WORLD MATERIALS FORUM

Innovative technologies in Industry

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23 & 24 June 2015

ARKEMA
INNOVATIVE CHEMISTRY

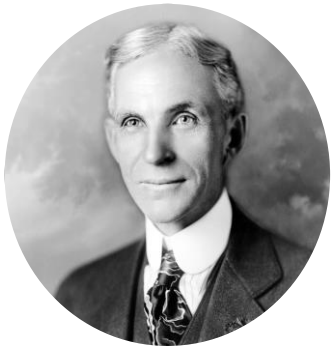
What is your definition of innovation?

"To innovate doesn't mean to have a new idea but to stop to have an old idea"

Edwin Herbert Land

"There is no innovation without desobedience"

Napoleon



"If I would have asked my customers what they were expecting they would have answered: horses with longer legs"

Henry Ford

1) Time required for commercialization of new materials

*** (M.Boren, V.Chan, C.Musso: "The pass to improve returns in material commercialization" McKinsey on Chemicals, May 2012)**

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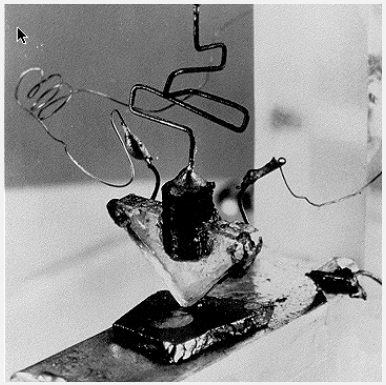
The semiconductor industry: a mature and conservative industry

1st Transistor
5mm Schokley

1947 bell labs

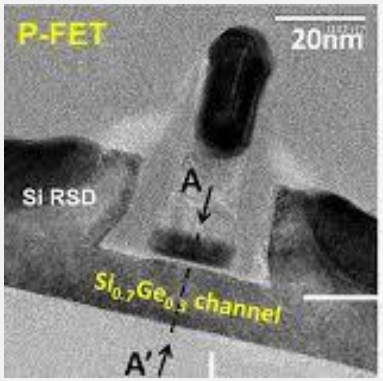


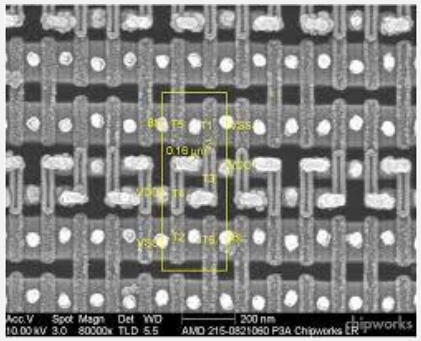
1st Circuit
(1tr, 1C, 1R)

Kilby 1958 TI

P-FET Transistor
(20nm node)

Intel 2014





SRAM circuit
AMD 2012

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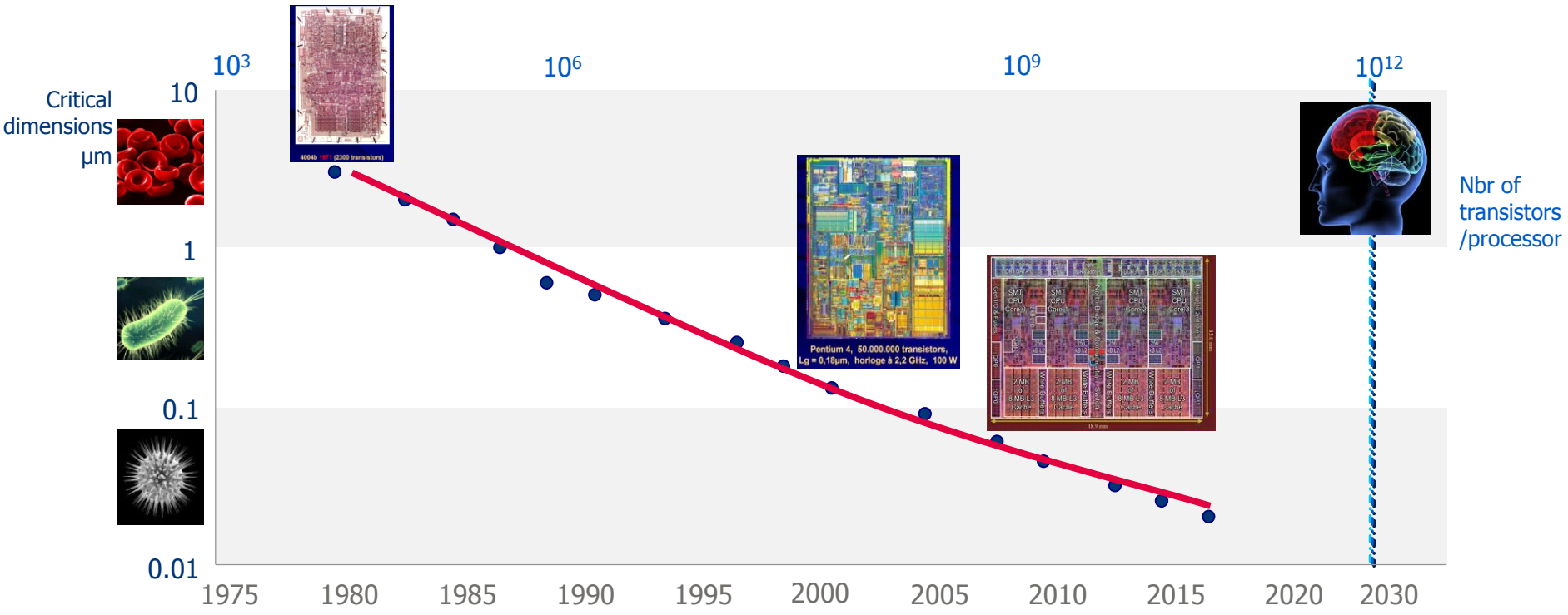
Moore's Law



Improving the performance of integrated circuits is possible thanks to the miniaturization of transistors which allows:

- **The reduction of consumed energy**
- **To increase the number of transistors/chips**
- **The reduction of costs that are proportional to the silicon area occupied by the chip**

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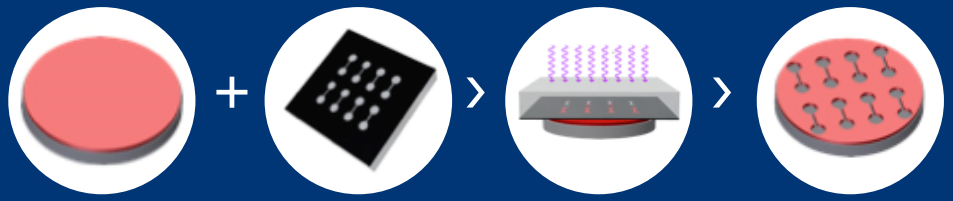
Lithography enables Scaling

PHOTOLITHOGRAPHY PROCESS



SILICON WAFER

We begin with a clean silicon wafer spincoated with photoresist

PHOTOMASK

A glass or mylar mask coated with an opaque film defines the features

EXPOSURE

A mask aligner is used to pass UV light through the mask onto the wafer

DEVELOPMENT

Exposed resist is washed away while unexposed resist remains

DEPOSITION

Metallic, semiconducting or insulating layers are evaporated or sputtered onto the surface

LIFTOFF

Photoresist is removed, leaving behind precisely deposited features

WET OR DRY ETCH

Exposed sections are etched away while the resist protects the remaining areas

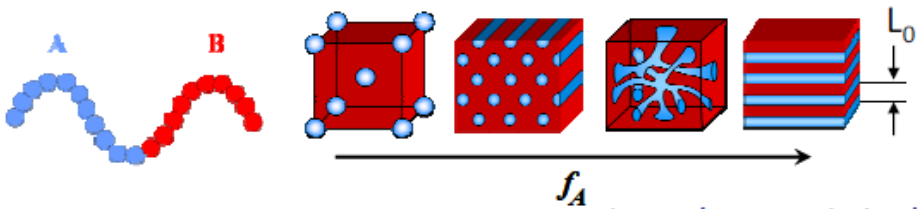
RESIST REMOVAL

Photoresist is removed, leaving behind precisely etched features

A paradigm shift: DSA lithography

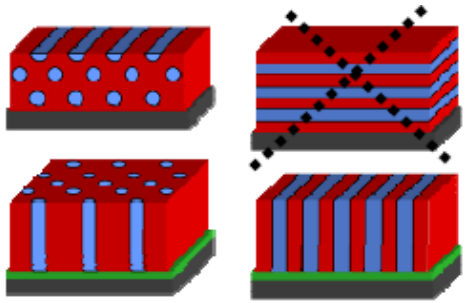
DSA is a bottom up lithography. Patterns are in the chemistry:

Pitch/Critical dimensions	**Molecular Mass**
Structure (cylindrical, lamellar, spherical)	**Composition**
Orientation	**Surface energy**



$$f_A = \frac{N_A}{N_A + N_B}$$

L_0 : *characteristic domain length scale*
N : *number of chain segment*



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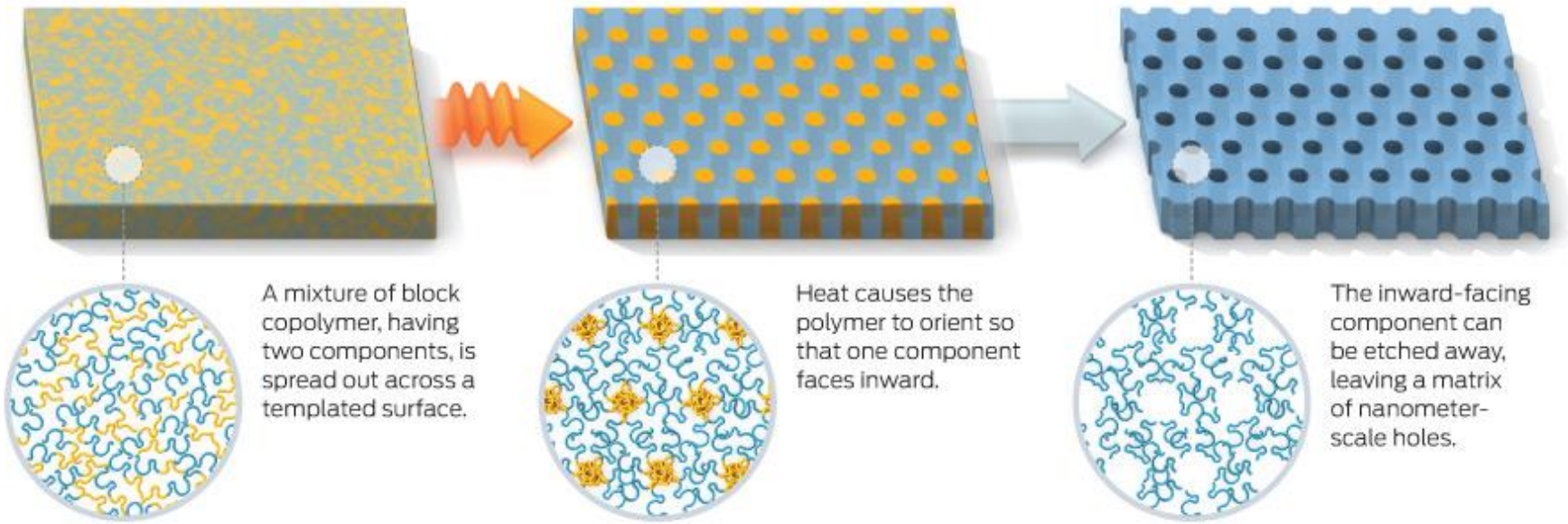

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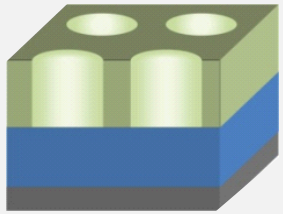
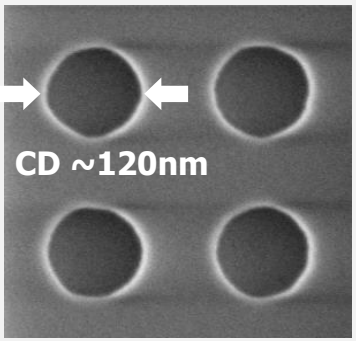
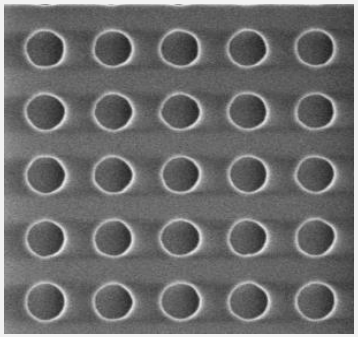
Example of contact shrink

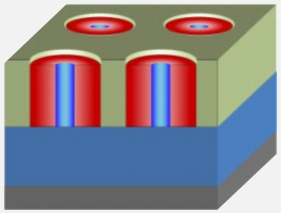
193nm or e-beam litho pattern

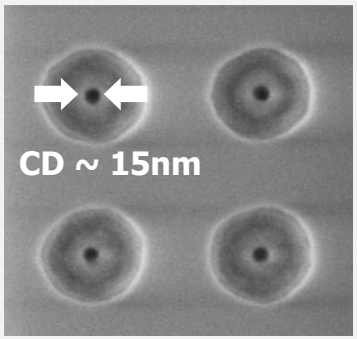


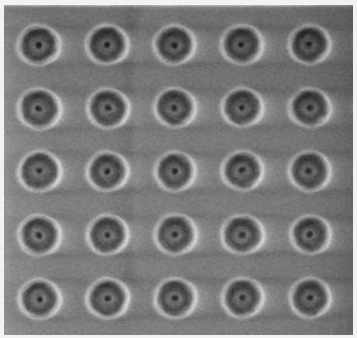




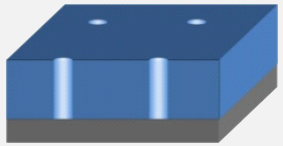
BCP self-assembly

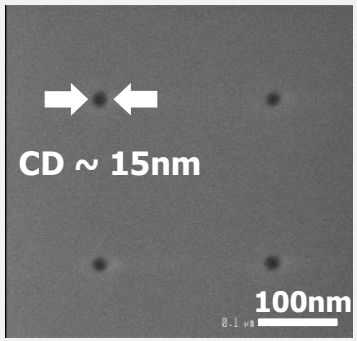


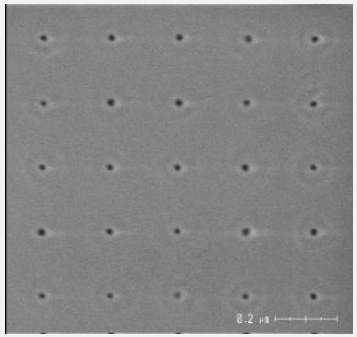




BCP pattern transfer







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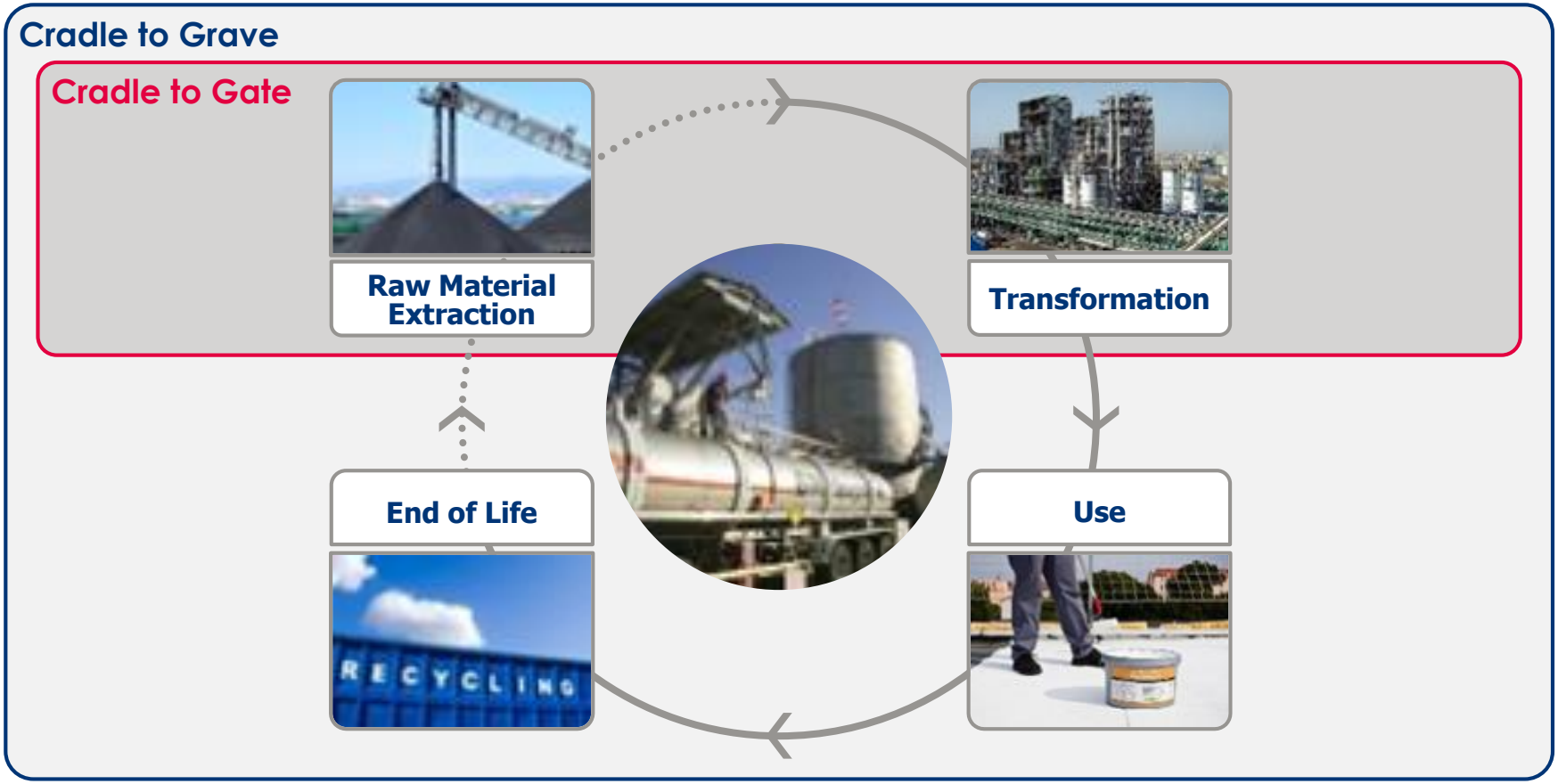
2) Life Cycle Analysis
A reference tool for a sustainable industry

Assess the environmental impacts through the whole life cycle



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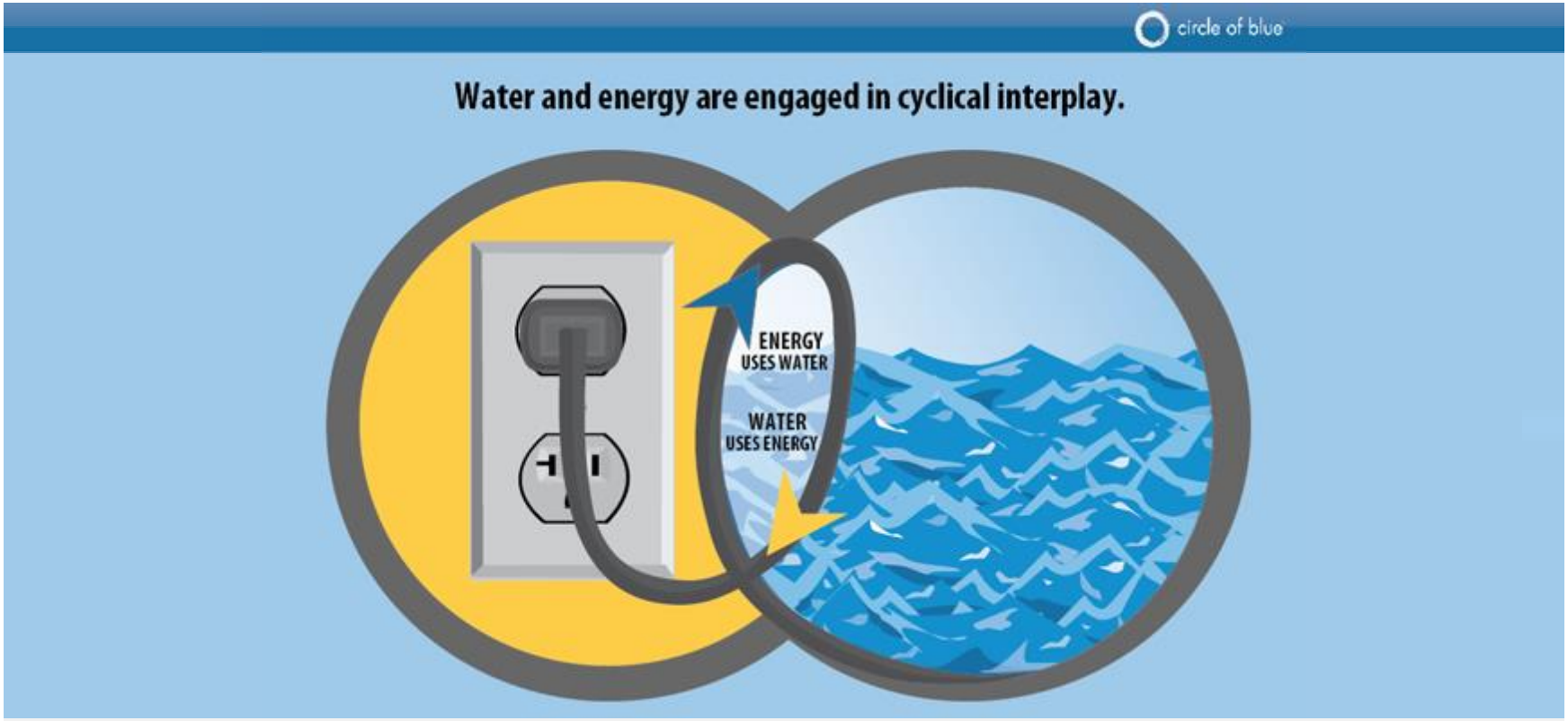

WATER for ENERGY

- 45 m^3/GJ (Biomass)
- 0.1 m^3/GJ (Coal or oil)
- 0.5 m^3/GJ (Solar or Wind)
- 0.08 m^3/GJ (Nuclear)

Source: circle of blue
http://www.circleofblue.org/waternews/2010/world/infographic-water-and-energy/

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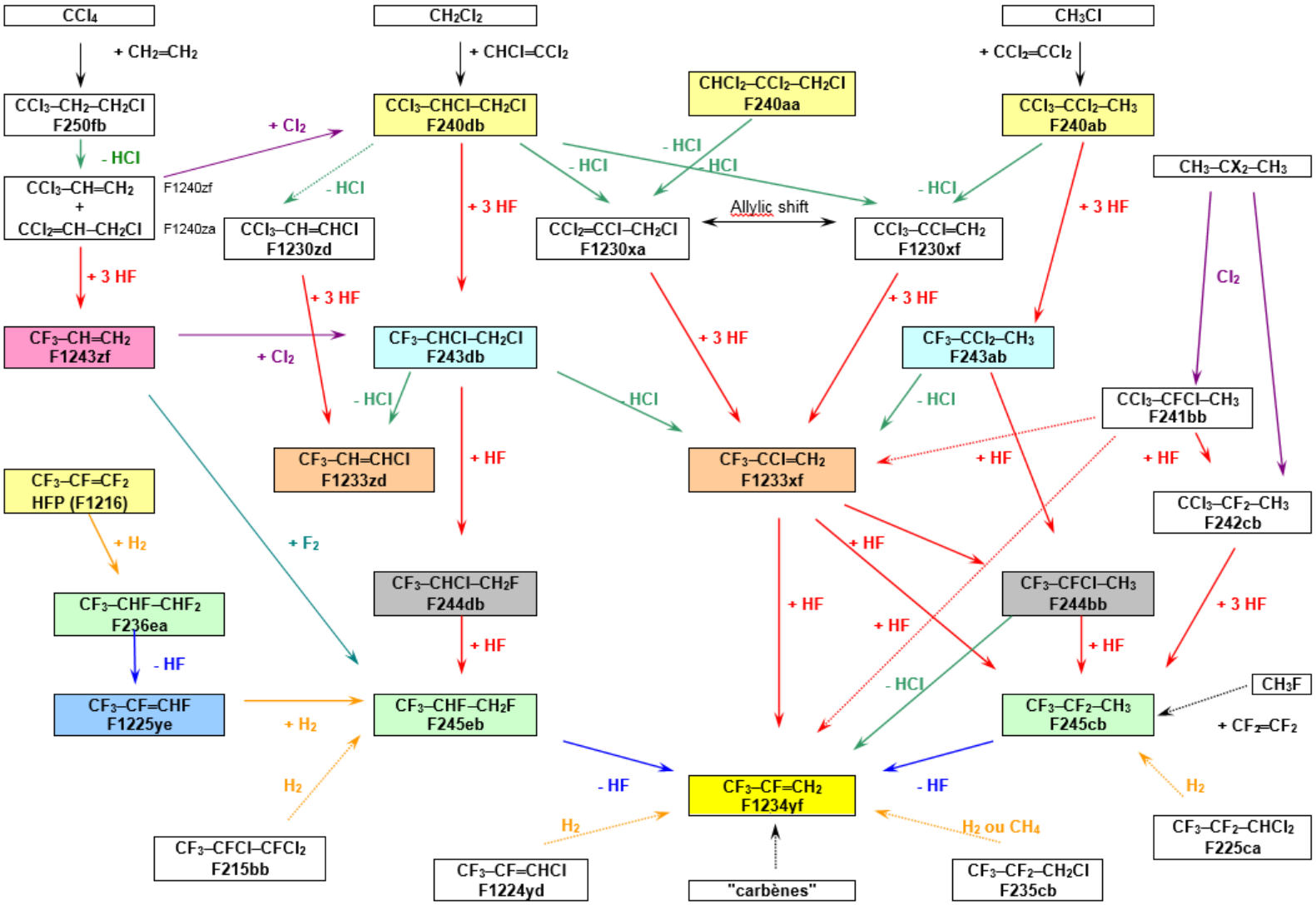
2,3,3,3-tetrafluoropropene (F1234yf) synthesis



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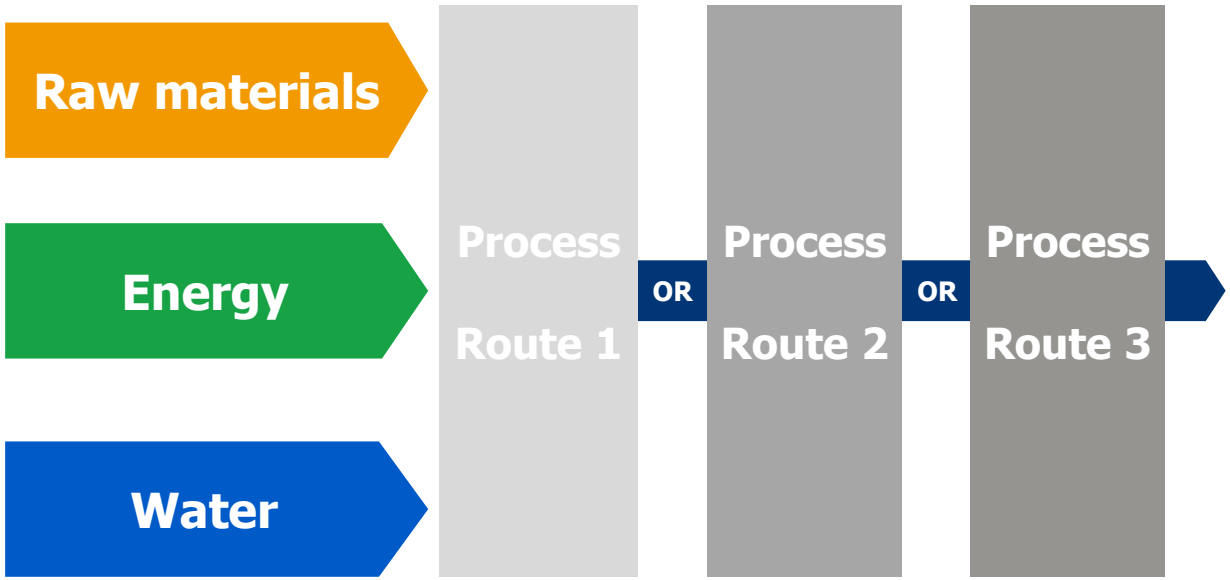
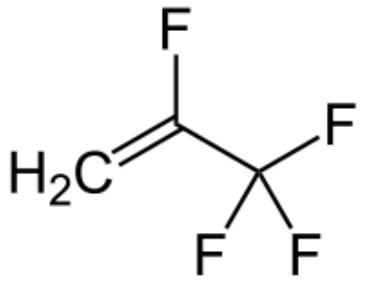
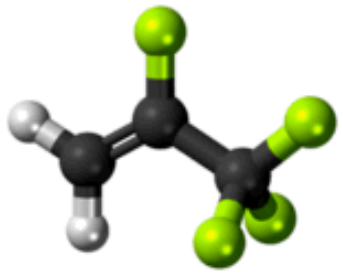
A tool to compare several routes, at the early stages of the R&I process



2,3,3,3 Tétrafluoropropène





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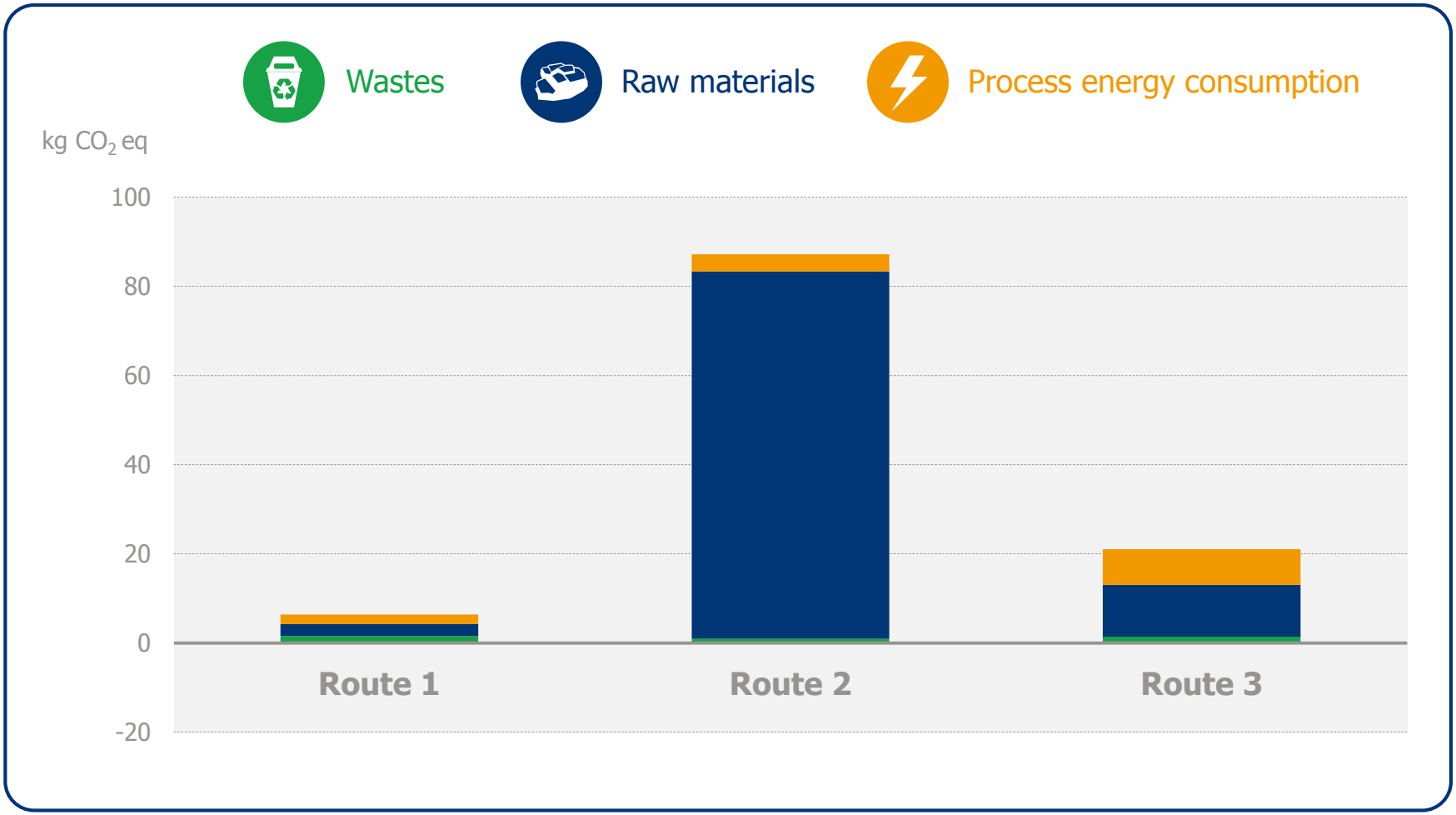

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Conclusion

Long way from the idea to the first commercialization

Life cycle analysis: the key parameter involved in the choice of new products and processes

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