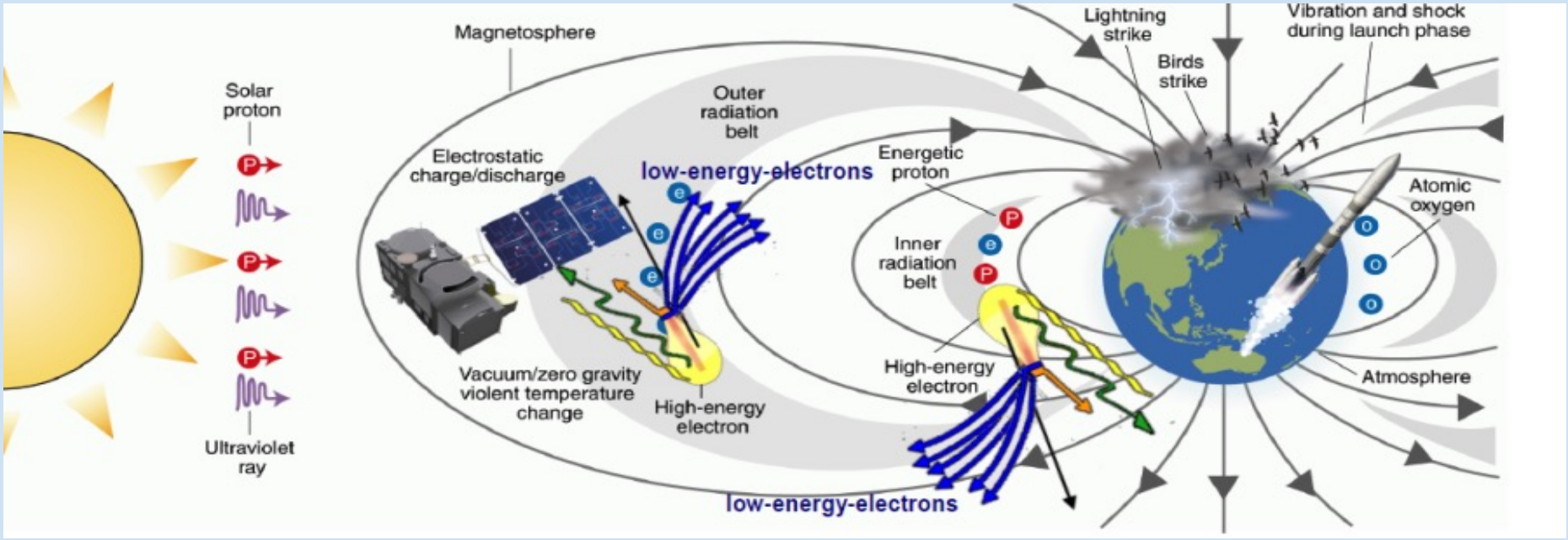
LEE2022

a brainstorming meeting on relevance of Low Energy Electrons in aerospace



THE UBIQUITOUS ROLE OF SECONDARY ELECTRONS

Giovanni Stefani

Research Associate

ISM-CNR

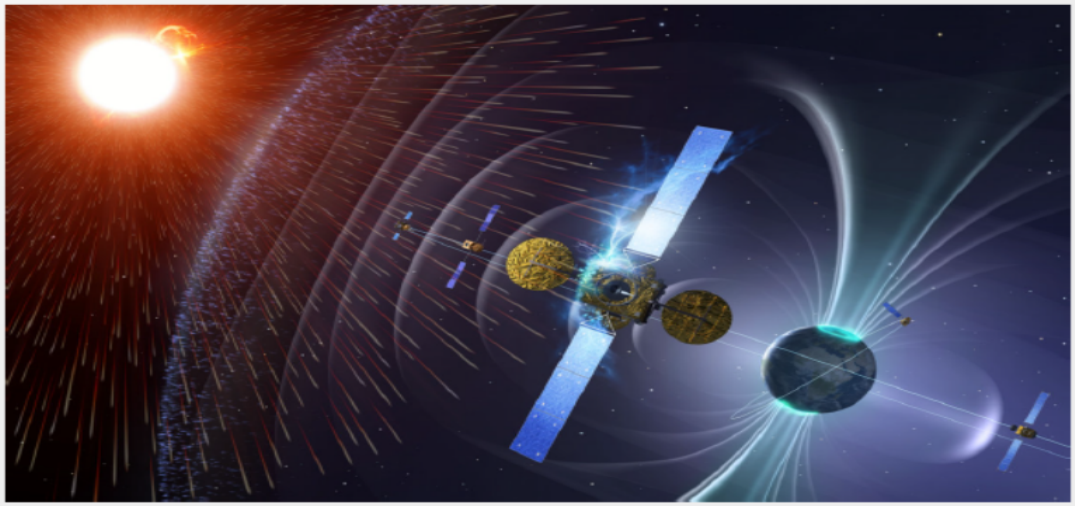
LEE2022 Rome November 15, 2022

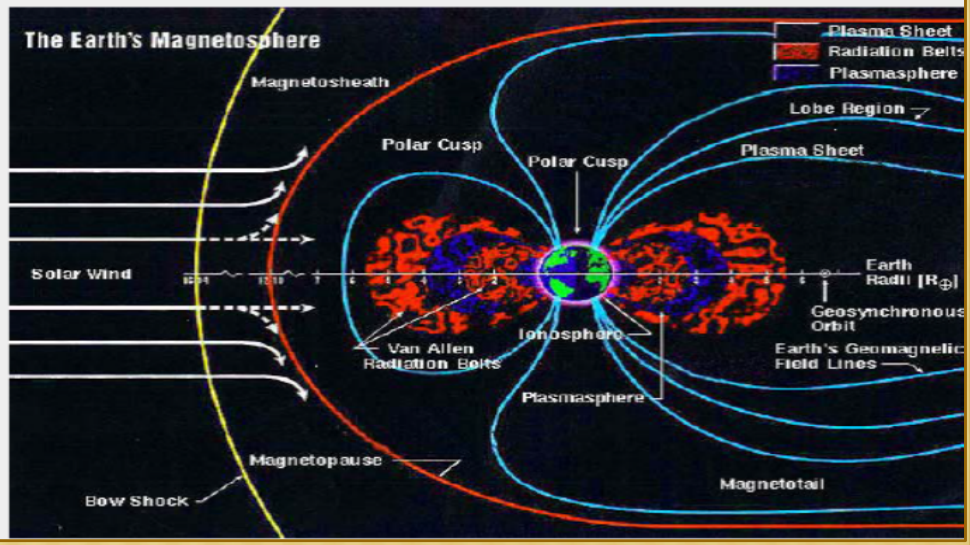

LEE2022 Rome, November 15, 2022
EUROPE
LEE 2022
35 registered
15 in person
20 on line
Iceland
Norwegian Sea
Sweden
Norway
Faroe Islands
Shetland Islands
Orkney Islands
Hebrides
North Sea
Gulf of Bothnia
Baltic Sea
Estonia
Latvia
Lithuania
Russia
Belarus
Ireland
United Kingdom
Netherlands
Germany
Poland
Ukraine
Czech Republic
Slovakia
Austria
Hungary
Romania
Switzerland
France
Bay of Biscay
Serbia
Bulgaria
Black Sea
USA
Portugal
Spain
Balearic Islands
Mediterranean Sea
Greece
Aegean Sea
Turkey
North Atlantic Ocean
Morocco
Algeria
Tunisia
Malta

SPACE RADIATION & SPACRAFTS

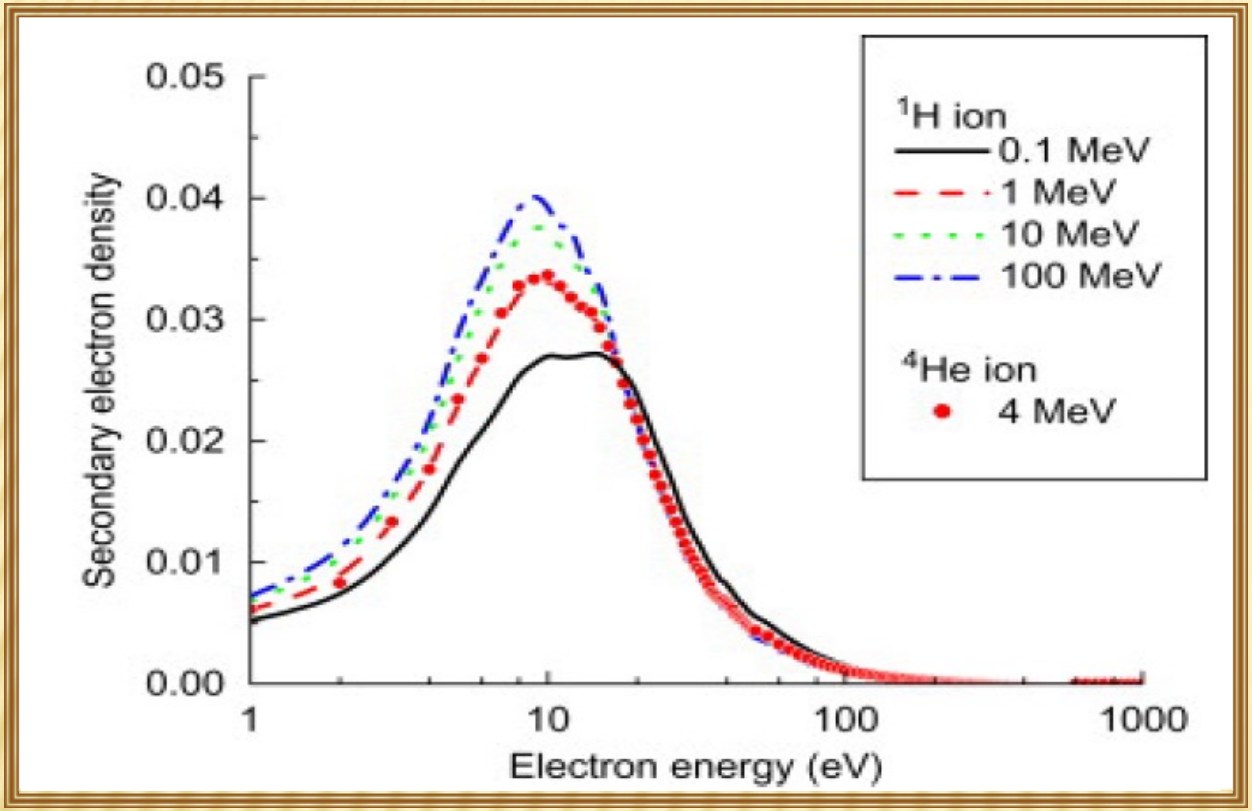
In 25 years the National Geophysical Data Center recorded over 4500 spacecraft anomalies or malfunctions that have been traced to the effects of the space radiation.

- Solar activity causes a continuous flux of high energy elemental particles towards the spaceships.
- These particles can penetrate in the satellites, reaching the electromagnetic field region of the passive RF components and leading to a very harmful multipactor discharge.





THE UBIQUITOUS S.E. PEAK



S.E. spectrum largely independent from energy and particle type

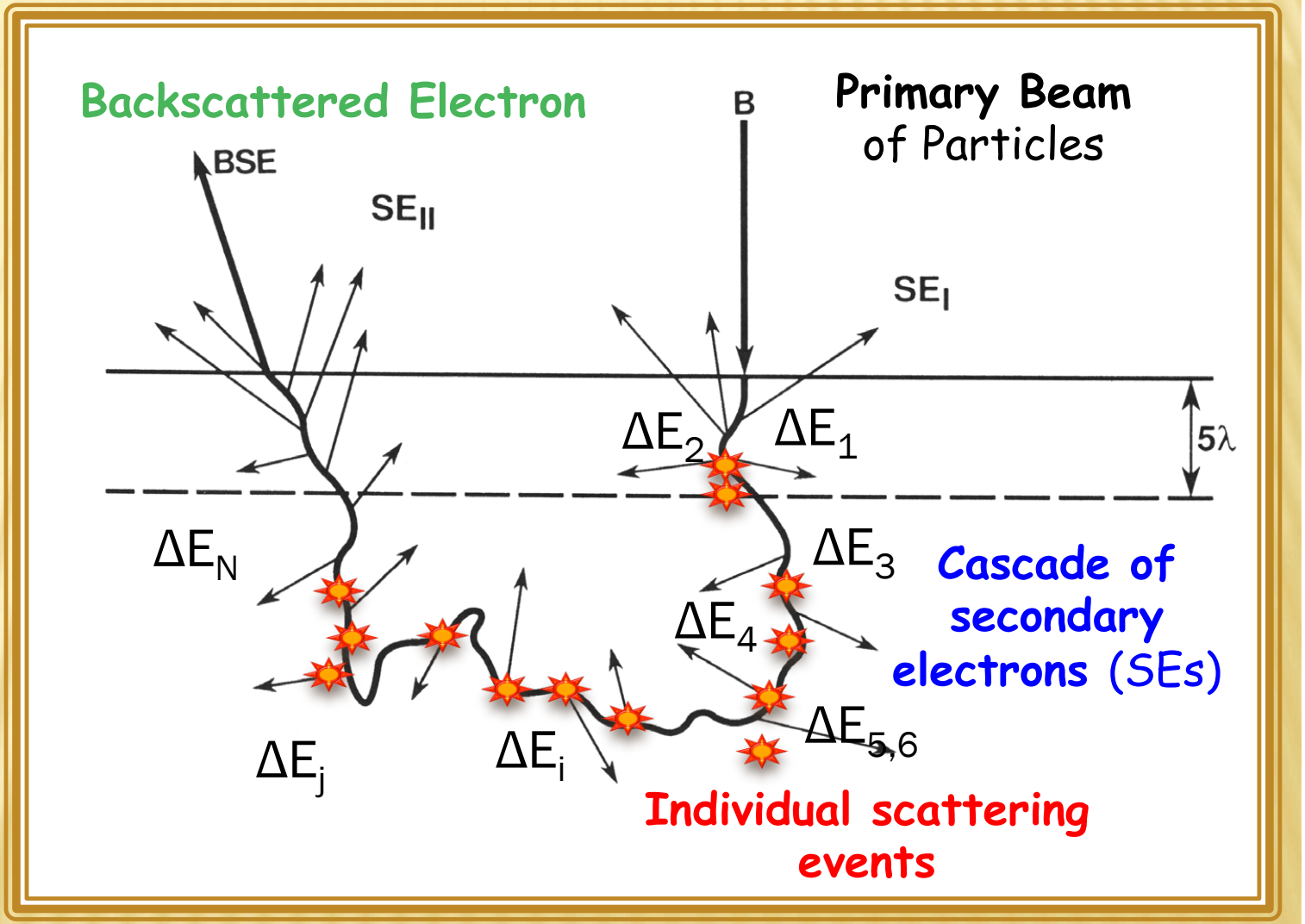
Space radiation:

1. particles trapped in the magnetic field
2. particles shot from solar flares
3. cosmic rays i.e. high-energy protons and heavy ions from outer space.

All of them are ionizing radiation.

Need for individual events knowlwdge & comprehensive predictive model

The SE spectrum results from multiple collisions with fractional energy transfer. First Born interactions dominate. Similar spectra of emitted SE. Comprehensive model for multiple collisions.



INSULATOR CHARGING EFFECTS

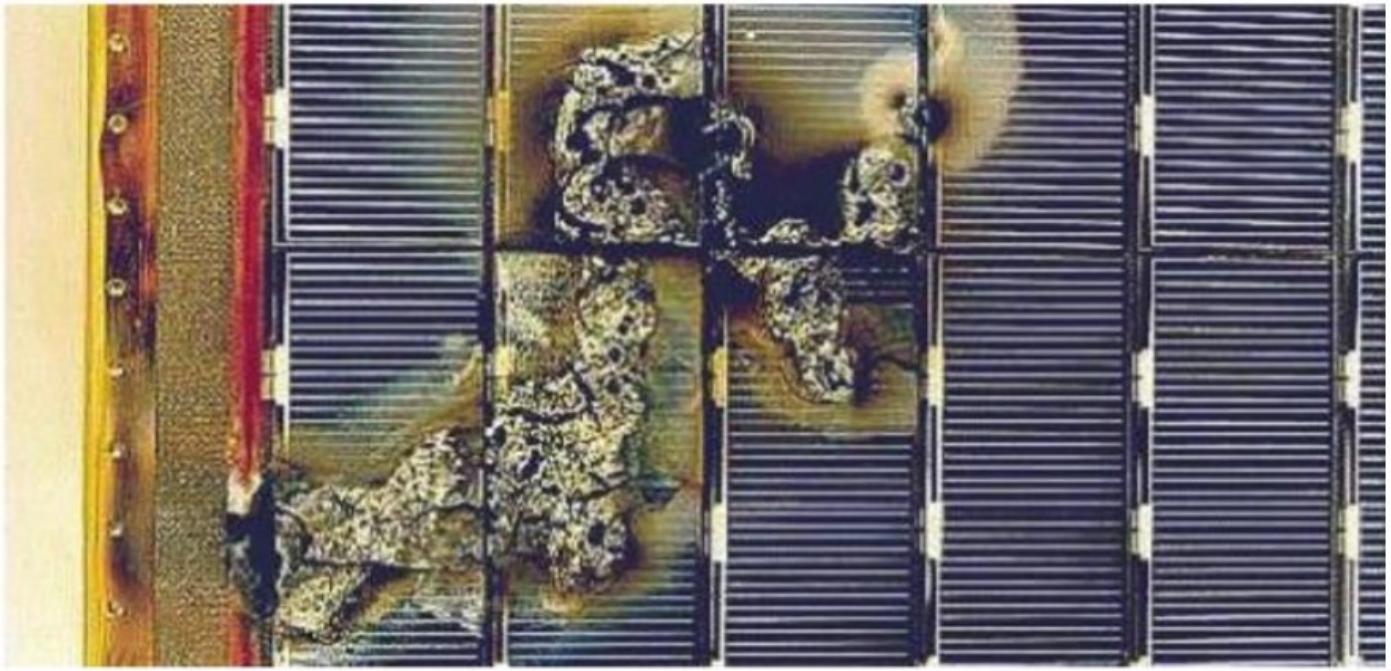


Figure 1.19. An example of the consequences of an electrostatic discharge in a solar panel. Two adjacent components with different SEY has produced an electrostatic discharge due to the potential difference between them. In this case, the arc discharge has damaged and destroyed part of a solar panel array. Credit: ESA.

MULTIPACTOR DUE TO S.E.

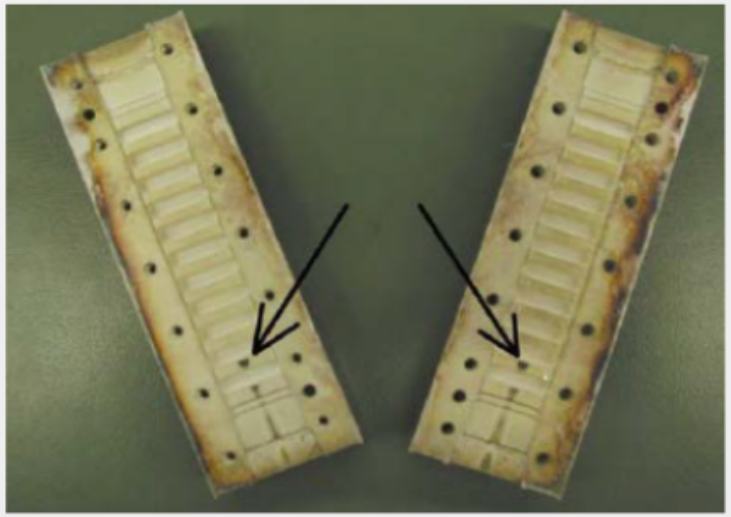
Effects of a multipactor discharge on the device

- Increase of signal noise
- Increase of reflected power
- Heating up of device walls
- Detuning of resonant cavities
- Physical damages

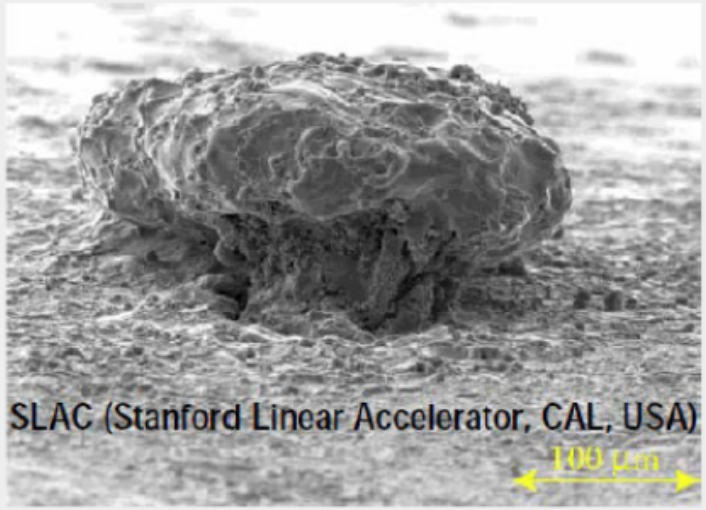
→ Degradation of the device performance

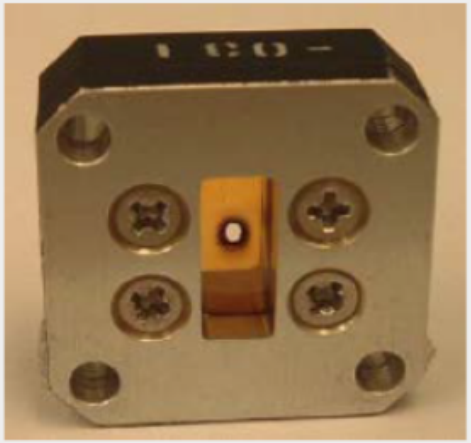
↓

Limitation of the managed RF power



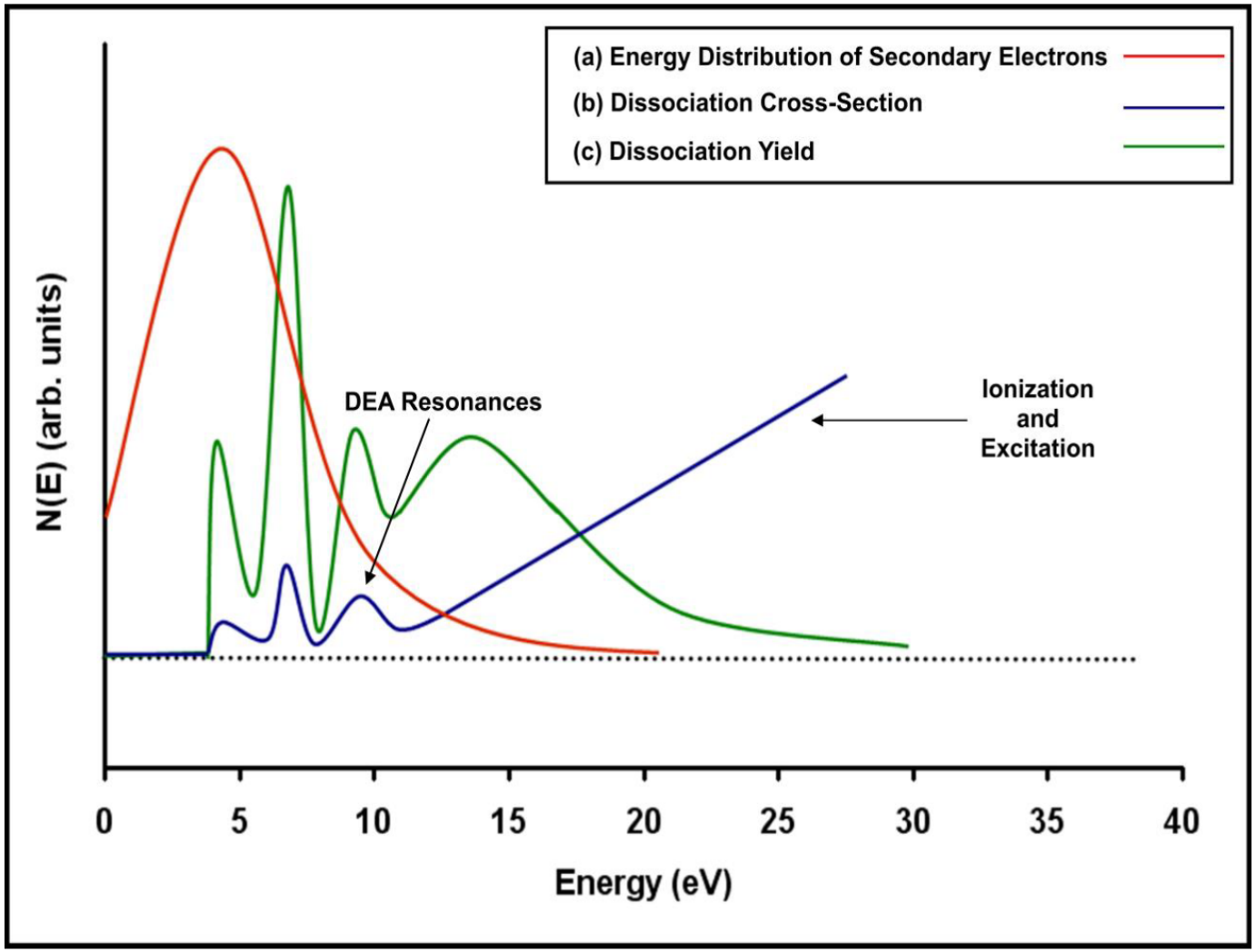
Low pass filter





Kapton window

S.E. INDUCED REACTIONS



Relevant to :

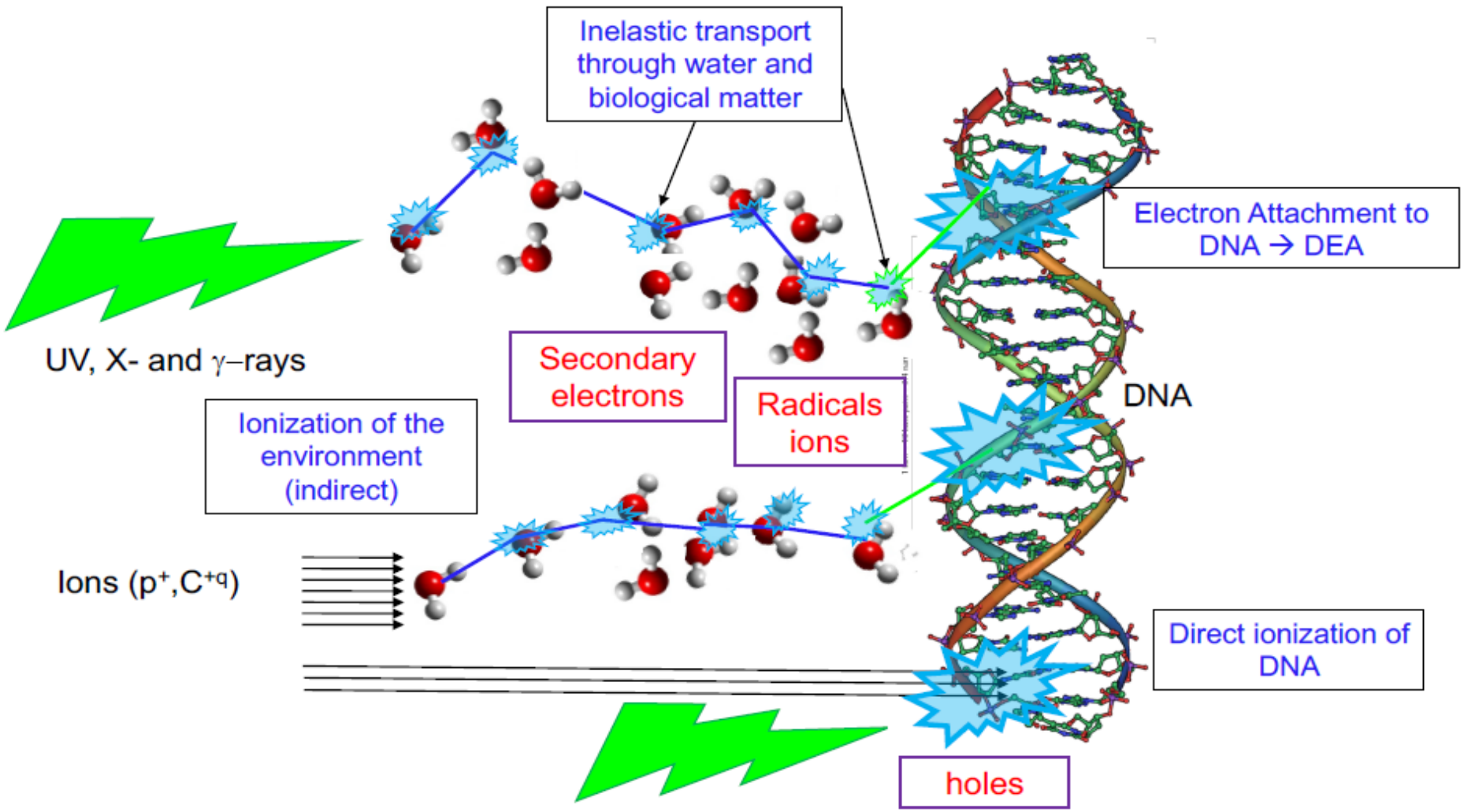
Environmental

Material

Biology

Astrochemistry

S. E. AND DNA INTERACTION



Journal of Physics: Condensed Matter (2017)
Jorge Kohano, Maeve McAllister, Gareth A. Tribello and Bin Gui

S. E. RELEVANCE TO LITHOGRAPHY

Chem. Soc. Rev. 2013, 42, 9219

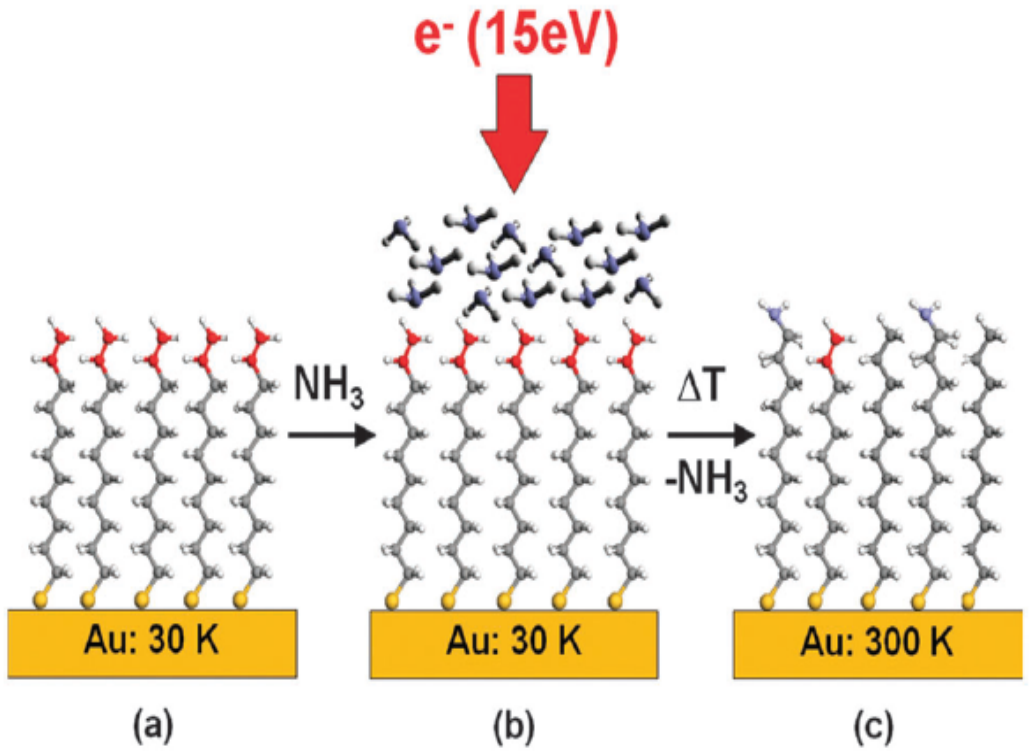
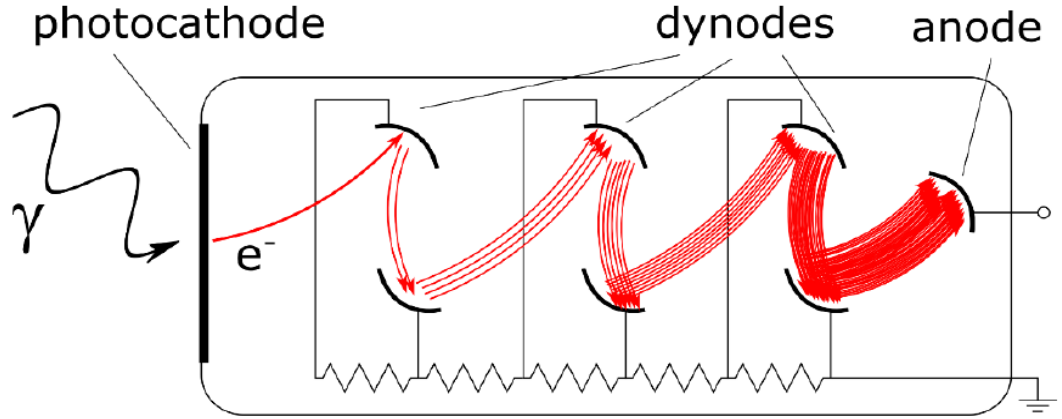


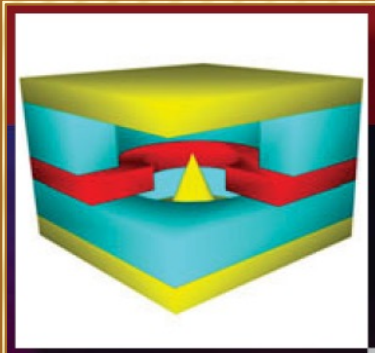
Fig. 10 Electron-initiated functionalisation of an alkanethiol self-assembled monolayer with a terminal CC double bond (a). Condensation of ammonia and electron exposure at 15 eV (b). Subsequent thermal desorption of remaining ammonia to unveil a surface terminated by nitrogen-containing functional groups resulting from attachment of NH_3 and saturated hydrocarbon units produced by the reducing action of ammonia under exposure to electrons (c).[36]

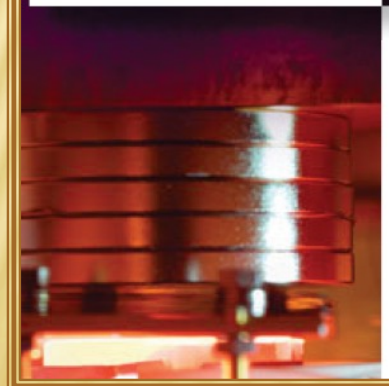
Relevance of SE on lithography based on the following pillars:

- EUV resist exposure is based on low energy (5-20 eV) electron chemistry
- Propagation of low energy electrons is the major responsible of the electron blur that limits EUVL spatial resolution
- To control electron blur effects, a thorough understanding of the microscopic mechanisms of generation and propagation of low energy electrons (secondary electrons) is mandatory
- The above mentioned mechanisms will be the foundations for dependable simulation codes

HIGH SECONDARY ELECTRON YIELD







Electron-emission materials: Advances, applications, and models

Daniele M. Trucchi and Nicholas A. Melosh, Guest Editors

WE AIM TO REALIZE