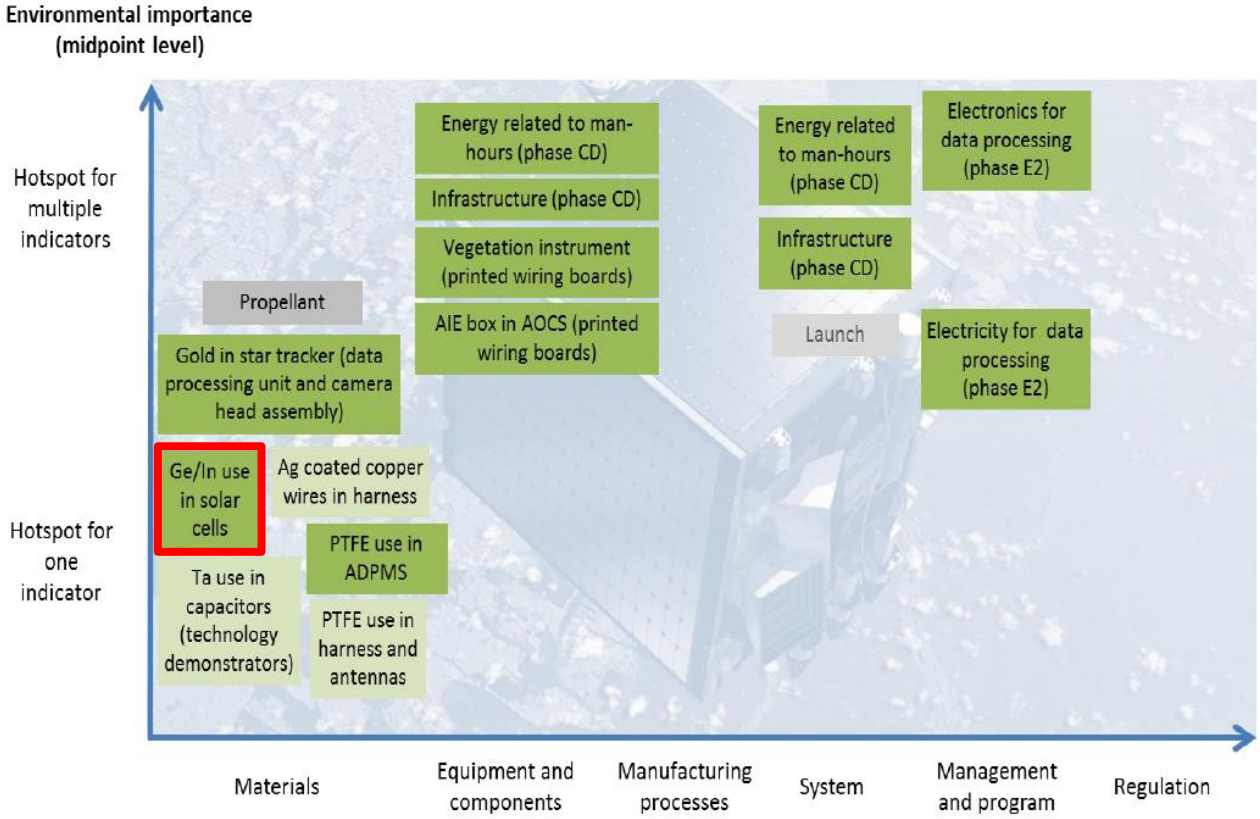
umicore

# Increasing Ge resource efficiency for future low-$CO_2$ multijunction solar cells

**R. Kurstjens, M. Schurmans, K. Dessein**

# Ge as environmental hotspot in space missions

## Hotspots of Proba V



# Who we are

## A global materials technology and recycling group

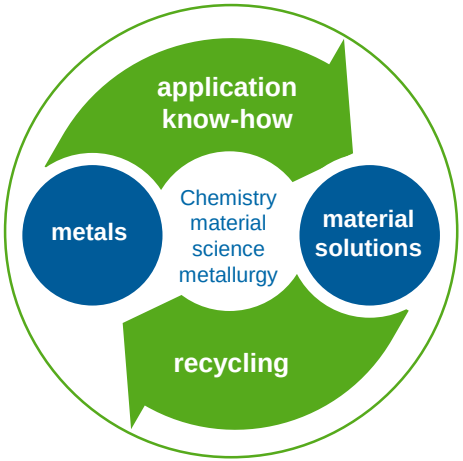
One of three global leaders in emission control catalysts for light-duty and heavy-duty vehicles and for all fuel types

A leading supplier of key materials for rechargeable batteries used in electrified transportation and portable electronics

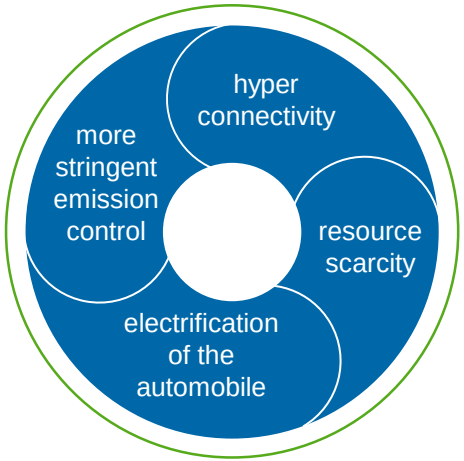
The world's leading recycler of complex waste streams containing precious and other valuable metals

# Our foundations

## Unique business model




## Supportive megatrends




## Industry leader in sustainability

# Umicore’s strategy

horizon 2020

**By 2020 we have…**

clear leadership in clean mobility materials and recycling

turned sustainability into a greater competitive edge

# Germanium sourcing & supply

## 2015 - 2016 Germanium life cycle analysis study (LCA)

Comparing The primary and secondary production of germanium

*Published in Journal of Metal (Jan, 2015)*

| | GWP* (kg $CO_2$ eq/kg Ge) | | |
|---|---|---|---|
| | Recycled | Primary from Zinc residue | Primary from coal |
| To GeCl4 | 160 - 240 | 619 | 5566 |

- Recycling of Germanium can be done both by hydro- or pyro- metallurgy.
- Germanium is hydrometallurgically removed from Zinc ore, prior to the actual Zinc refining.
- Coal needs to be burned off without energy recovery, in order to extract the Germanium.

Primary Germanium from Coal has a Global Warming Potential that is 10x higher than Germanium from other sources

** GWP : Global Warming Potential*

# EOM vision on Sustainability

- Main focus is on Sustainable Sourcing of Germanium
- Adherence to Umicore's Sustainable Procurement Charter is the baseline
- Key differentiator for EOM is to establish a germanium supply chain with minimal $CO_2$ impact

→ EOM's target is to reach 100% sustainable Ge

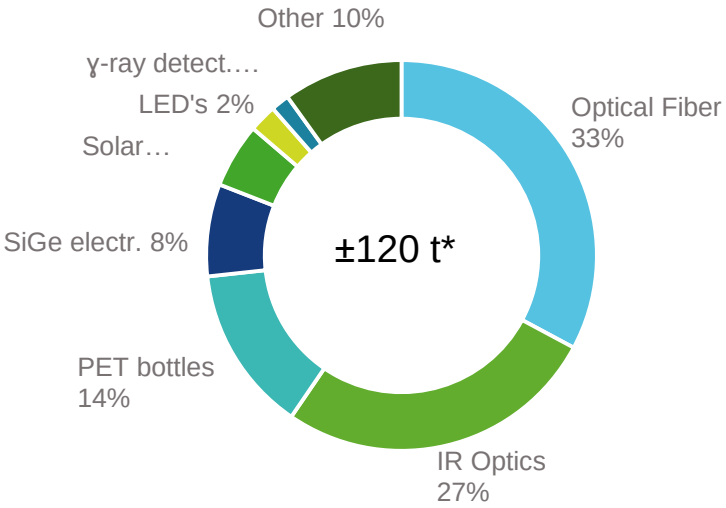
# Approach

- Primary sourcing: NMC (No More Coal) Ge sources
- Secondary sourcing: maximize Ge from recycling
- Quantify by Life Cycle Assessment (LCA)
- Education of customers and connect to their sustainability models
- Involve entire downstream value chain

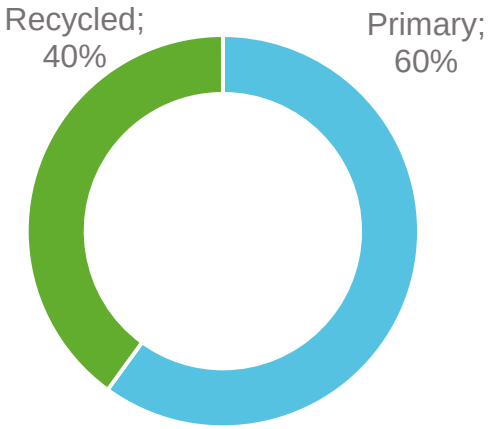
# Germanium sourcing & supply

## We focus on developing recycled Germanium sources

### Annual Germanium consumption




### Umicore Germanium supply

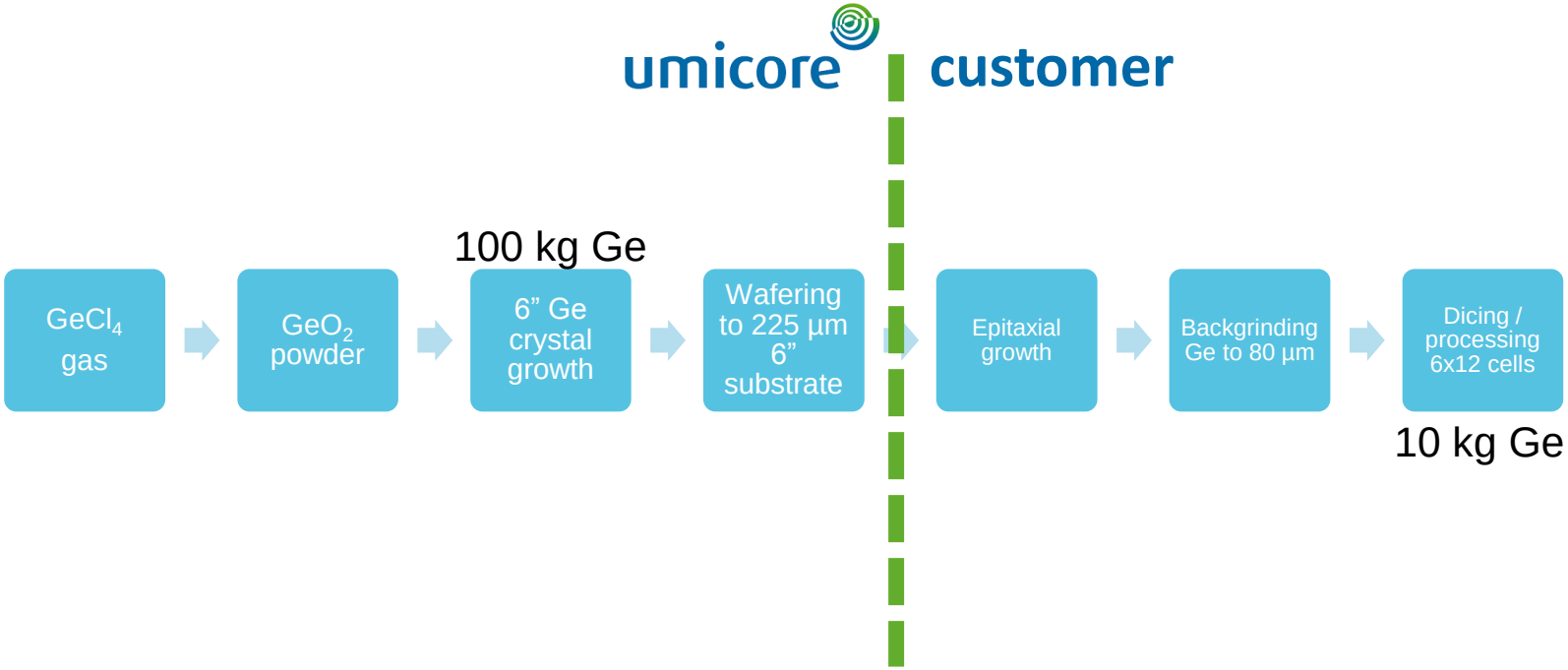



We actively develop recycled Germanium sources from various application areas which makes us less dependent on coal based sources

* Annual fluctuations are in the order of ± 15%

# Current substrate + process flow

## Ge utilization example for 6x12 cm² cell of 80 µm




Closing the loop is vital due to today's low efficiency usage of Ge for this product

# Current substrate + process flow

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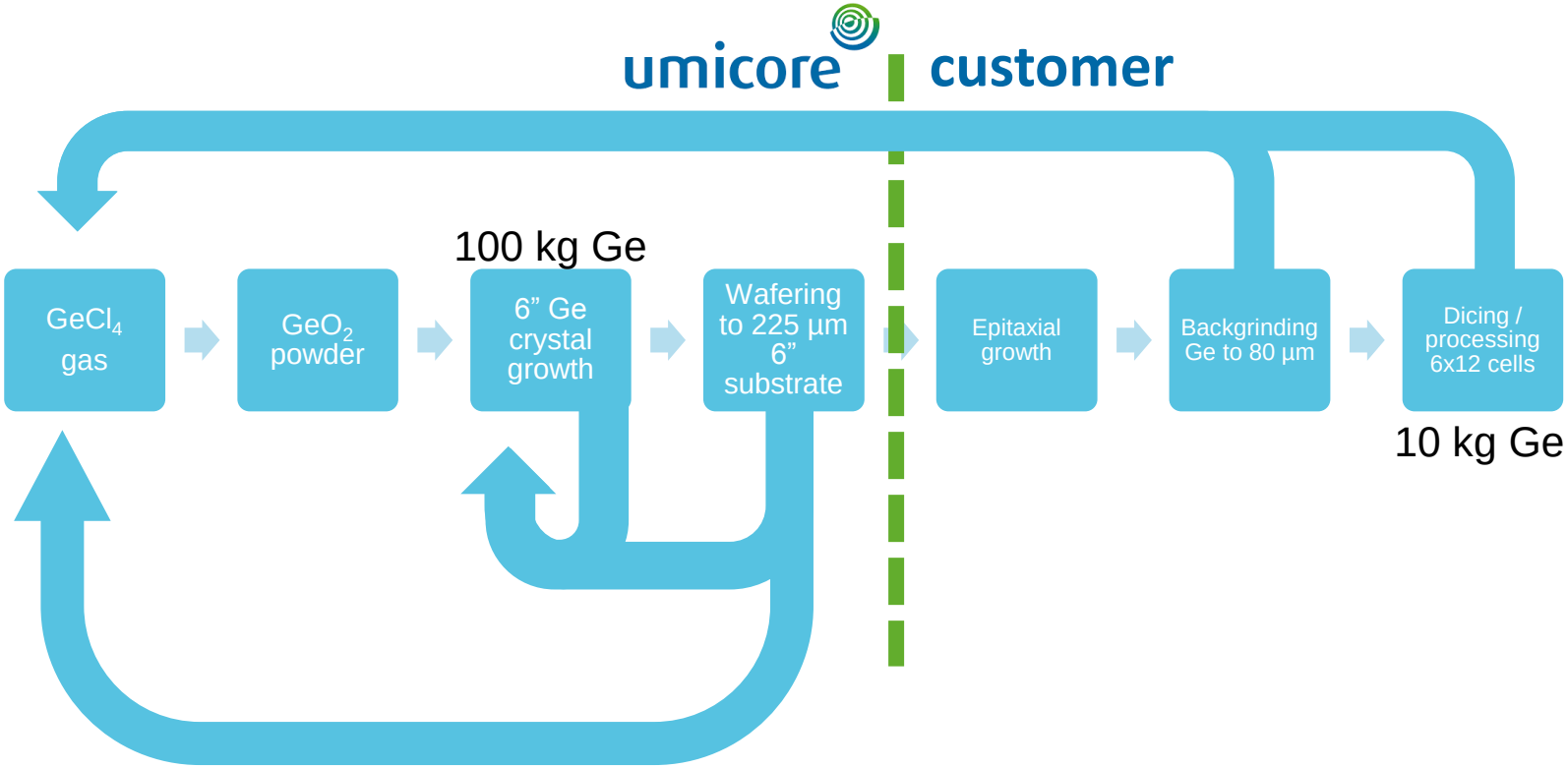
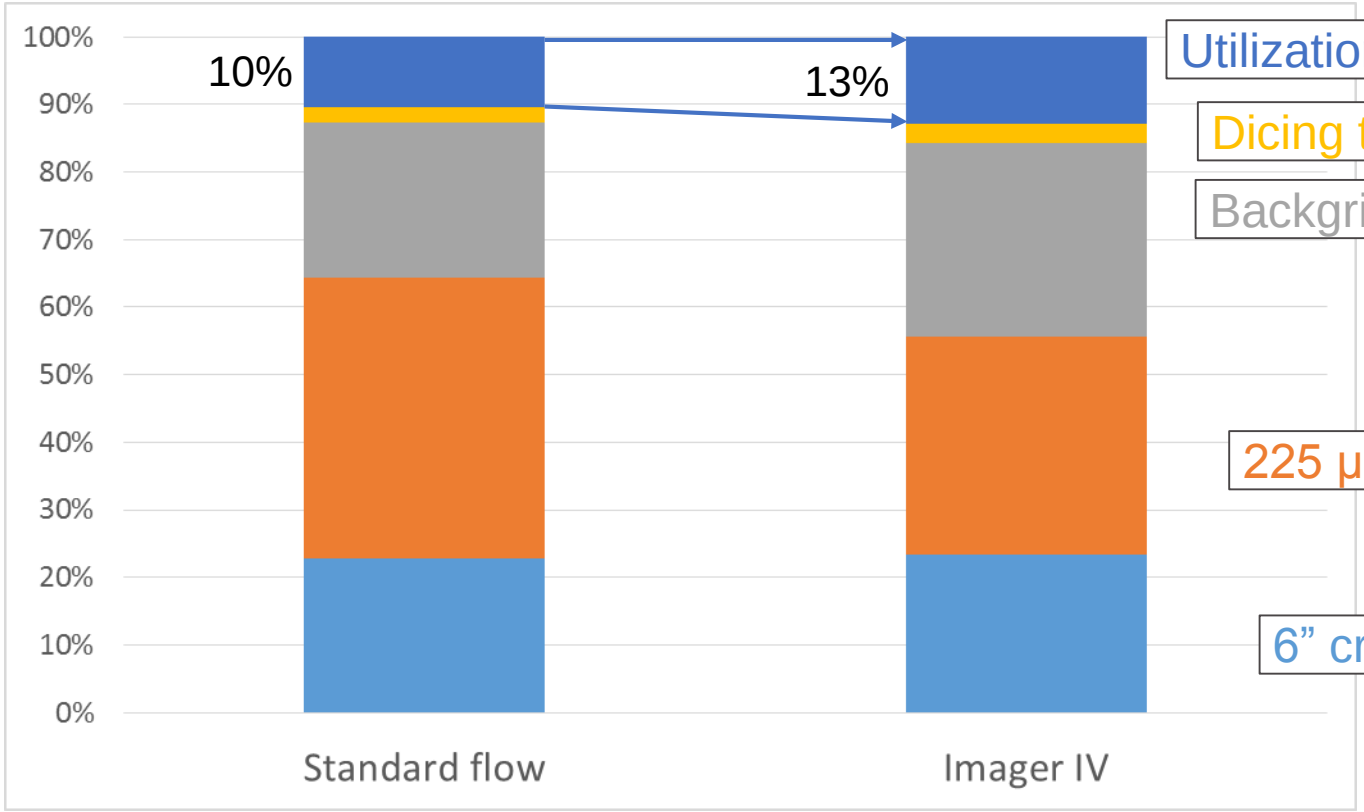



Closing the loop is vital due to today's low efficiency usage of Ge for this product

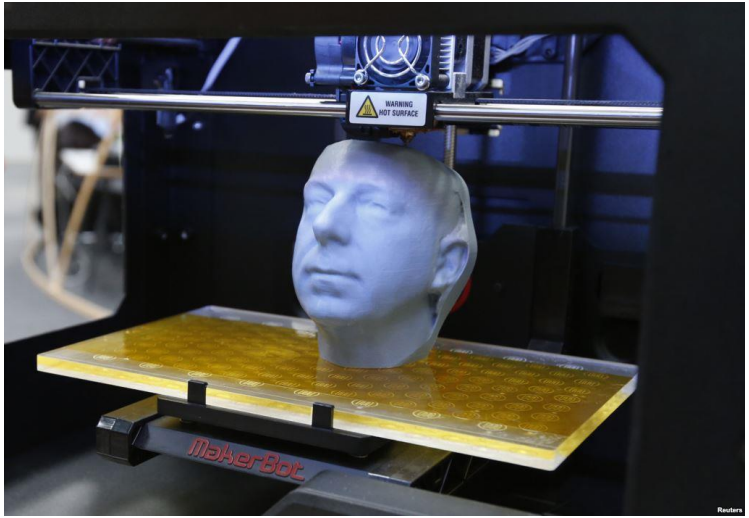
# Coming soon to a solar cell near you

## ESA Imager IV: reduced losses in wafering




Current projects target incremental improvements

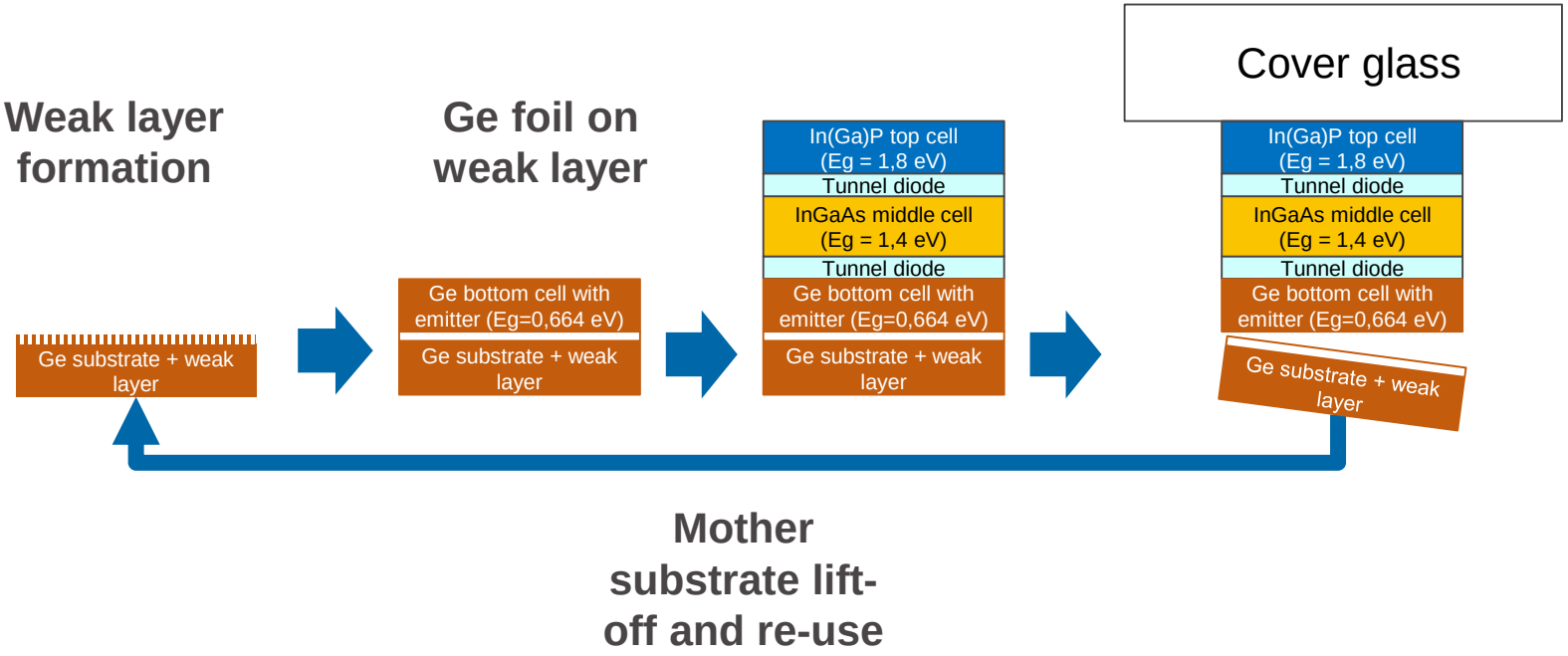
# From subtractive to additive manufacturing



# Substrate process flow of the future

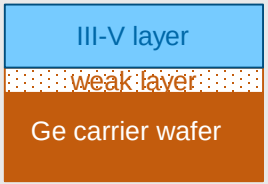
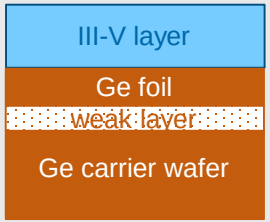
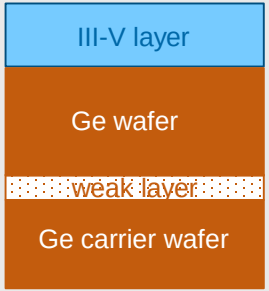
## Thin film Ge substrates by additive manufacturing

Only launch the Ge you need!



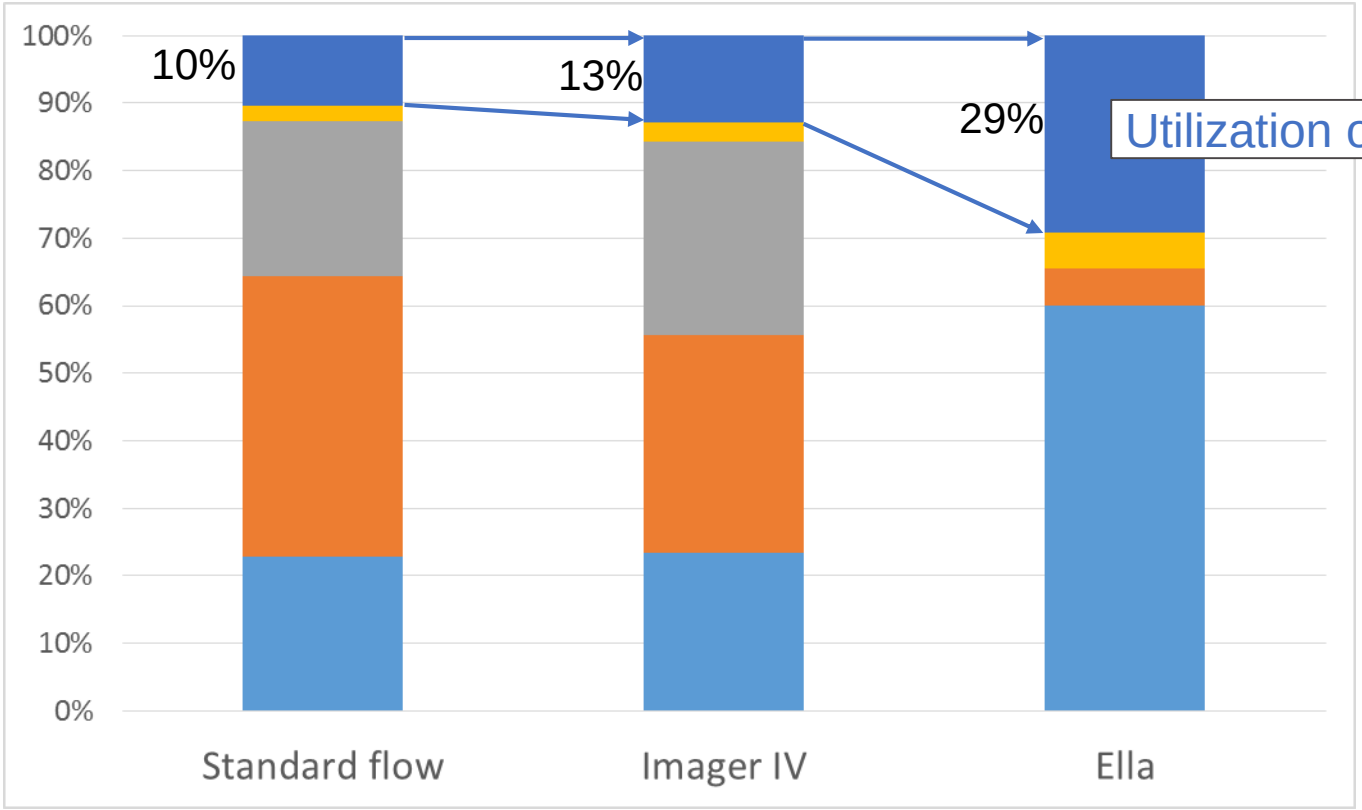
# Substrate process flow of the future

## Thin film Ge substrates

| |  |  |  |
|---|---|---|---|
| Product code name | ELLA III | ELLA II | ELLA I |
| Ge thickness | No Ge | < 80 µm Ge | > 80 µm Ge |
| Potential uses | • Ge-less III-V multijunction cell concepts<br>• III-V on Si multijunction cell (i.e. cell concepts of ISE or NREL)<br>• Replacement of ELO (i.e. for Alta Devices)<br>• III-V on Si hybrid integration for photonics | • Thin film lattice matched multijunction solar cell (replacing backgrinding/etching/ spalling/ELO) | • Ge drop-in replacement wafer (replacing Cz crystals and wiresawing) |

# Substrate process flow of the future

## Ge utilization example for 6x12 cm² cell of 80 µm

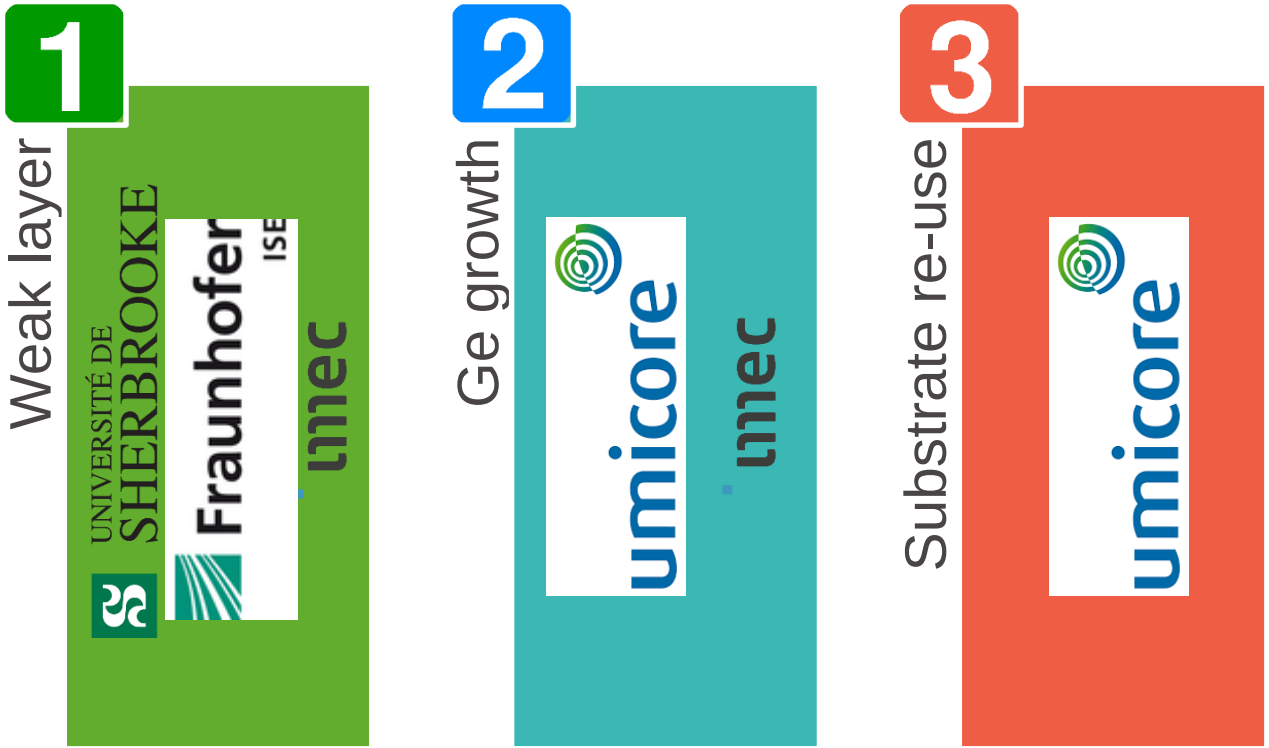



The targeted reduction in Ge need is roughly a factor of 3

# One small step

- Project has received the green light from Umicore / EOM management
- The consortium of partners is nearly formed
- 2 Initial de-risking projects have started and 1 is targeted to start in November 2018
- Full project proposal to be written in months to come

# Project team

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# Thank you