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Pure Silicon Carbide

NEW MATERIALS FOR SUSTAINABLE LIVING

Unleashing the disruptive potential of silicon carbide

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SUMMARY

PSC is a Berlin-based startup offering game-changing technologies for silicon carbide (SiC) through a licensing model.

With use cases across a broad range of industries, we develop cleantech applications with a high potential for greenhouse gas reduction. Presently, PSC focuses on **anode material for lithium-ion batteries,** coatings with silicon carbide and 3D printing of silicon carbide alloys.

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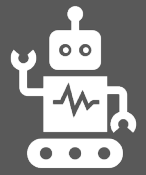
OVERVIEW

BASIC INNOVATION



APPLICATIONS

COMPANY

MARKETS & VALORIZATION

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BASIC INNOVATION

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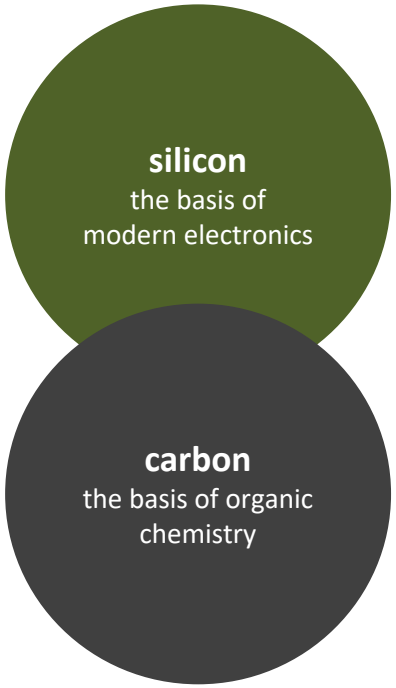
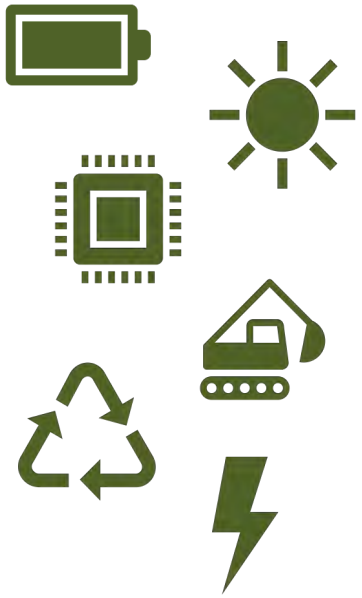
SILICON CARBIDE IN THEORY



two ubiquitous elements

amazing properties



hundreds of applications in clean tech and beyond

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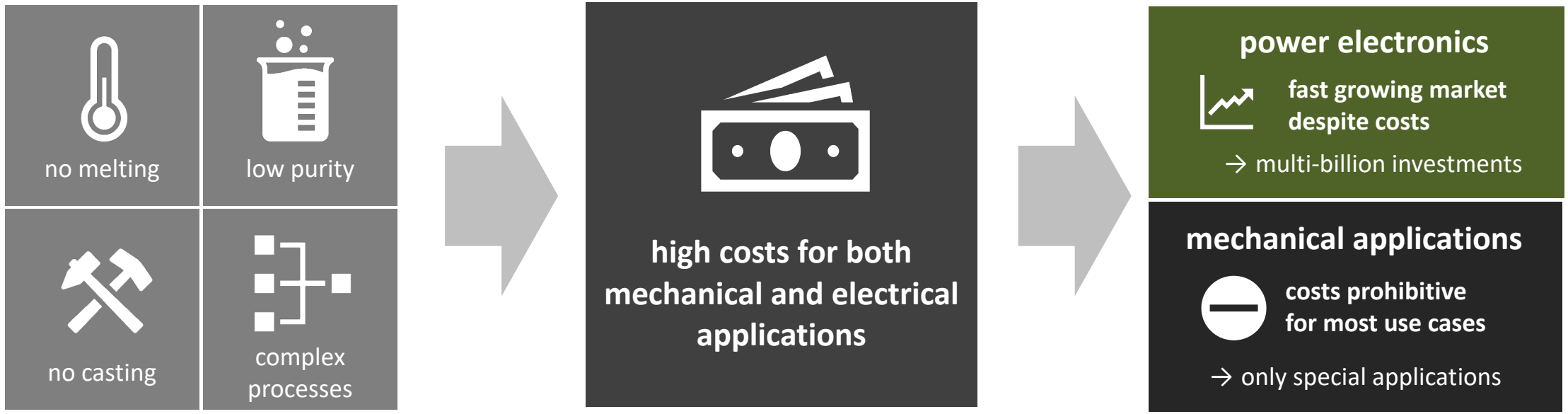
SILICON CARBIDE IN PRACTICE



hard to work with

currently X times more expensive than alternative

underutilized potential

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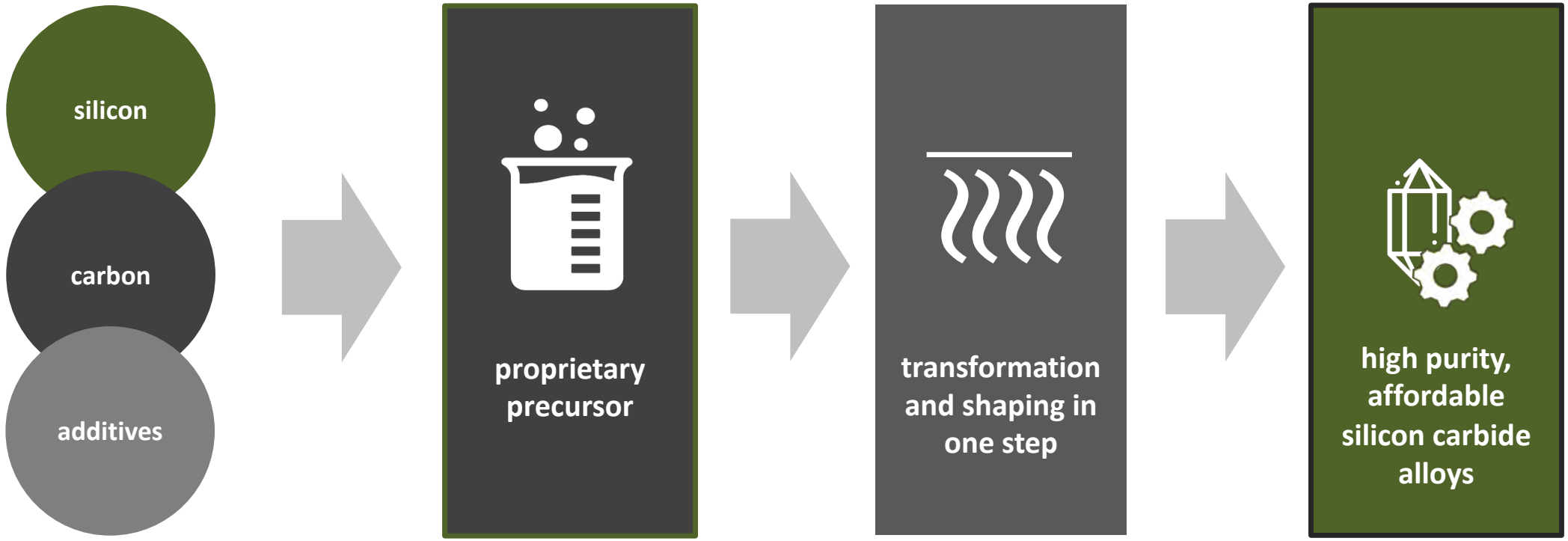
THE INNOVATION: SILICON CARBIDE BY PSC



→ **A new path for producing silicon carbide**

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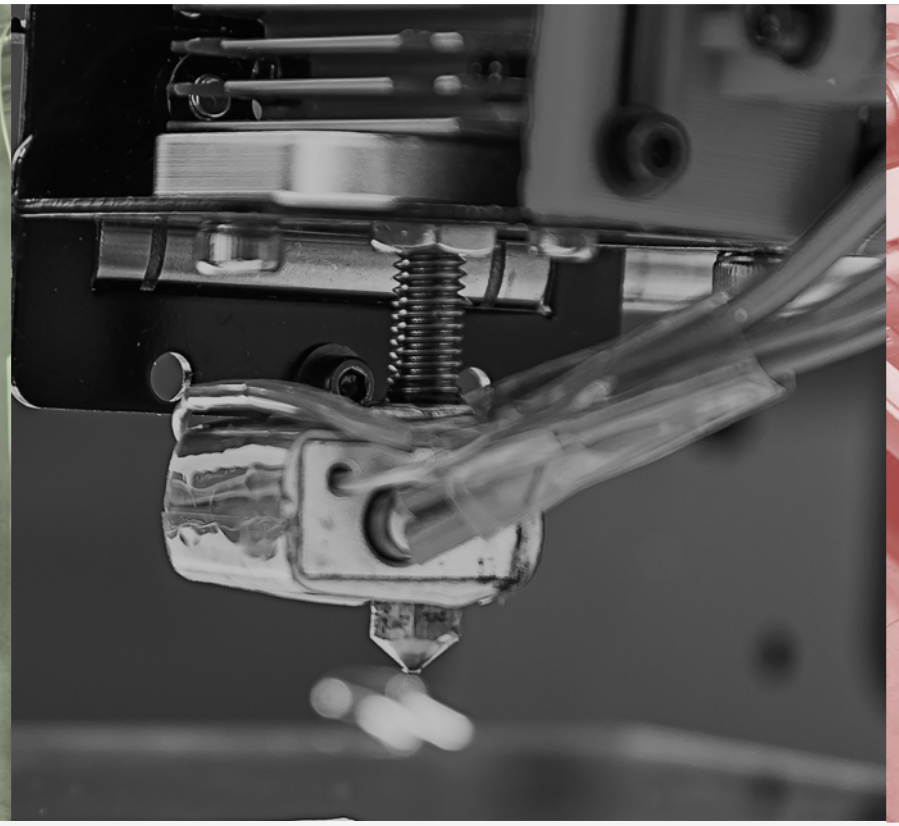

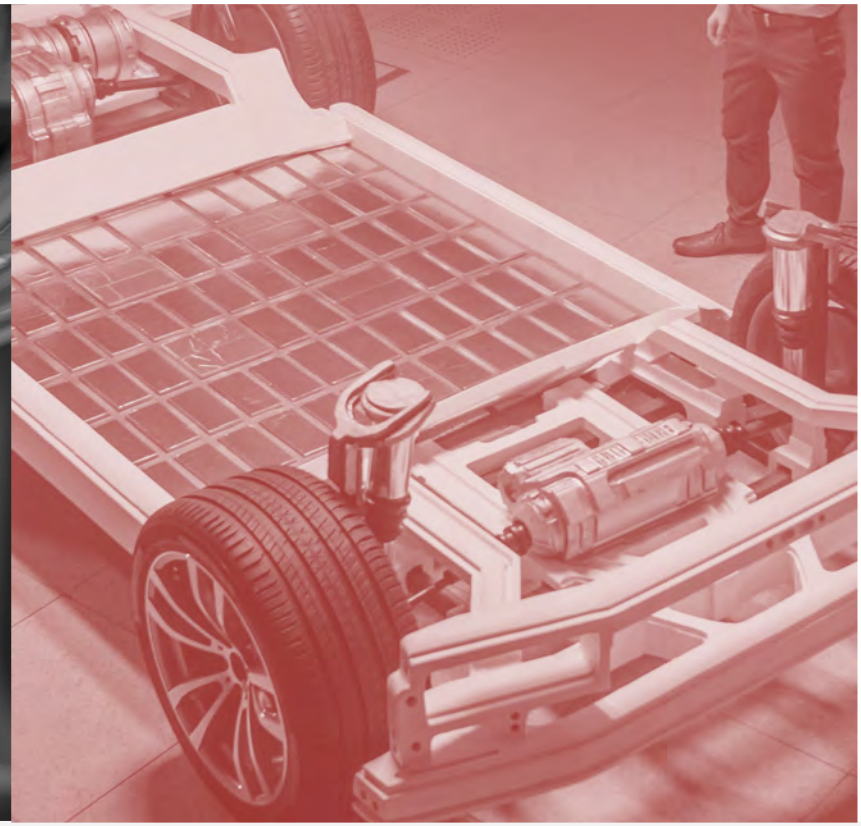

APPLICATIONS

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CLEANTECH APPLICATIONS

proprietary precursors
liquid & granulate

	complexity	climate impact	present focus
SiC-coating heat & corrosion protection			15%
SiC-3D-printing mechanical & electronic parts			on hold
SiC-battery anodes high capacity & lifetime			85%
SiC-solar cells very high efficiency PV			future possibility

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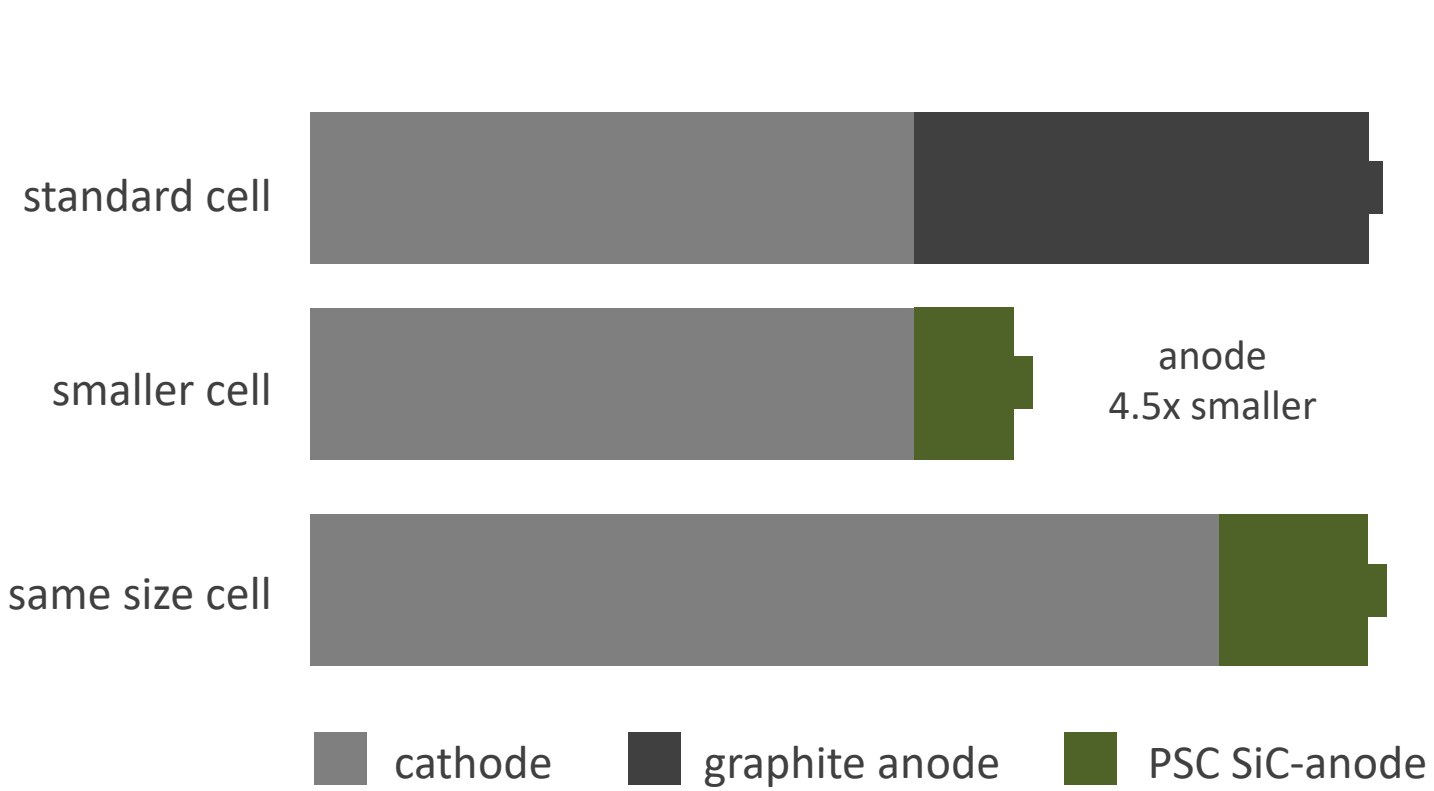
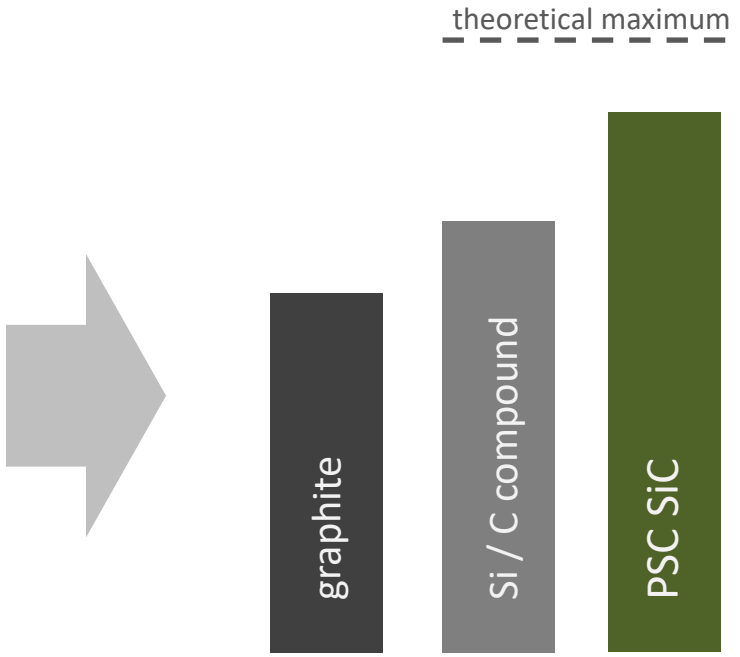
SiC-ANODES FOR LI-ION BATTERIES





> 50 % more capacity than graphite

> 25 % more capacity than Si/C compound

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SiC-ANODES FOR LI-ION BATTERIES

Battery Systems

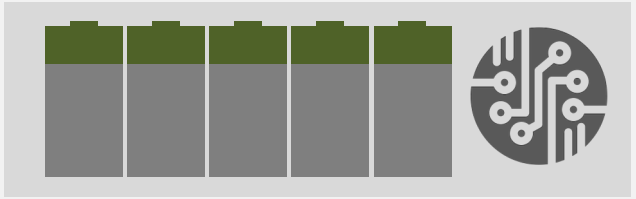
Graphite anode
current technology

capacity
costs

Silicon/carbon compound anode
main contender for drop-in graphite substitution in existing & planned factories (SILA [*Daimler, VW*], nexeon [*Wacker*], SCT)

capacity +20%
costs +-0

PSC SiC-anode
superior performance in all categories



capacity > +50%
costs -15%

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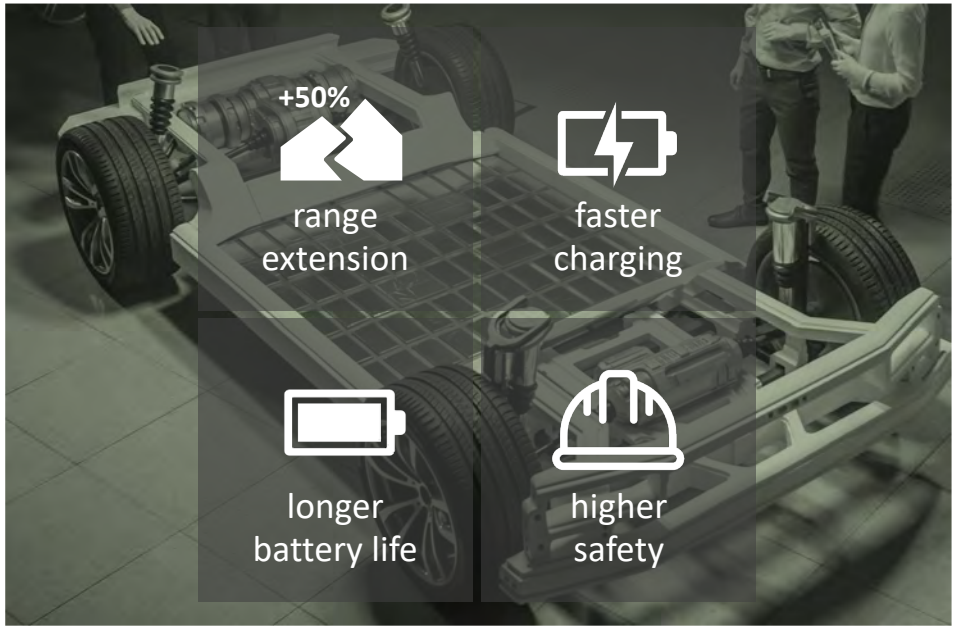
SiC-ANODES FOR LI-ION BATTERIES



until 2030	**SiC in current Li-Ion technology** most performant drop-in anode material for current and planned factories
2030 onward	**SiC in future battery concepts** great potential for use in future battery technologies

strong value proposition for automotive & beyond

competitive technology for decades to come

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SiC-ANODES FOR LI-ION BATTERIES

Why can a small newcomer compete with decades of battery research?

Battery anode research

Si — high potential but expansion problem

decades of research to tame expansion

SiC — high potential but missing technology

PSC SiC: invented in another context

- nitrogen free
- simple processes
- custom nano structures

PSC SiC → +50%

chance match of PSCs materials

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SiC-ANODES FOR LI-ION BATTERIES

Comparison with Competing Technologies

	Graphite	Si/C Compounds	Nanowires	PSC-SiC Anode
available	yes	in development	in development	in development
…for present battery technology	yes	yes	no	yes
density	reference	lower	higher	higher
lifetime	reference	shorter?	as graphite?	higher
safety	reference	as graphite?	???	better
charging speed	reference	lower?	higher?	higher
cell energy density	100%	< 120%	< 150%	> 150%
anode cost per kWh	reference	similar	more	less
battery cost per kWh	reference	higher?	???	less

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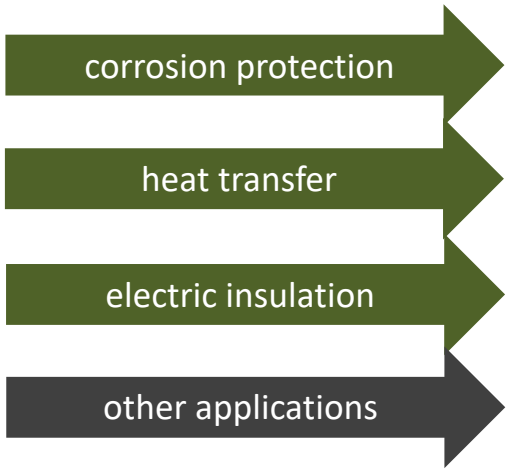
SiC-COATINGS BY PSC



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SiC-COATINGS BY PSC

Process

I. precursor preparation

II. precursor application

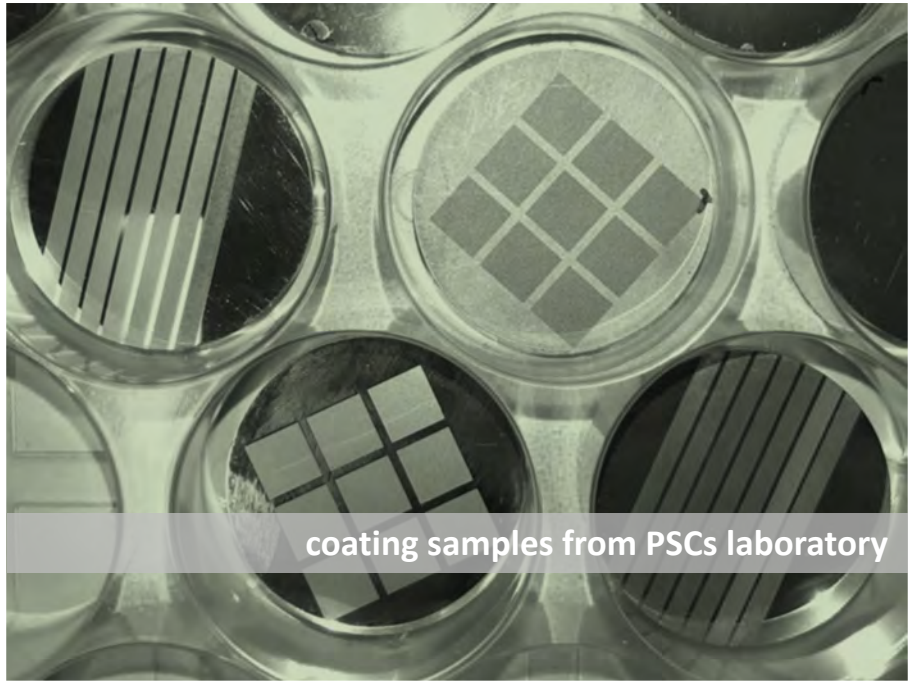
III. transformation to SiC by radiation

Ongoing Pilots

automotive

communication

sensors



coating samples from PSCs laboratory

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SiC-COATINGS BY PSC

Competing Technologies for Ceramics & SiC Coating

Chemical Vapor Deposition
CVD – many providers for SiC & other ceramics

- high quality
- very slow & expensive
- vacuum chamber
- >1000°C high substrate temperature
- noxious gases

Thermal Spray Coating
ThermaSic (Seram Coatings) for SiC
many providers for other ceramics

- particles in metal matrix
- cheaper than CVD
- no vacuum required
- >1000°C high substrate temperature
- lower toxicity than CVD

PSC SiC Coating
proprietary process

- SiC & SiC-alloy coating
- very fast & cheap
- no vacuum required
- low substrate temperature
- no toxic gases or elements

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SiC-3D-PRINTING BY PSC

2017
first patents on SiC 3D-printing technology

November 2018
acquisition of commercial metal printing machine for development

Early 2019
extensive testing of printing strategies and crystallization

Mid 2019
first successful SiC-prints
low speed and material density

SiC requires much lower laser power and longer exposure times than metal
-> new opportunities using high-speed printing technology

Early 2020?
starting development of high-speed printer with machine manufacturers

Early 2021
high-speed printer available

2021
printing SiC gets cheaper than printing metal

development currently on hold
depends on available resources

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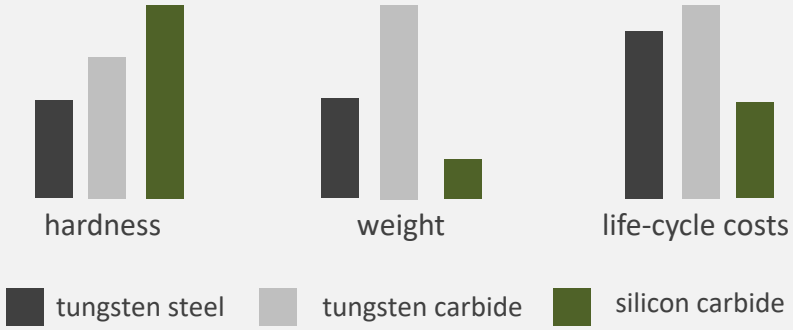
FIRST MARKETS FOR 3D-PRINTING

Tools

substituting tungsten steel and tungsten carbide



2.7 bn tool steel world market 2019

15 bn tungsten powder world market 2016

mechanical parts
for optics and micromechanics

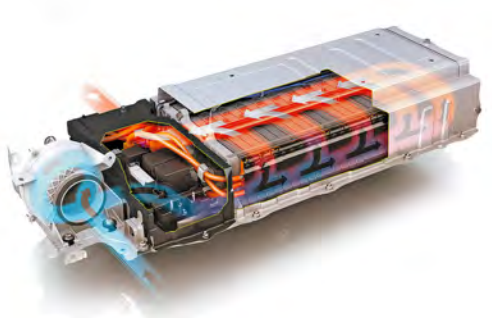
heat management
in electronics, batteries…

wear parts
in machine and plant construction

→ 3D printed SiC will be cheaper than 3D printed aluminium

→ 3D-PSC-SiC competes with special ceramics from 3M, Ceramtech etc.

battery temperature management system



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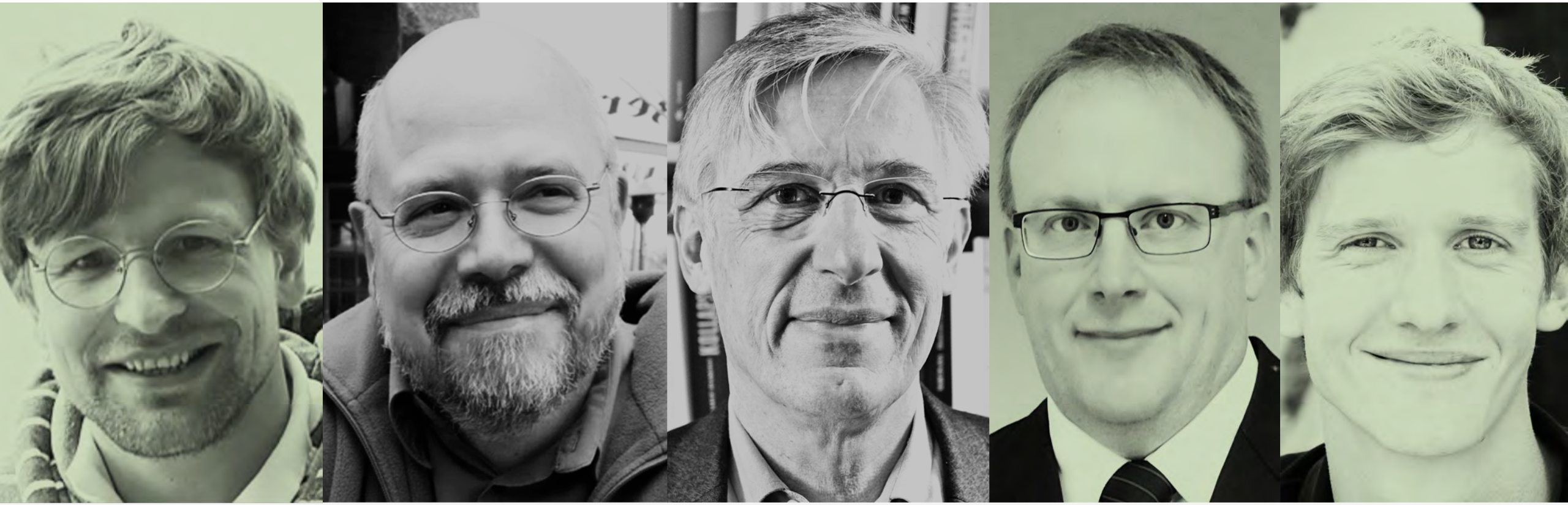

COMPANY

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COMPANY DEVELOPMENT

A Berlin startup based on decades of research

Late 1970s
Prof. Greulich-Weber starts working on perfecting the crystallization of silicon

Early 1990s
Greulich-Weber turns to silicon carbide

2015
Founding of PSC to transfer SiC-research to industry. Greulich-Weber gives up his chair at the University of Paderborn

2017
5 patent applications
First investors

2018
PSC moves to new laboratories in the Berlin-Adlershof Science Park

Mid 2019
End of stealth mode
Presentation at fairs and conferences

November 2019
7 employees
10 own patents pending

ACADEMIC RESEARCH | FOUNDING PHASE | DEVELOPMENT PHASE

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THE TEAM

Prof. Dr. Siegmund Greulich-Weber
Experimental physicist, *1957
Co-founder, managing director, CTO
Technology & Innovation

Basic research on silicon (since 1970s) and silicon carbide (since 1990s) at Univeristy of Paderborn ✦ Head of AG "Hybrid Materials for Photonic Applications" ✦ Cooperations with Wacker, Schott, Siemens, Realizer, SLM Solutions ✦ Scientific management at Solar-Weaver GmbH

Ruggero Schleicher Tappeser
Dipl. physicist, social scientist, *1952
Co-founder, managing director, CBDO
Business Development

Founder & Head EURES Institute for Regional Studies in Europe KG, Co-Founder SQM-Praxis GmbH ✦ Secretary General Alpine Convention ✦ Indep. consultant sustainablestrategies.eu ✦ Advisor on the establishment of IRENA ✦ Coordinator of the European Gigawatt Project xGWp on behalf of Fraunhofer, CEA and Meyer Burger

Erik Thiel
Dipl.-Ing. Mechatronik
coating and 3D printing specialist

Dissertation at Federal Institute for Materials Research and Testing (BAM)
visiting lecturer TU Berlin
2009-2014 WOM GmbH

Dr. Holger Mikus
Chemist
battery specialist

2008-2019 Li-Tec Battery GmbH:
developer, head of prototype production
Dissertation at Universität Siegen

Tobias Thiede
Physicist
material scientist

Dissertation at Federal Institute for Materials Research and Testing (BAM)
MA University of Potsdam, WHK

Paul Knappe
Chemistry lab technician

Philipp Kosikowski
Physical-technical assistant

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MARKETS & VALORIZATION

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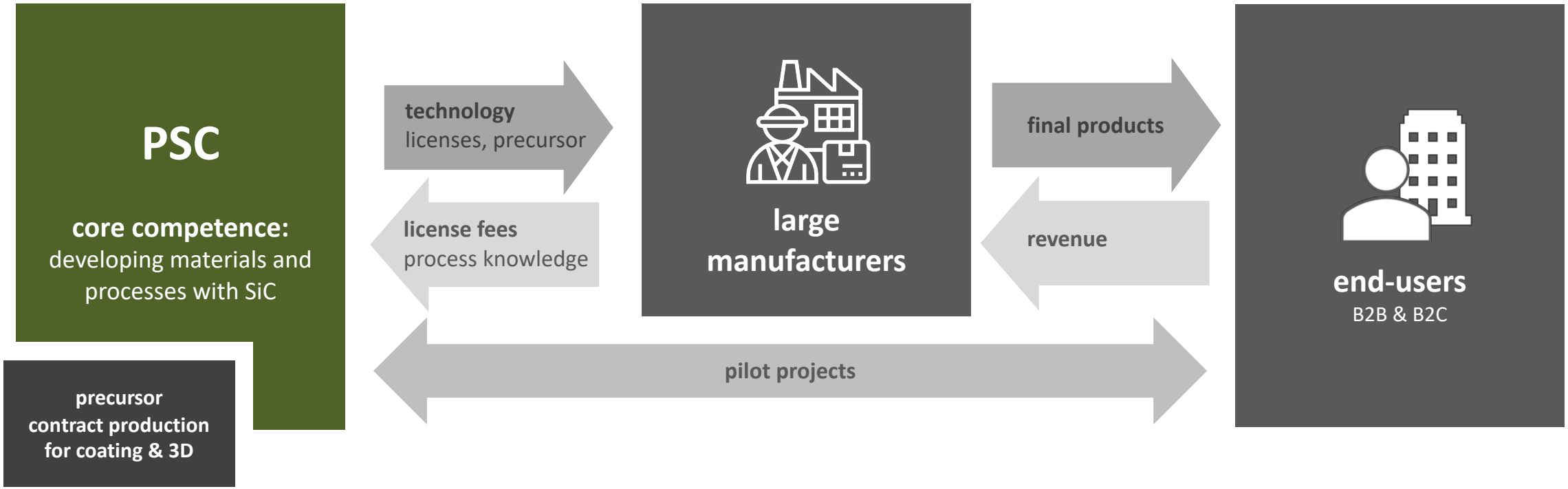
BUSINESS MODEL



→ **fast scaling through cooperation with large organisations**

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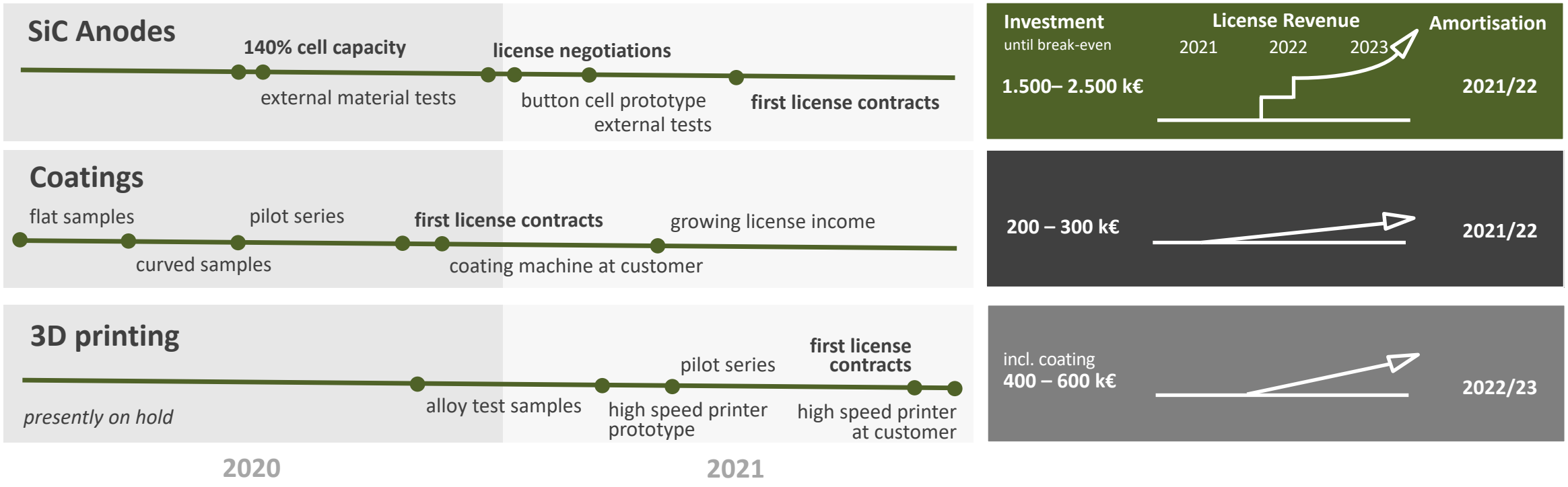
TECHNOLOGY DEVELOPMENT TIMELINE



speed depends on available resources and priority focus

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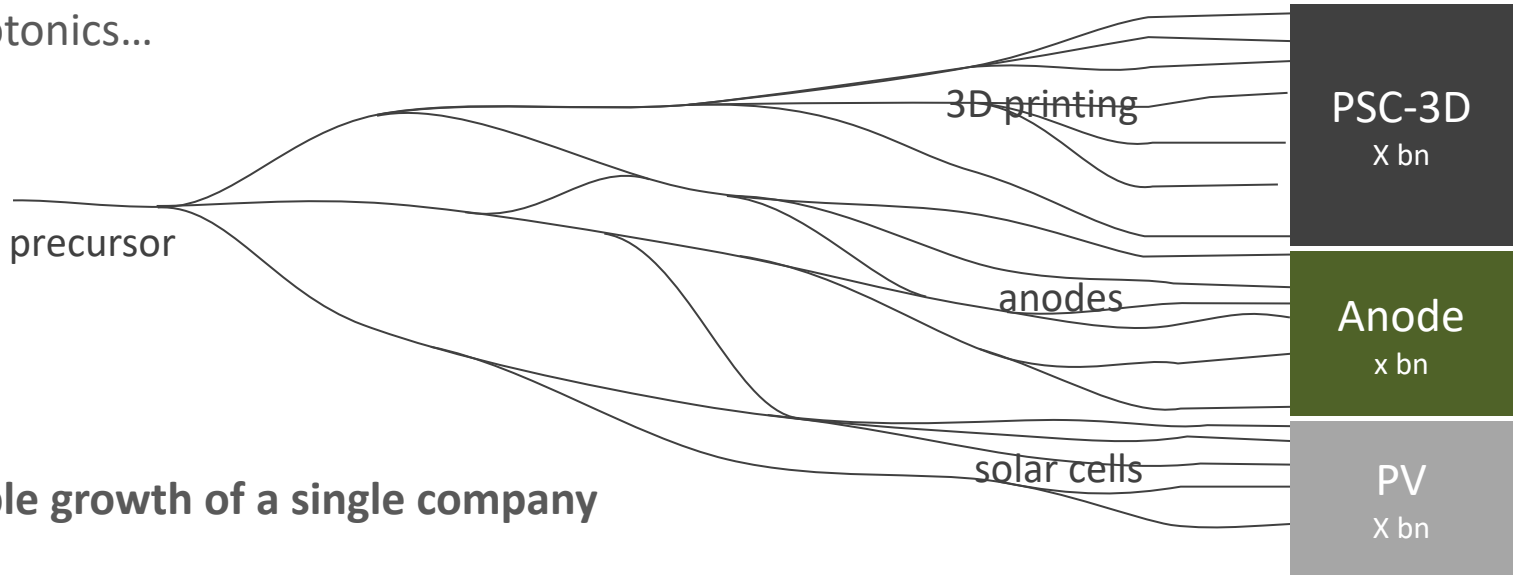
DEVELOPMENT PERSPECTIVES

Disruptive technologies for markets already developing disruptively

miniaturisation, lightweight construction, power electronics,
energy storage, electromobility, photonics…



→ **market potentials exceed possible growth of a single company**

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MARKET POTENTIALS

			markets 2030	potential "PSC inside"	added value PSC	potential PSC's tech	required marketing effort
Anodes for Li-ion batteries	anode material	Li-Ion battery market **2024: 92 bn $** CAGR 16%, anode 7%	anodes **15 bn**	**30%**	**100%**	**5 bn**	**low**
Coatings	ceramic coatings	ceramic coatings market **2020: 10 bn $** CAGR 7.5%	**20 bn**	**10%**	**50%**	**1 bn**	**high**
3D SiC printing special markets	heat exchangers, cooling elements, lasers, sensors, medical, tools, filters, power electronics		**270 bn**	**5% - 10%**	**3% - 40%**	**3 – 5 bn**	**high**
3D SiC printing substitution	substitution of ceramic and metal parts	aluminium casting market **2022: 80 bn $** …				**1 – 5 bn**	**high**
Photovoltaics	photovoltaic cells	photovoltaics market **2026: 330 bn $** CAGR 25 %	**800 bn**	**10%**	**25%**	**20 bn**	**low**

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INVESTMENT OPPORTUNITIES

PSC is looking for

strategic investors
who want to broadly deploy the technologies

investors
wishing to invest for a transitional period

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www.psc-tec.com

Contact: ruggero.schleicher-tappeser@psc-tec.com

VISUAL CONCEPTION & DESIGN: Valentin Tappeser – www.tappeser.com // **ICON & PICTURE CREDITS:** silica carbide (title): Marco Fine/shutterstock.com // chemical reactor (basic innovation): FOTOGRIN/shutterstock.com // spray coating (applications): al7/shutterstock.com // 3D printer (applications): Alex_Traksel/shutterstock.com // electric car (applications): Gorodenkoff/shutterstock.com // screen discussion (markets): SFIOCRACHO/shutterstock.com // Icons from www.flaticon.com: laser icon made by Those Icons // 3D Printer, crystal, fridge, manufacturing and circuitry icons made by Freepik // helmet icon made by xnimrodx // manufacturer icon made by Eucalyp

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ANNEX: DETAILS

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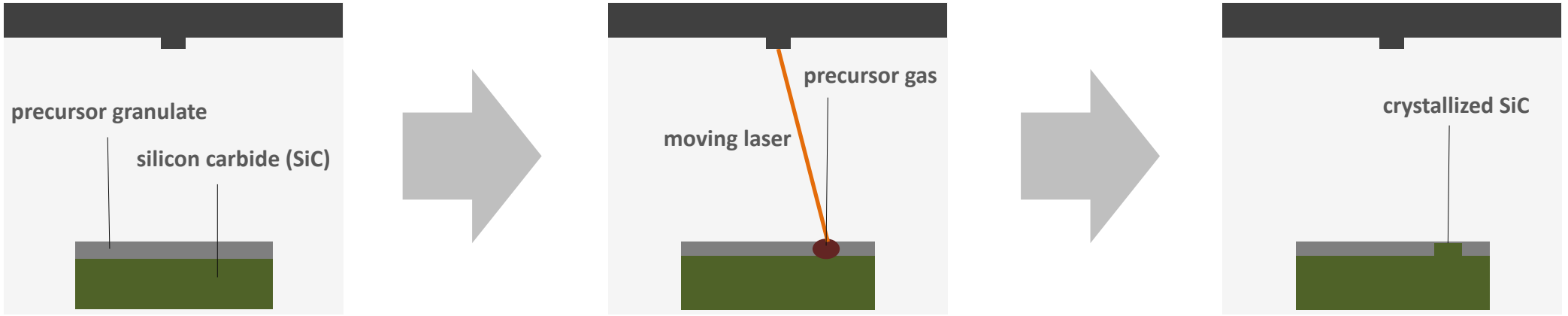
SiC-3D-PRINTING BY PSC

Current Process



Added Value

- arbitrary geometries
- small printers
- custom properties (alloys)

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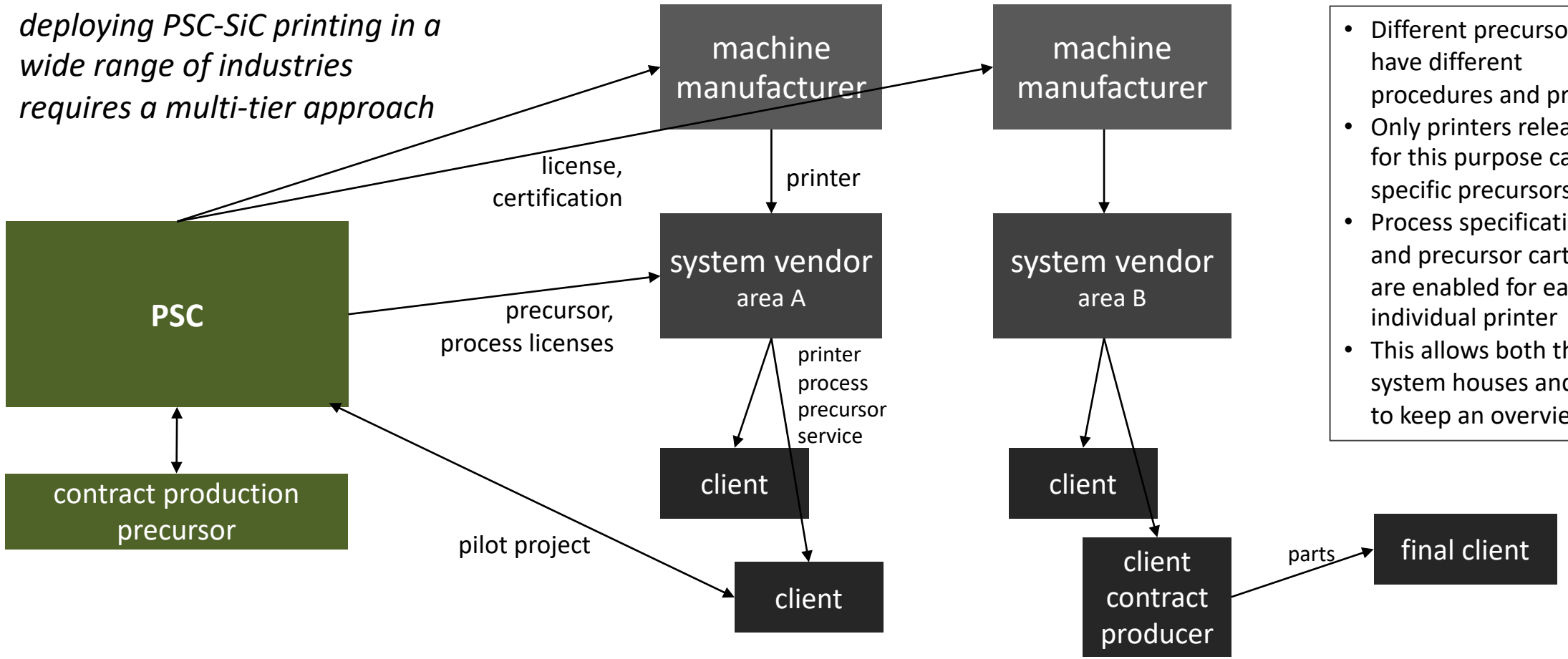
COATING & 3D PRINTING BUSINESS MODEL

deploying PSC-SiC printing in a wide range of industries requires a multi-tier approach



- Different precursors have different procedures and prices
- Only printers released for this purpose can use specific precursors
- Process specifications and precursor cartridges are enabled for each individual printer
- This allows both the system houses and PSC to keep an overview