFL-2427 – Eletroquímica e Interfaces

O que é Eletroquímica?

- **A eletroquímica estuda reações que produzem transferência de elétrons de uma substância para outra.**

- **A transferência de carga origina uma corrente, e sua magnitude nos proporciona informação sobre as características das substâncias envolvidas.**


Eletroquímica
Podem gerar corrente
Podem consumir corrente
envolve
Células Voltaicas
Células Eletroquímicas
Células Eletrolíticas
Células à Combustível
Corrosão
Baterias
Sensores
Eletroliberação de drogas
Eletrodeposição
Eletrocromismo
Prevenção à Corrosão
Concentração
Potenciais Padrões de eletrodos
Eletrotrólise
Íon-Lítio
Níquel-Hidreto
Força redutora-oxidante
Energia livre
Chumbo ácido
Equação de Nernst
Constante de equilíbrio

A eletroquímica está ao serviço da medicina?
Como se relaciona?
O que estamos fazendo?
Saímos na mídia?

Aspectos a considerar:
No século XXI a física, a química, a matemática e a biologia são consideradas **partes** de uma **mesma** disciplina científica.

Não é reconhecido o impacto da eletroquímica em medicina ou em dispositivos médicos?

Eletroquímica ⟷ Ciência dos Materiais

Metais e ligas metálicas

Polímeros

→ Materiais Inteligentes

Nitinol: 50% Ni, 50% Ti

Shape-Memory Alloys are metals that, after being strained, at a certain temperature revert back to their original shape. A change in their crystal structure above their transformation temperature causes them to return to their original shape.

SMAs enable large forces (generated when encountering any resistance during their transformation) and large movements actuation, as they can recover large strains.

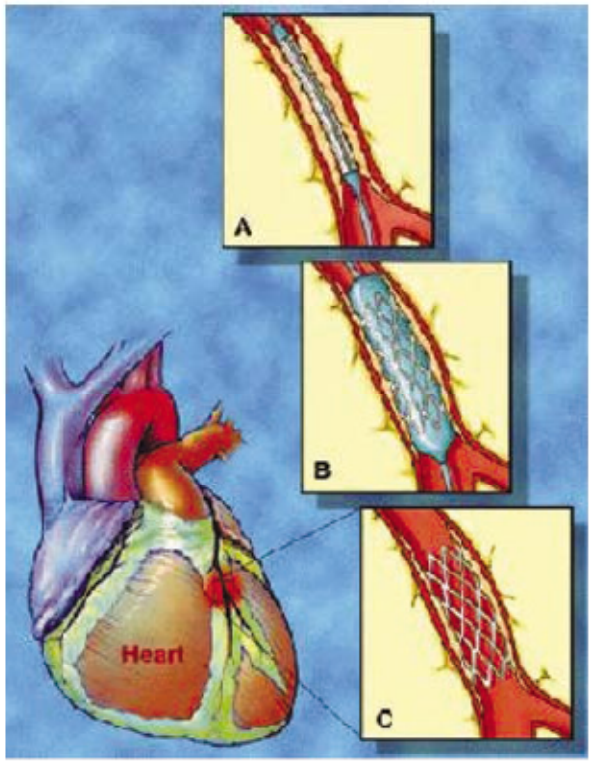


FIG. 2. Stents are used to open arteries of the heart blocked by atherosclerotic plaques: (a) a balloon and stent are placed across the plaque; (b) and then the balloon is expanded, leaving the stent to prop open the artery; (c) restenosis is the process wherein scar tissue builds up around the stent, again causing a flow restriction. A balloon is required for stainless steel whereas a nitinol stent will expand on its own due to the shape memory property of nitinol. Figure from Ref. 1; reproduced with permission.

Qual é a ciência que viabilizou a utilização comercial do Nitinol desde a sua descoberta?

Eletroquímica

Proteção a corrosão

Deposição de polímeros carregadores de fármacos

Tratamento eletroquímico para a criação de “buracos”

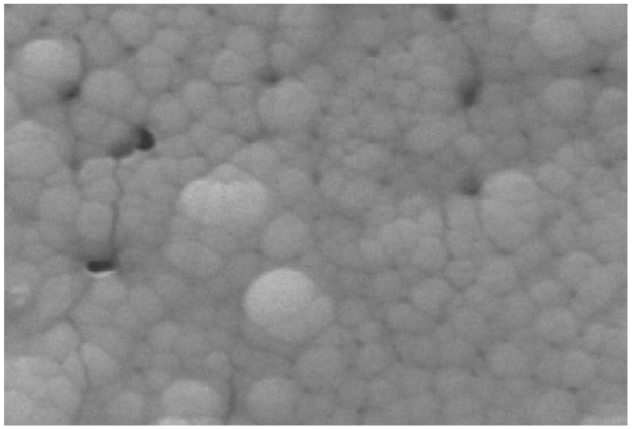


Fig. 7. The surface of a medical device coated with a nickel-phosphorous alloy deposited via electroless deposition. The white calibration bar represents 500 nm. Bioactive materials can be incorporated in between the grains. Courtesy of Nanomedical Technologies, Inc.

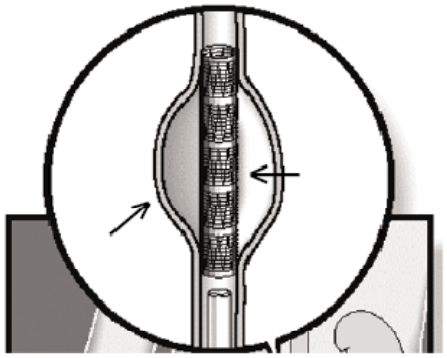


Fig. 6. An aortic stent graft is depicted in the figure. The polyester weave around the stent (short arrow) creates a barrier to blood flow from entering the aneurysm sac (long arrow). Failure of the metallic struts will lead to weakness in the stent and leakage back into the aneurysm.

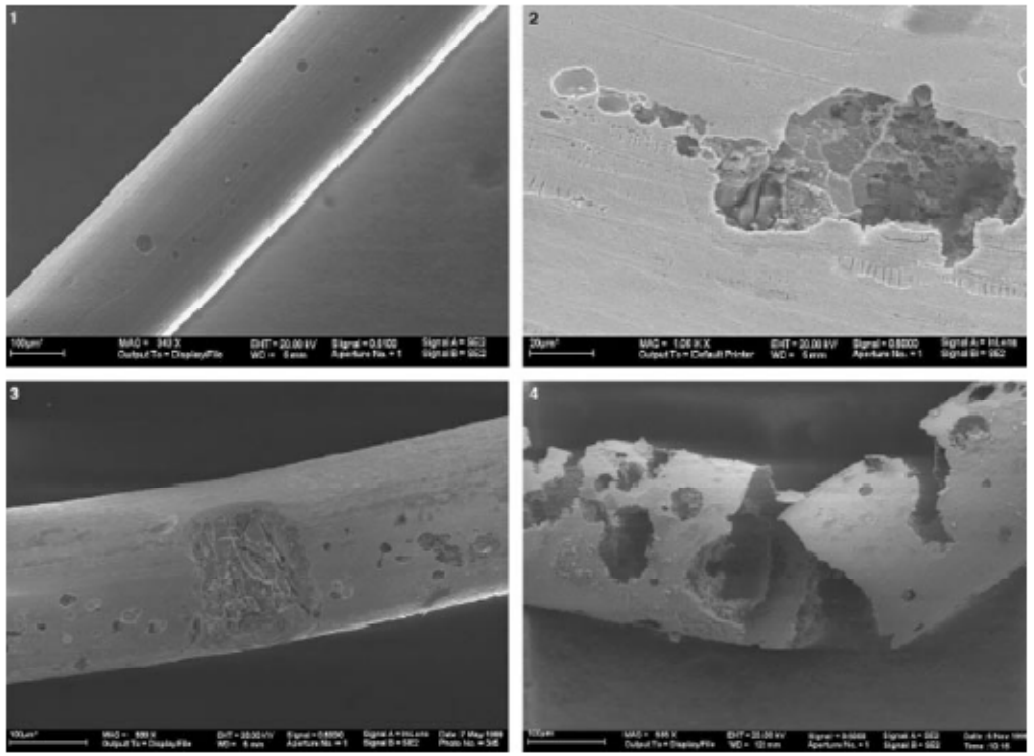


Fig. 5. Explanted nitinol struts from failed aortic stent grafts.[4] The arrow represents approximately a 100 μm scale. The large surface pits seen in the top right and bottom left are likely responsible for the failures seen in the bottom right. The surface pits are likely expansions of the defects seen in Figs. 3 and 4. Figure from Ref. 4; reproduced with permission.

E as pilhas?

1960 – Primeiro marca passo implantado.

1972: baterias de lítio.

Neuro estimulação.

Dispositivos de liberação controlada de fármacos

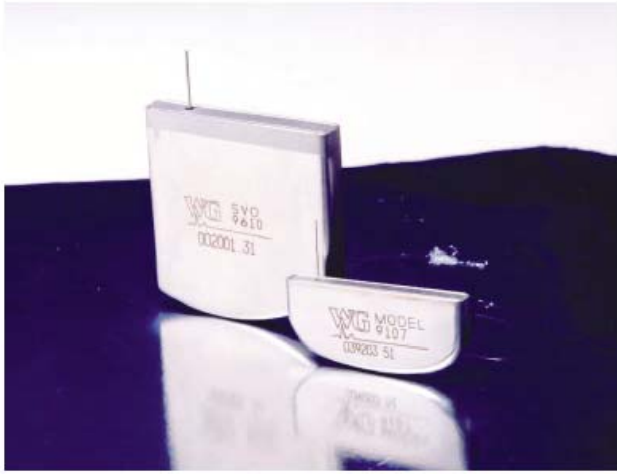


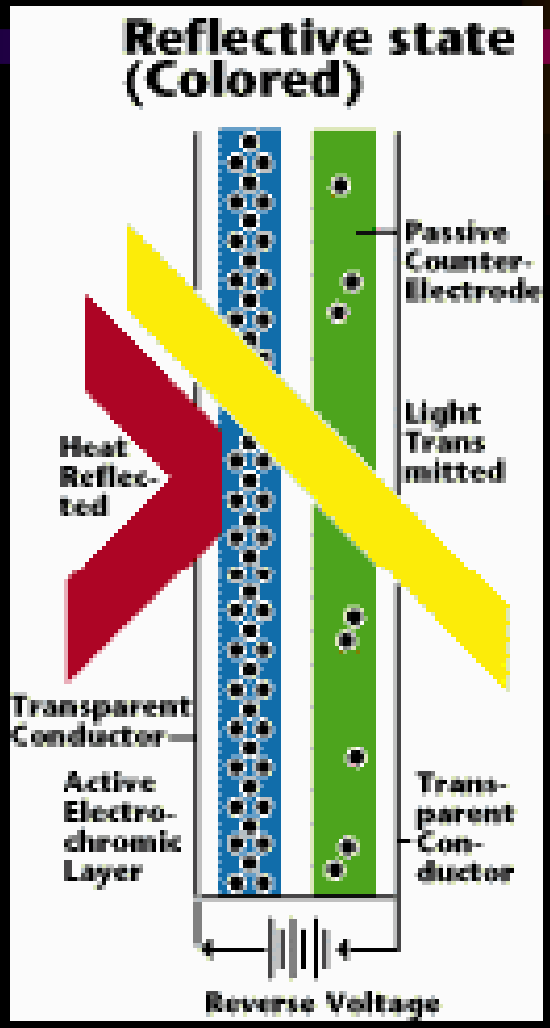
Fig. 2. A lithium/silver vanadium oxide battery (left) used in an implantable cardioverter/defibrillator, and a lithium/iodine pacemaker battery (right). For size perspective, the battery on the right is 0.5 inches tall. Image courtesy of Wilson Greatbatch.

Qual é o desafio?
Pilhas confiáveis, estáveis e de diferente desempenho segundo a demanda:

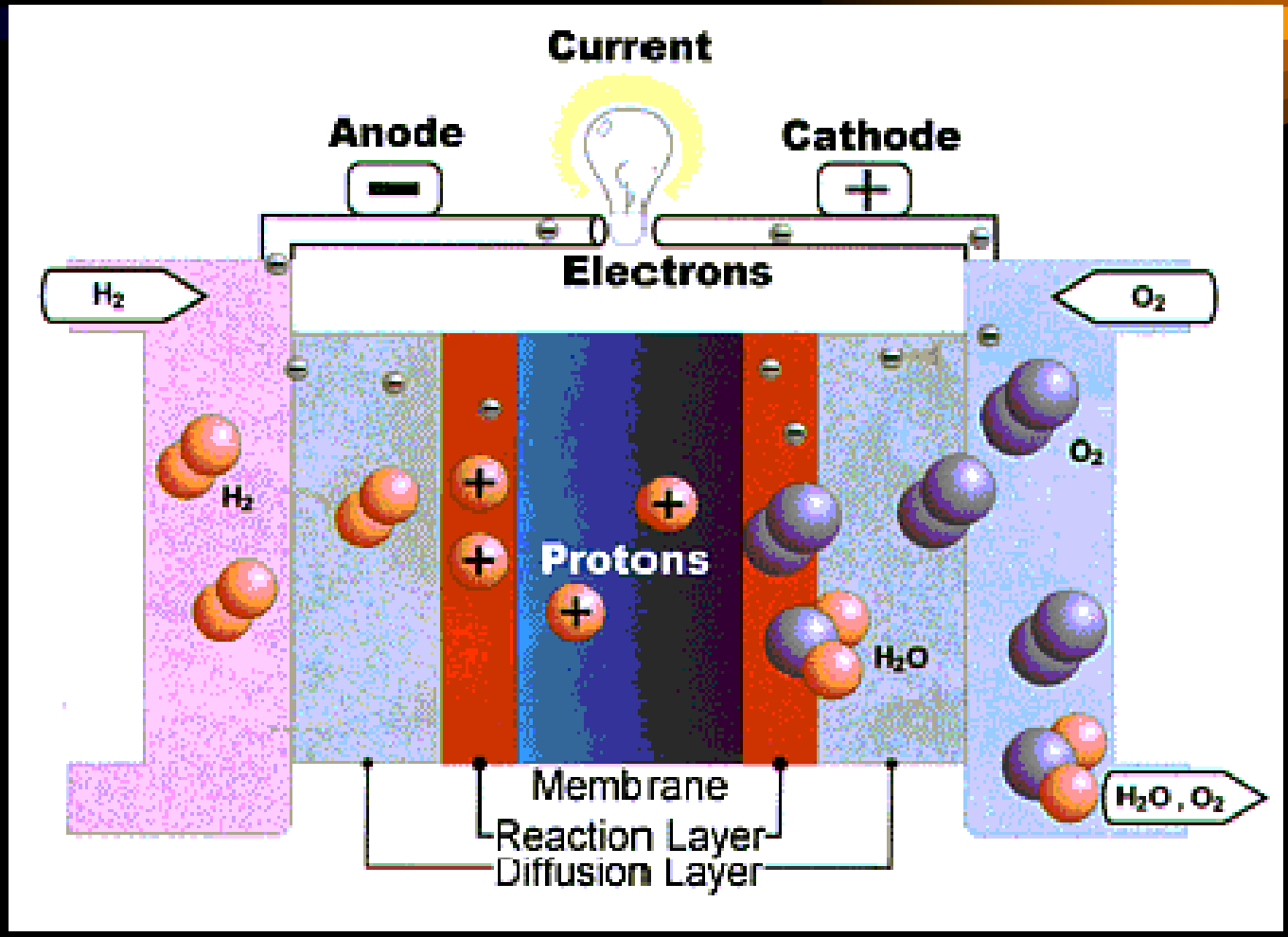
Tratamento	Necessidade ou demanda	Exemplos
Doenças cardiacas, Marcapassos	5-10 Microamperes	Zn/ZnO Lithium batteries
Taquicardia	Microamperes, mas deve liberar at e 40J quando a fibrilação é detetada	Li/V_2O_5, Li/ $Ag_2V_4O_{11}$ Li/ MnO_2
Neuro estimulação	Pulsos de mA	Li/Ioso-PVP, Li/cloreto de Tionila, Li/CF

Fig. 1. Battery-powered implantable devices have been in use for over 40 years, and the first successful cardiac pacemaker was implanted in 1960. Shown here is a "history of pacing" — from the first implantable (upper left) to the Kappa DR 401 (lower right). Image courtesy of Medtronic.

Eletrocromismo



Pilhas à combustível



Pilhas a combustível enzimáticas – Bio fuel cells

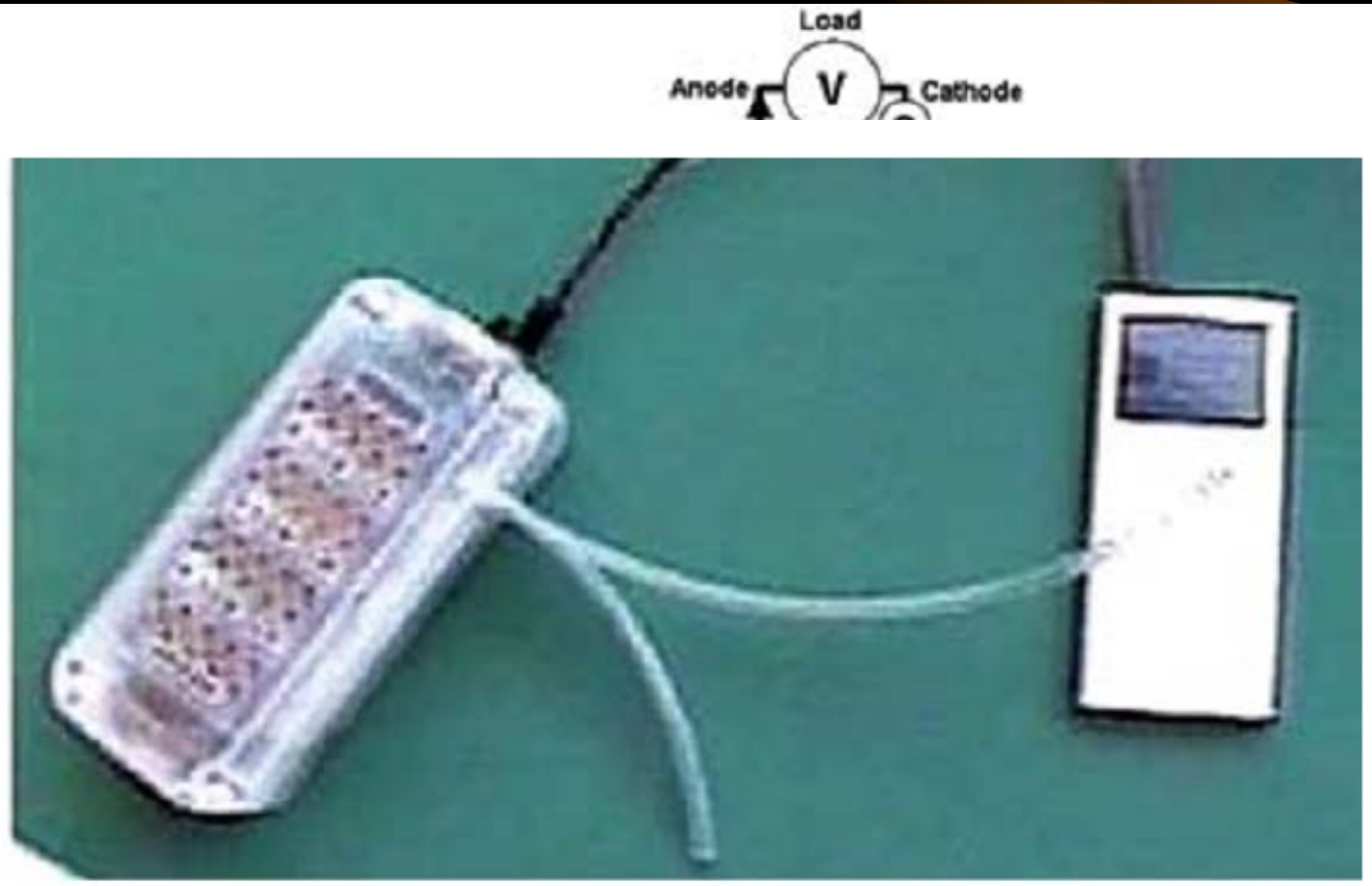


FIG. 4. *Ethanol/air biofuel cell stack. This prototype, developed by Akermin, Inc. in 2006, powers an iPod. Photograph courtesy of Akermin, Inc.*

CORROSÃO

FIG. 4. Photograph of badly corroded truck after unknown years of marine atmospheric exposure. Photo was taken in Hawaii while attending a meeting of The Electrochemical Society.

Eletrodeposição

FIG. 1. *Miniature copper mask from the site of Loma Negra on the far north coast of Peru, ca. 200 C.E. Removal of the green copper corrosion products reveals a bright gold surface. The extremely thin layer of gold was applied to the sheet copper by electrochemical replacement plating. [Figure reprinted with permission from Heather Lechtman,* Sci. Amer., *250(6), 56 (1984).]*

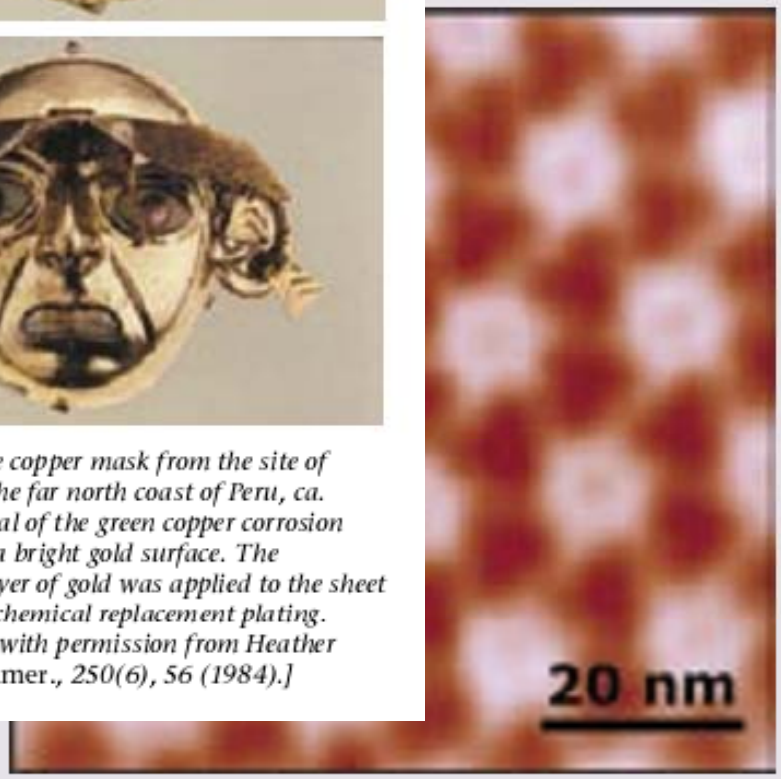


FIG. 1. *Nanometer-scale cuprous oxide (colorized red) can be electrodeposited through the openings in the hexagonally packed intermediate layer protein (white regions) from the bacterium Deinococcus radiodurans. Purified crystalline protein sheets are first adsorbed to a conductive substrate, and then electrodeposition is carried out to fill the nanometer-scale pores in the protein (see scale bar). Details of the method are given in Ref. 4.*

Sensores Eletroquímicos

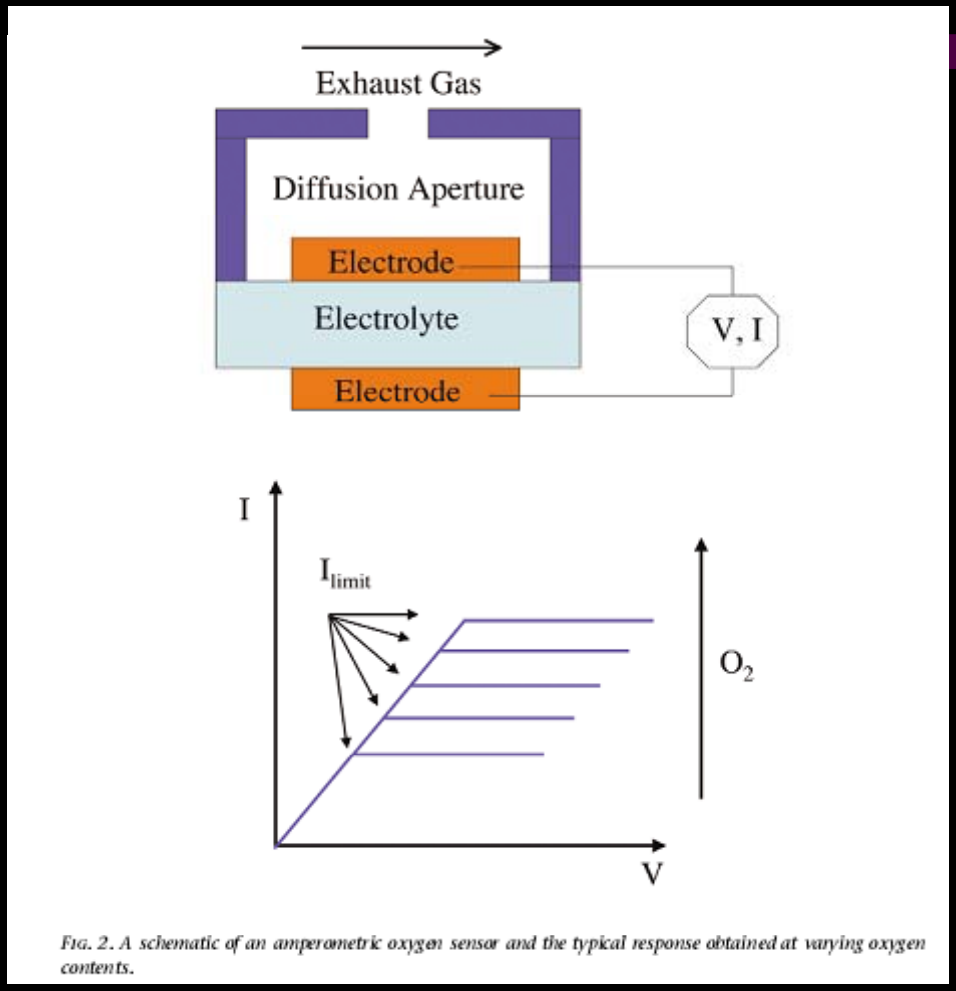


FIG. 2. A schematic of an amperometric oxygen sensor and the typical response obtained at varying oxygen contents.