

# nanomakers

## Materials booster





Develops, produces & sells  
**Silicon-based nanopowders** that  
**disruptively improve** the  
properties of industrial **materials**



# Continuous Innovation

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# Continuous Innovation

- A spin off of  (2010)
- The technology is protected by several CEA patents,  
granted with exclusive rights to  nanomakers
- which pursued innovating and filed several own patents :



Patent Title	Grant dates	Filing dates
"Method for producing multilayer submicron particles by laser pyrolysis" : coated particles ( $\text{Si}\Omega\text{C}$ )	juin 2015 (France)	Juillet 2012 (France) Juillet 2013 (PCT)
"Submicron particles containing aluminium" : $\text{SiC}\Omega\text{Al}$		Nov. 2013 (France) Nov. 2014 (PCT)
"Method for producing a polymer based material"		Sep. 2015 (France)
"Valve and sealed container for submicron particles, and method for using same" : Safe Containers and NanoAirlock valves	sept. 2016 (Japan)	Nov. 2011 (PCT) Nov. 2012 (France)
"Suspension system for sub micron particles in a liquid, and method for using same" : Safe Containers external pump system		Février 2013 (France)



# Continuous Innovation

 nanomakers with & for global partners





Highest quality  
process & products

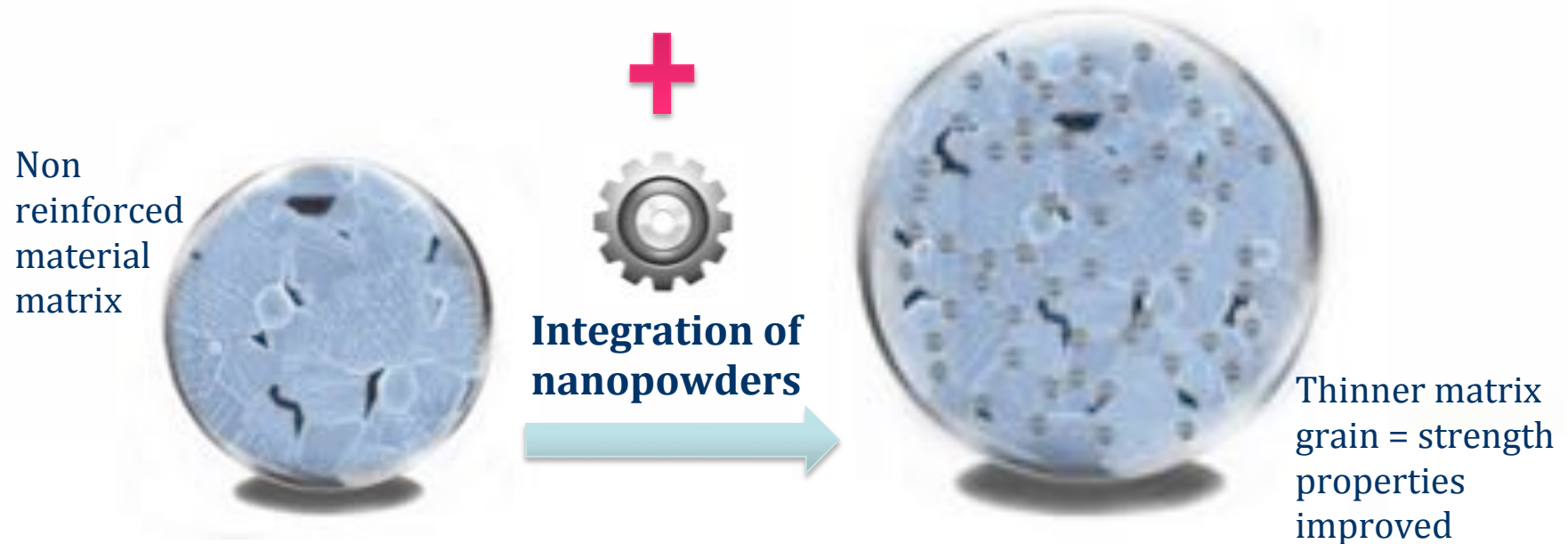
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# Highest quality process & products

**+** The « nano effect» >> improving material's performance

The nano effect: material re-structured at the atom scale



Our value creation lies into dramatic improvement of material performance enabling our customers to offer outperforming products: lighter, stronger, more durable.





# Highest quality process & products

Precise, reliable and secure technology

... guarantee of results

## Laser pyrolysis process:

1. The laser beam breaks the molecules of gaseous or vapor-phase precursors
2. Nanoparticles start building up abruptly
3. Particle size is controlled by a fast quenching which stops the particle growth

## Experience and expertise:

- 33 years of  know how
- 7 years at pilot scale 
- 5 years industrial scale 



 Patented technology



# Highest quality process & products

Laser pyrolysis  ... 4 advantages

✧ **Homogeneous:**

Low particle size deviation.

✧ **Pure :**

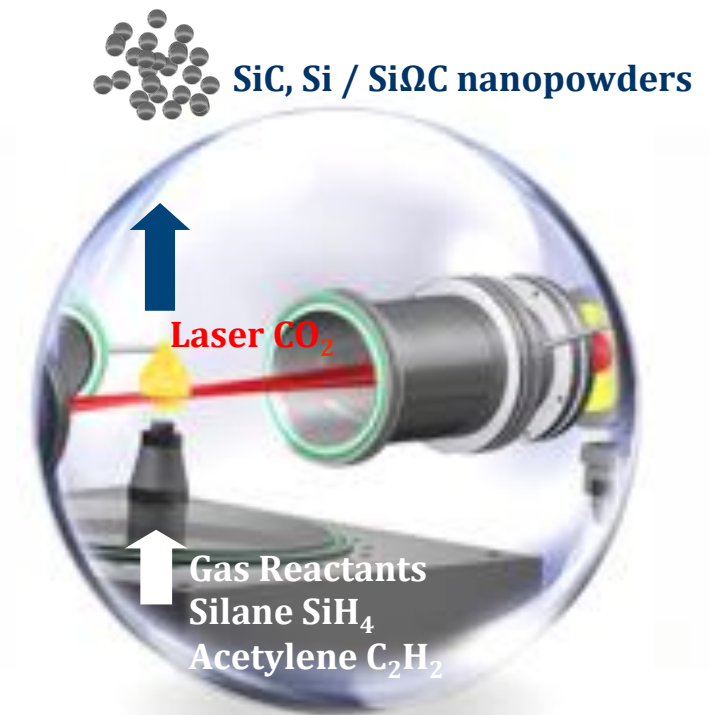
High purity batches, low O<sub>2</sub> & metallic content

✧ **Reproducible:**

Similar particle size distribution, chemical composition from one lot to another.

✧ **Customizable:**

Size, Surface, Coating



*Our customers say* (Eck Industries, April 2014):

« First of all the **quality** of the powder received from Nanomakers was very good. The particle distribution was very **tight** and there was no apparent chemical **contamination**. From a practical aspect that means better incorporation into the melt and shorter processing times to get an acceptable particle distribution. I do not hesitate to say the **Nanomakers SiC** is the **best on the market**. »



# Highest quality process & products

Various value propositions

... under different forms

Si $\Omega$ C |  Very High Purity  
(available 40 & 75 nm)  
internally patented

SiC |  Very High Purity  
(available 35 & 75 nm)  
Mass production

 High Purity « Mass Market »  
(under development)

Value



Flowing  
powder



Granulated  
powder



Suspension



# Highest quality process & products

Superior **quality** recognized ... by experts :

**Kazuya Shimoda** of National Institute for Materials Science (NIMS), Ibaraki and  
**Takaaki Koyanagi** of Kyoto University, Kyoto



**nanomakers = n°1**

- IEST - Institute of Energy Science & Technology Co. Ltd., **Japan**
- Marketch International Inc., **USA**

regarding :

- Particles size distribution, and
- C/Si ratio, and
- Impurities content and O<sub>2</sub>, and
- Industrial production capability

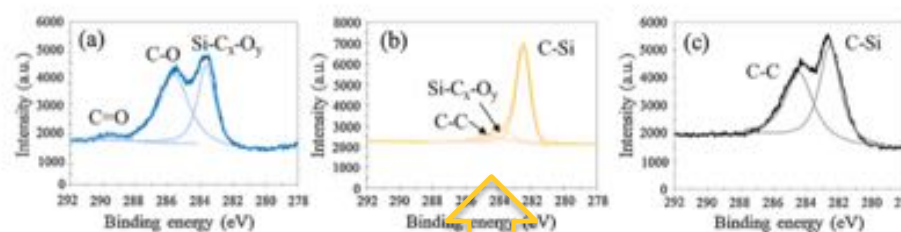
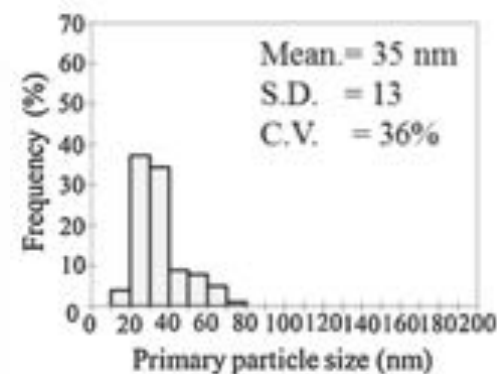


Fig. 7. XPS spectra of C 1s peak for (a) SiCN-1, (b) SiCN-2, and (c) SiCN-3.



In :

« Surface properties and dispersion behaviors of **SiC nanopowders** »,  
in Colloids and Surfaces A: Physicochem. Eng. Aspects 463 (**Sept. 2014**) 93





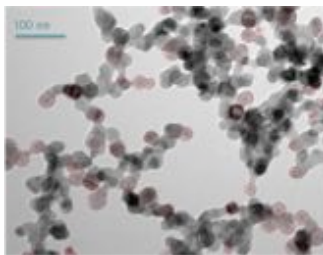

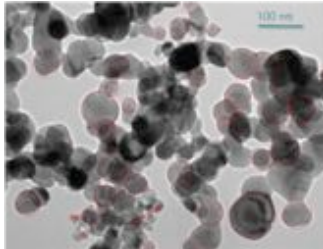


# Highest quality process & products



NM SiC 99

... @ 35 to 75 nm

 NM SiC 99	Color (Free powder)	SSA (m <sup>2</sup> /g)	Density (g/cm <sup>3</sup> )	APS (nm)	Stand. Dev. (nm)	TEM
35nm	 Gray	48 - 58	3,1 – 3,2	35 - 40	<10	
75nm	 Light gray	24 - 29	3,1 – 3,2	65 - 80	<20	



# Highest quality process & products



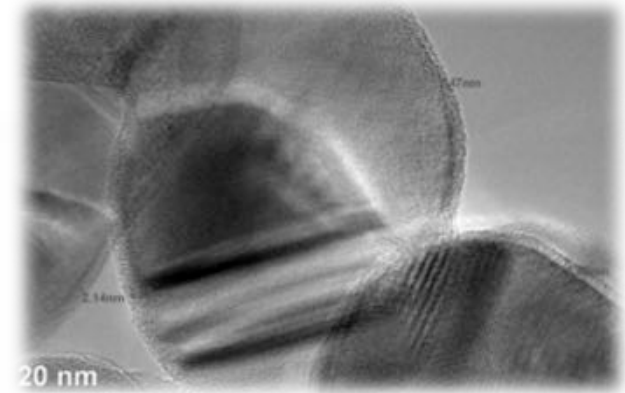
NM Si $\Omega$ C 99

... @ 40 to 75 nm



## Product features:

- Silicon nanoparticles with carbon coating
- Different sizes:
  - 40 nm
  - 75 nm
- **Homogeneous particle size distribution**
- **Crystalline silicon core – mainly amorphous carbon shell (uniform carbon coating of 1-2nm)**
- **Low oxygen content (< 2 % wt.), No SiC, High purity**





# An Industrial Company

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# An industrial company

Industrial production facility in Rambouillet

... since 2012



## ➤ 10-20 Ton/year

- Storage & distribution  AIR LIQUIDE for 150+ ton/year



## ➤ Quality controls

- Procedures, Material Certificate
- Internal laboratory of controls



## ➤ Strategy « 0 contact »

For small and big quantities





















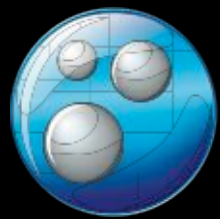
Creating value for  
our customers



# Creating value for our customers

## Examples of applications: mech & chem reinforcement / batteries density

PRODUCT	MATERIAL improved	APPLICATIONS	MARKETS	LOAD nano SiC	VALUE PROPOSITIONS 
SiC 99 	Perfluorolastomers <b>marketed</b>	<b>Very high performances seals</b>	Semi-Conductors (Production equipment) 	10-20%	<b>Purity (ppm)</b> <b>Chemical resistance</b> <b>Seal lifetime</b> Eqpt. reliability & availability
SiC97 	Fluoroelastomers	High performances seals	Aerospace, Automotive 	5-20%	Mechanical performances Seal lifetime
SiC99, SiC97  	Aluminum	<b>Structure Envelope</b>	Aerospace, Defence, Automotive 	2-5%	<b>Lighter vehicle</b> (-30% aluminum mass) Carbon footprint
SiC99, SiC97  	Metallic, plastic or composite powders	<b>Additive manufacturing</b>	Aerospace, Automotive 		<b>Mechanical performances</b>
Si $\alpha$ C99 	Anodes 	<b>Li-ion batteries</b>	Electric vehicles Mobile communication 	15-30%	<b>Energy density (x 2)</b>  Patent n°13 63098



# nanomakers



When infinitely small makes a difference :

the « **Nano effect** »