Plasma and Materials Processing group
Applied Physics department

Specialization afternoon M.Sc. Sustainable Energy Technology
September 12th 2022

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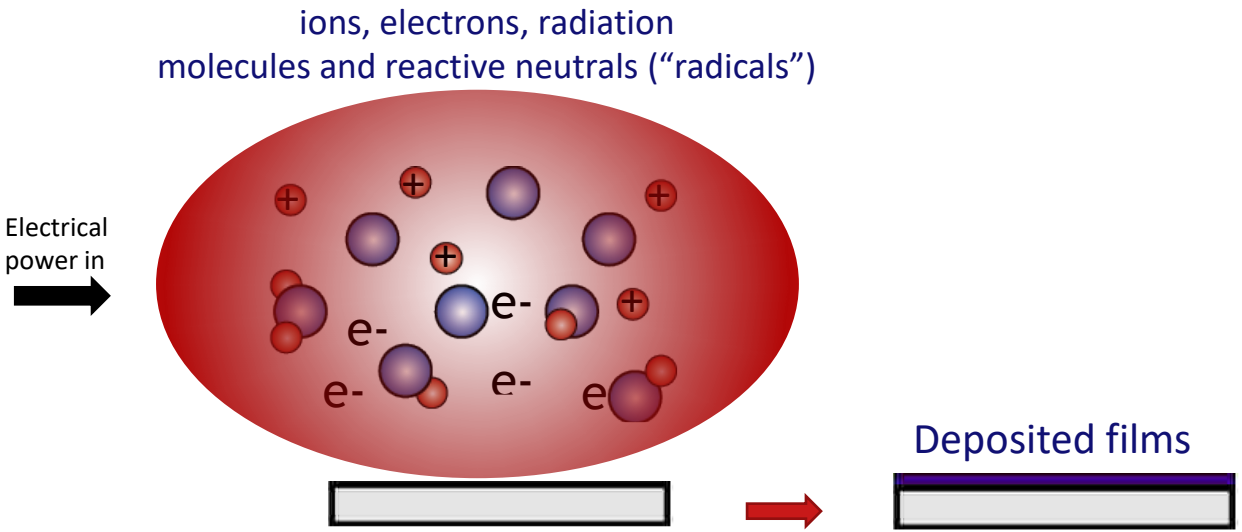
Plasma technology

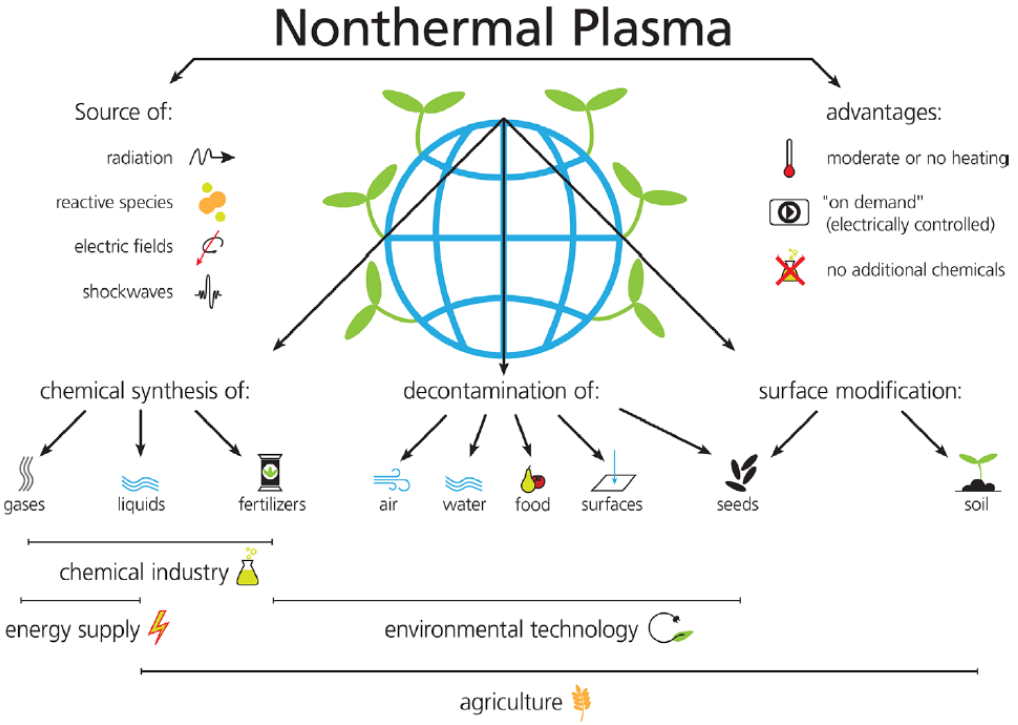


Applications:

- Micro/nanoelectronics
- Displays
- Abrasion protection
- Barrier layers vs. humidity
- **Energy!**

Plasma technology for clean energy & environment

Plasma-based synthesis of thin films and interfaces in energy conversion (photovoltaics) & storage (batteries, electrocatalysis) devices



Brandenburg *et al.*, *Plasma Process. Polym.* 16, 1700238, 2019

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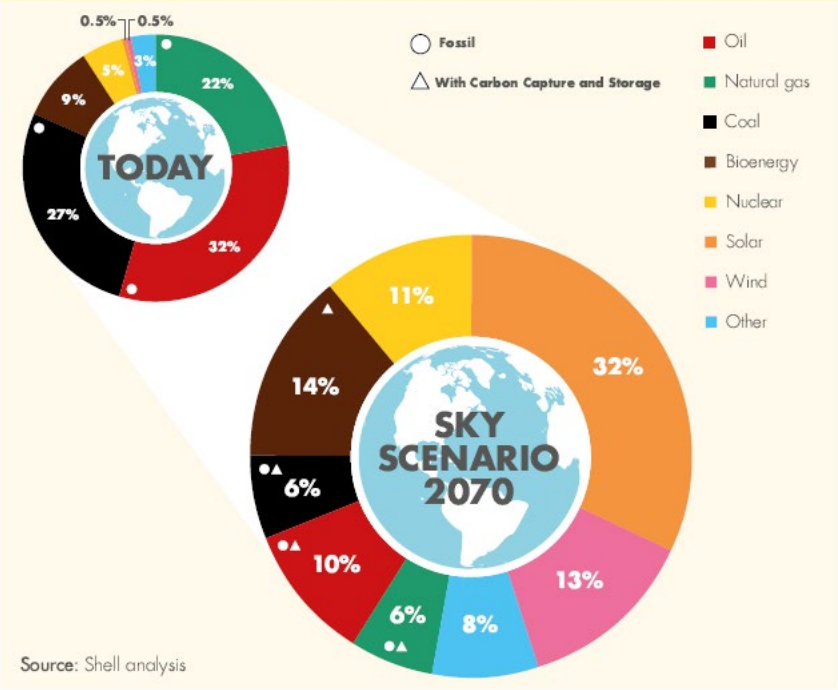
Energy transition scenario

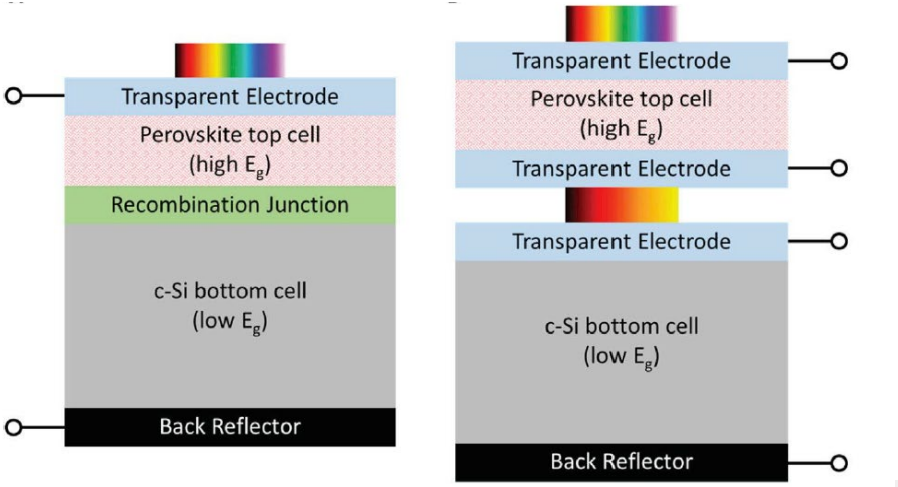
Photovoltaics as affordable and leading renewable energy source



- PV: nearly 2 TW, predicted 6.5 TW by 2035.
- **Lower cost** (below thermal- coal and gas plant-generation) and **higher efficiency needed for PV** to prompt development of 30-70 TW of solar energy capacity by 2050.

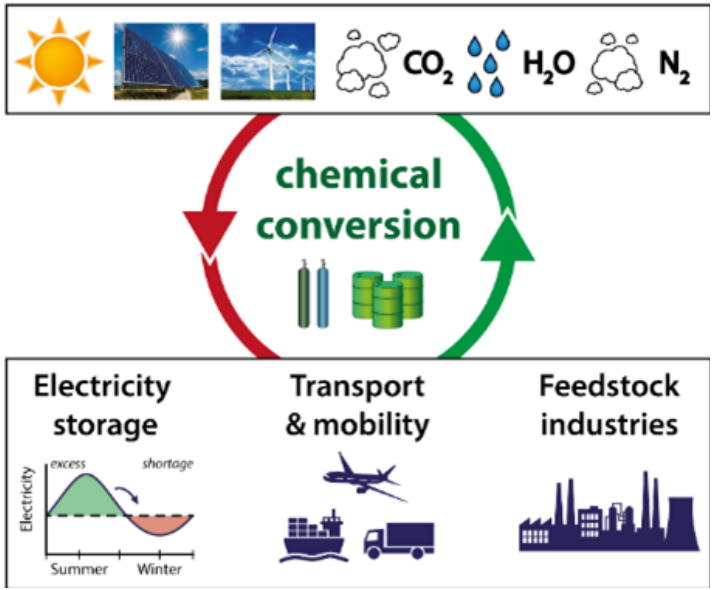
Beyond c-Si PV: the role of thin film PV

- Current cost reduction in c-Si is 80% the result of upscaling and 20% the result of innovation.
- As the cost reduction through upscaling is now limited, the relevance of innovation increases. In terms of conversion efficiency, c-Si PV (26.7%) approaches its thermodynamic limit (29.4%). **Beyond the thermodynamic limit: combining c-Si with thin film PV technologies in tandem PV.**



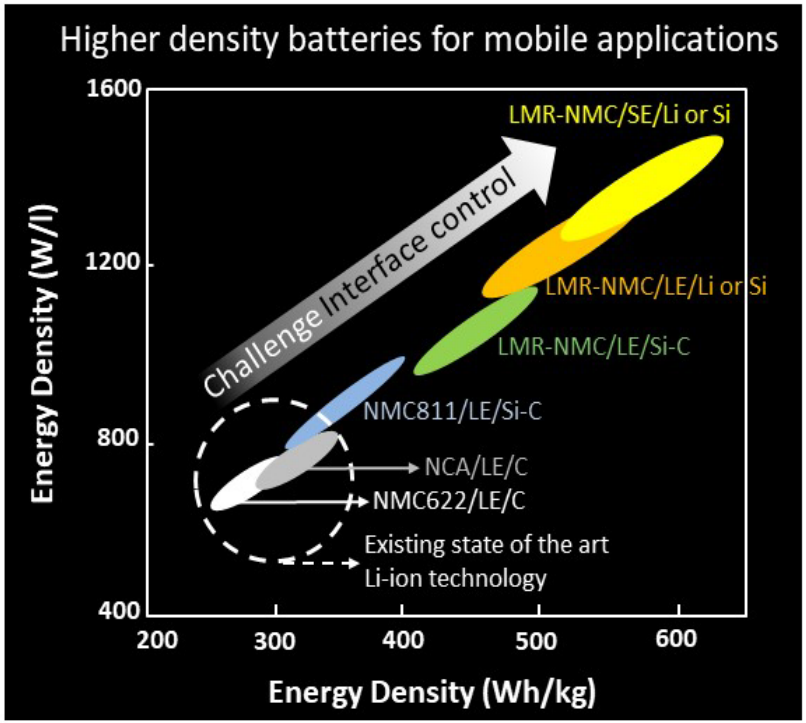
Energy transition scenario

Photovoltaics and the implication of electrification in all sectors



- Intermittent character: storage is necessary
- Major impact on sectors now running on fossil fuels
- **Transport**: electric vehicles, cost parity with combustion engine cars by 2025. By 2035, 100% new car sales are electric in EU, US, China.
- **Chemical industry**

Li-ion batteries: state-of-the art and beyond



Towards the next generation Li-ion batteries

- **Material challenges**
- **Interface challenges**: electro-chemical and mechanically stable; selective towards charge transfer & transport

BatteryNL
DUTCH BATTERY MATERIALS

R. Schmuch *et al.*, *Nature Energy* 3, 267 (2018)

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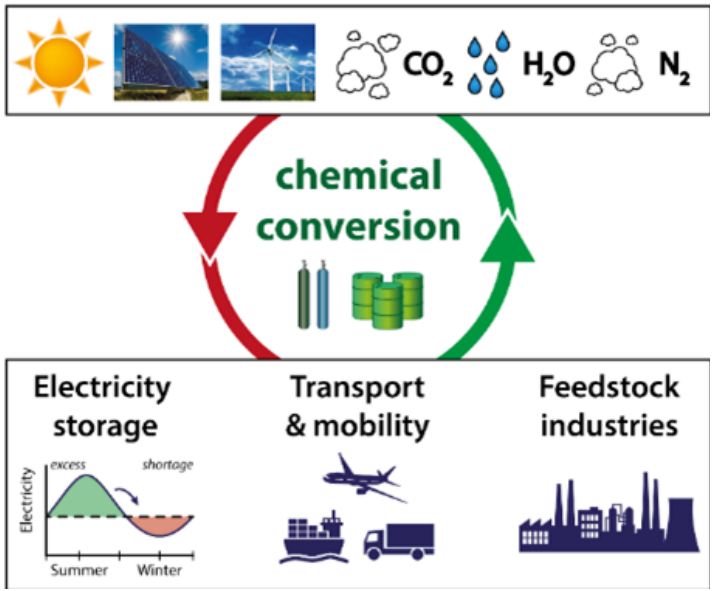
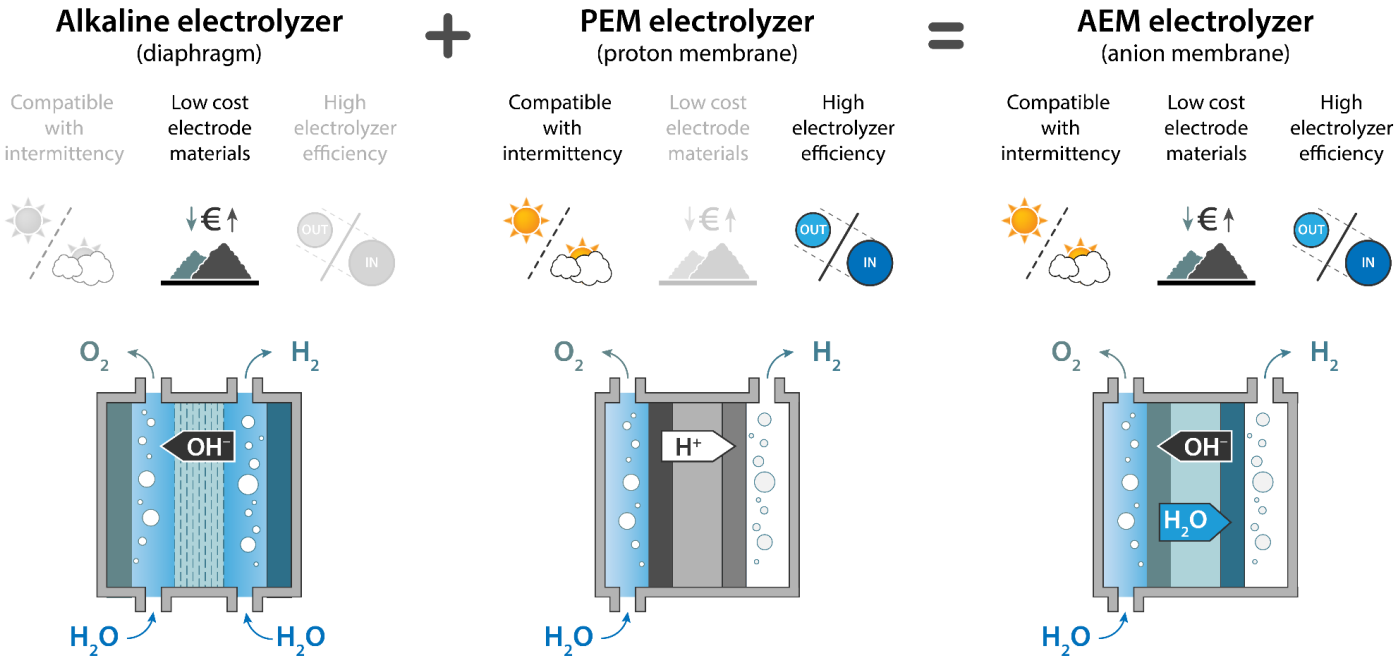
Energy transition scenario

Photovoltaics and the implication of electrification in all sectors



- Intermittent character: storage is necessary
- Major impact on sectors now running on fossil fuels
- **Transport**: electric vehicles, cost parity with combustion engine cars by 2025. By 2035, 100% new car sales are electric in EU, US, China.
- Greening of **chemical industry** via electrification: electro-synthesis of hydrocarbons from H_2O (to H_2) and CO_2 (to CO). Cost of solar electricity and electron-to-molecule conversion efficiency: key factors to make electrification competitive with thermal plants.

Electrolysis (H_2O splitting)



Quest for industrially compatible O_2 evolution reaction (OER) electro-catalysts

(multi-electron transfer steps for O_2)

Internships & job opportunities

- The Dutch industry is leading in the field of manufacturing vacuum equipment for thin film deposition.
- ASML, Solaytec, S-ALD, Tempress, Solliance, Hyet Lithium, SMIT Thermal Solutions, ECN part of TNO, DSM, PhD opportunities

Overview of courses for this specialization

- Plasma Processing Science and Technology 3MP170, Q3
- Solar cells 3MP110, Q3

E-mail me (m.creatore@tue.nl) by Friday the 16th, if you would like to meet and then we organize a meeting

@ Market: poster + in-depth presentation on our research activities with Kousumi Mukherjee (PhD candidate)