On Aluminum Tapes Treated for Missions at Jupiter

Isabel Montero[(1)] and Juan R. Sanmartín[(2)]

[(1)]Instituto de Ciencia de Materiales de Madrid-ICMM, Consejo Superior de Investigaciones Científicas- CSIC
imontero@icmm.csic.es
[(2)] E.T.S.I. Aeronáutica y del Espacio, Universidad Politécnica de Madrid
juanr.sanmartin@upm.es

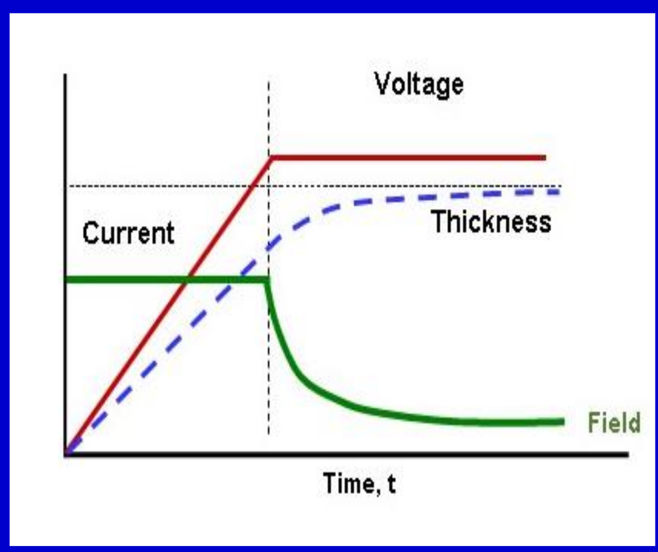
Abstract

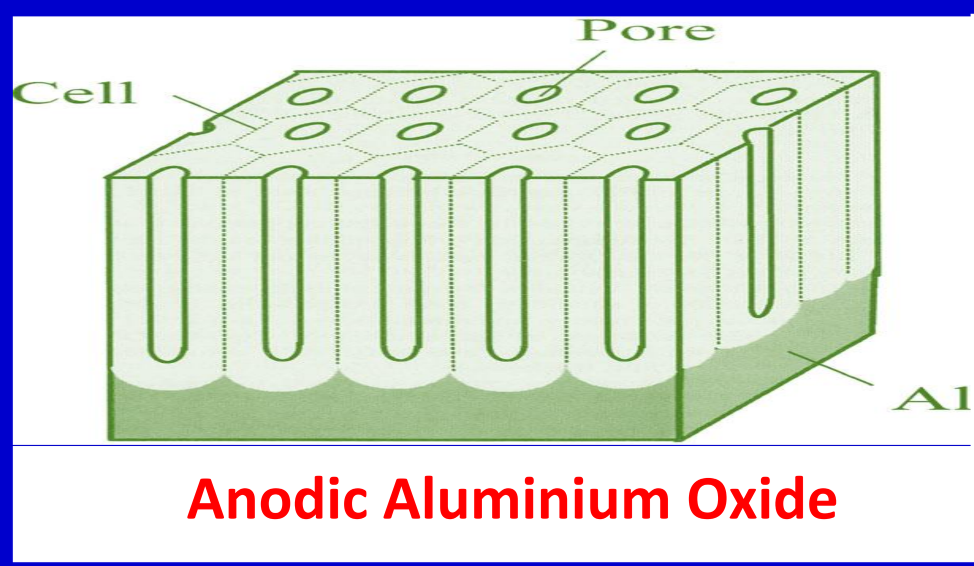
Electrodynamic tethers are effective at Jupiter because of its high magnetic field, the length-averaged tether current lying well below its high *short-circuit* bound for dimensions of interest. With aluminium tethers having thermal emissivity as low as 0.03 at a temperature of 300 K, over the entire spectrum, they present inadequate heat dissipation in the thermal infrared region. A nanostructured coating with high thermal-emissivity and high conductivity, as compared to Al and Al_2O_3 respectively, is being developed in the present work for tethers exposed to the hard conditions at Jovian operation.

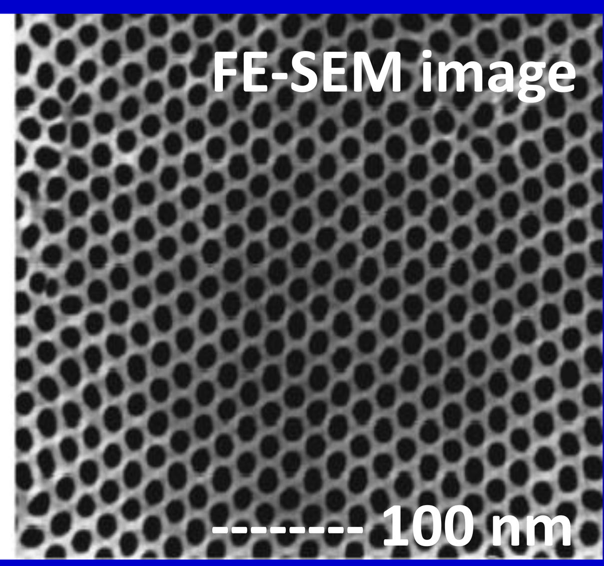
Nanostructured AAO

A coating of aluminum oxide is anodically grown on the aluminum tether and treated to make it electrically conductive, in particular to suppress discharges of static electricity, while compatible with emissivity about 0.7.

The design objective of this research is to anodically grow an alumina antidot array on Al tethers. This anodic aluminum oxide has an intrinsic double-layered structure: a porous external oxide layer and a barrier layer at the bottom of the pores. A chemical pore-widening technique is used to thin or even remove the barrier layer so as to reduce the transverse electrical resistivity.

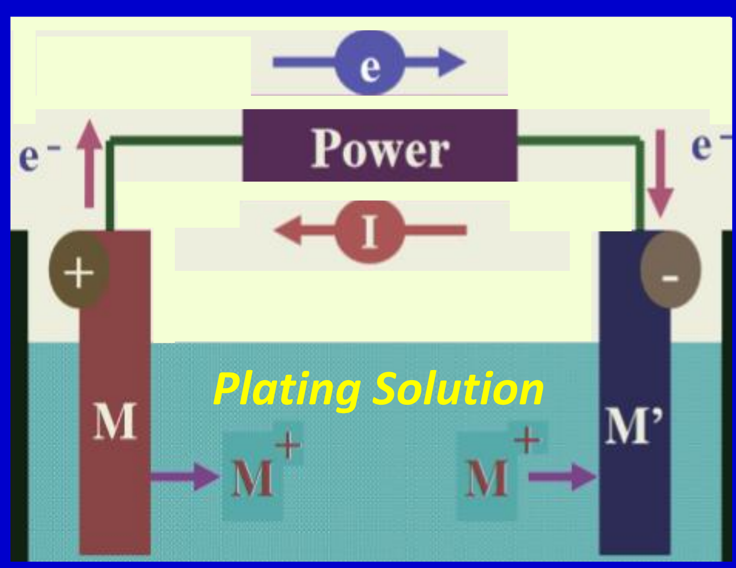


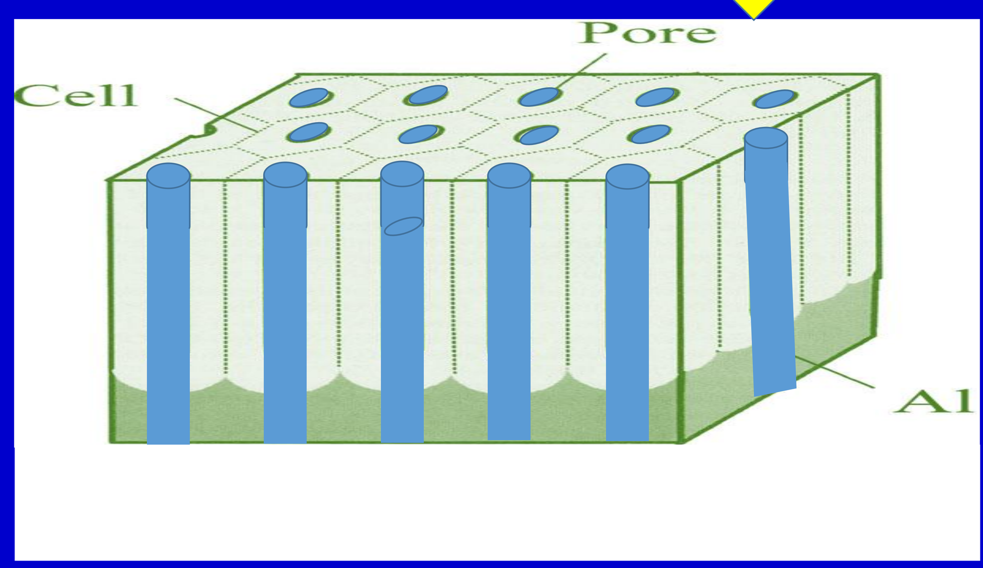




Barrier layer removed
Pores filled with a conductive material

Metallic nanowires

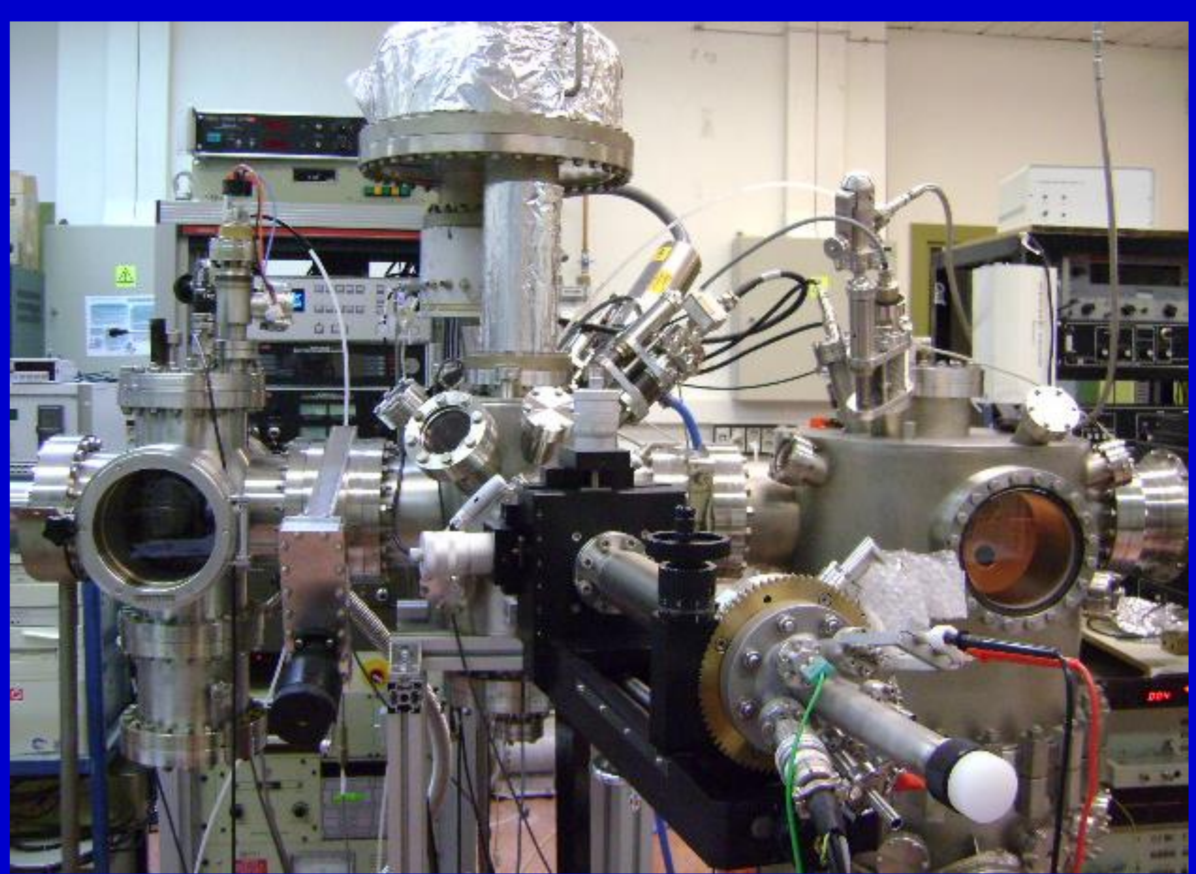




Tunable pore features

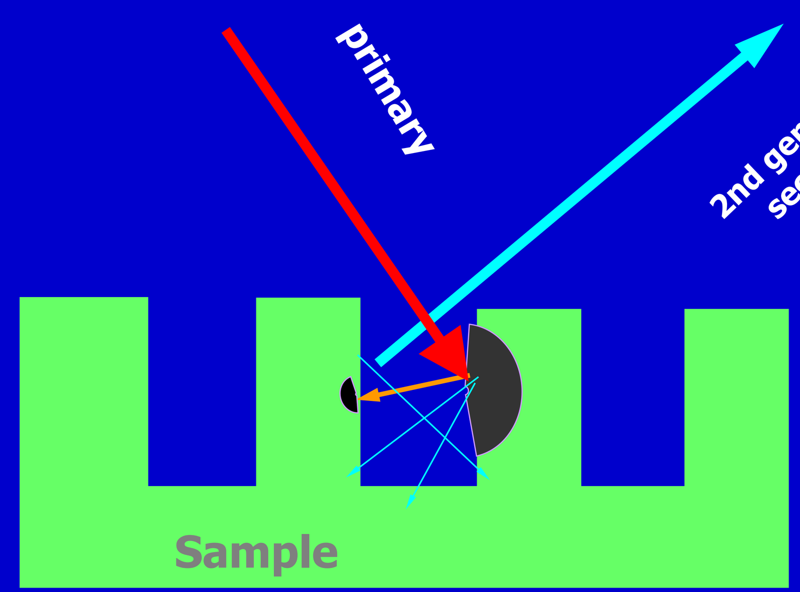
- **diameter (10 - 400 nm)**
- **density (10^8 - 10^{12} cm^{-2})**
- **spacing (30 - 500 nm)**
- **depth (up to hundreds of µm)**

Secondary Electron Emission and Optical properties



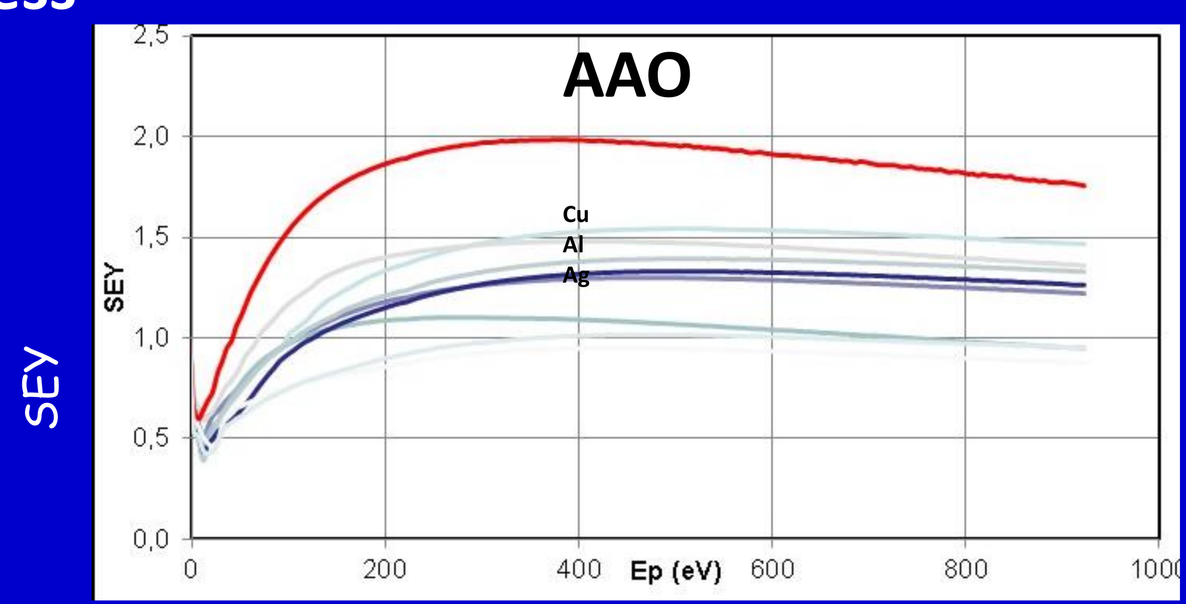
Experimental facility of ICMM of CSIC for surface physics studies: SEY, AES, XPS, RGA, PYS, EDC, REELS,

SEY reduction by Surface roughness



$$SEY = \sigma = \frac{I_\sigma}{|I_p|} = 1 + \frac{I_s}{|I_p|}$$

SEY curves of AAO + Al nanowires



SEY (Secondary Electron Yield): The dependence of the SEY on the incident electron energy and impact position of the primary electrons

Summary and Conclusions:

Tethers for mission-design depends on keeping electron *range* below tape thickness for all conditions at capture. Filling the nanopores with electrically conductive material also increases the coating conductivity. This proposed nanoscale patterned metal/dielectric coating offers the possibility of tuning the local distribution of dielectric surface in a controlled way. For space applications, such coating would also provide the required electrical contact with the outerspace plasma. Remarkably, the anodization and electro-deposition processes are compatible with commercial anodizing production lines.

Specific advantages: structural variability, optical transparency, excellent stability, excellent dielectric properties, low cost and high throughput, potential for large-scale production .

References

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