UNIVERSITÀ DEGLI STUDI DI GENOVA

LIFE12 ENVIT 000295 FIBERS Fibers innovative burning and reuse by Self-propagating High temperature Synthesis (SHS)

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CYPRUS 2016

4th International Conference on Sustainable Solid Waste Management

23 - 25 June 2016

Limassol, Cyprus

A multidimentional problem

- Health and occupational exposure
- Social outreach (local authorities, experts in management, monitoring networks, quality in monitoring…)
- Normative harmonisation (international ban, decommissioning, end of life for waste, second life for inertised products…)
- Environmental (geohazard from ophiolites, waste landfill)
- Technological (substitute materials, effective inerting)

European normative

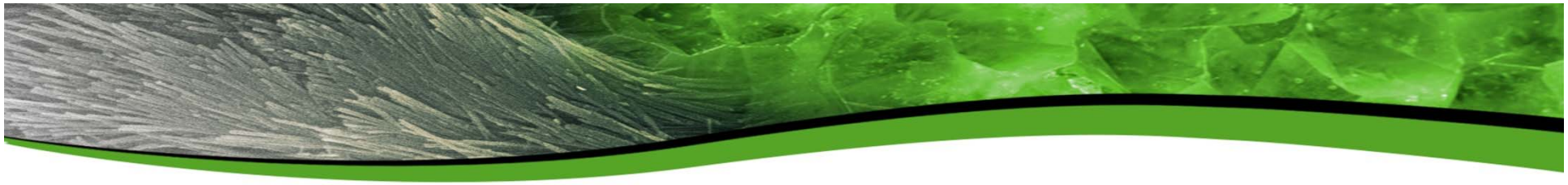
EC directive n. 77 26 July 1999
Starting from 1 Jan 2005 ban of asbestos from EU territory

EC directive n. 148 30 november 2009
Workers protection against asbestos exposure

Following the **WHO** prescriptions:

- All nations should have a "*national asbestos profile*" as for occupational and health responsabilities, as recommended by International Labour Organization (ILO)
- Up to now 55 countries worldwide adhered to total or partial ban of asbestos

Rationale



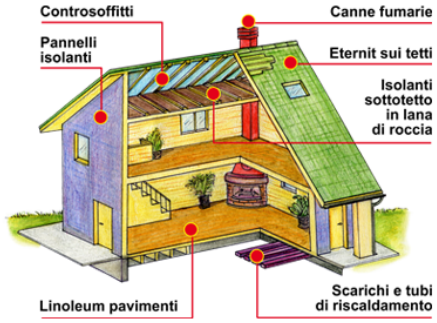
European normative

European Parliament resolution of 14 March 2013
Asbestos related occupational health threats and prospects for abolishing all existing asbestos

The EU proposes to adopt a shared strategy for the total elimination of asbestos still present in buildings, machinery, pipelines, trains and ships of the continent.

The 2028 will be deadline for its completion

32. *Measures must also be taken to promote and support research into, and technologies using, eco-compatible alternatives, and to secure procedures, such as* ***the inertisation of waste-containing asbestos****, to deactivate active asbestos fibres and convert them into materials that do not pose public health risks.*



MANAGEMENT OF ASBESTOS CONTAINING WASTE

LANDFILL OPTION In ITALY

- **73 landfills**
- **23 still operating landfills** host Demolition Waste containing asbestos
- **5 landfills** receive other ACW (total 2000 tons)
- On the whole: 111.202 m^3 residue volume

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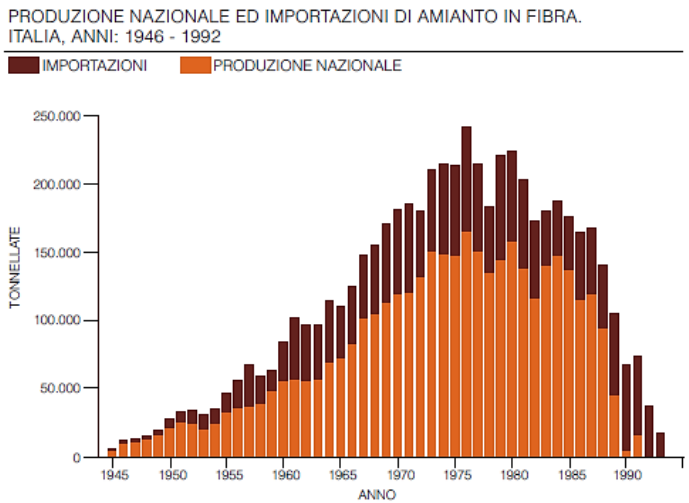
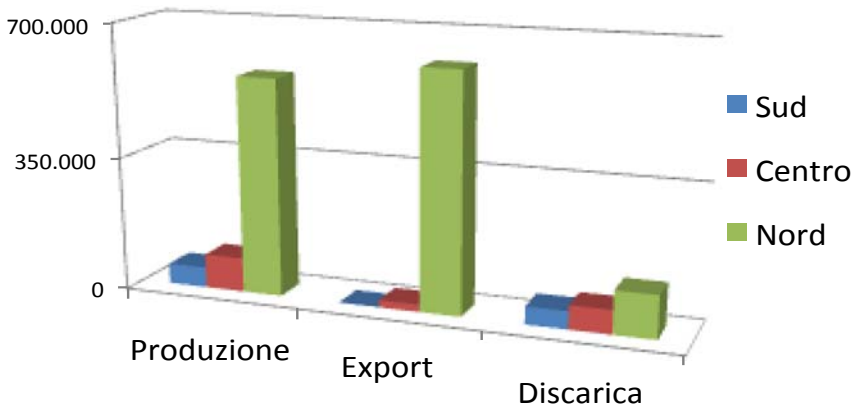
Rationale



Italy has been a major asbestos producer since the 70ies and consumer until the 80ies.
Between world war II and 1992 **4 million tons** of raw asbestos were extracted from the Balangero mine.
The imported amount attained **2 millions tons.**



In 2011 the German Saar region of communicated to the Lombardy region that wouldn't accept asbestos to be landfilled due to the risk of receiving polluted material.

Rationale

Method	Treatment	Cost
Thermal treatment by plasma	Fusion at T > 1600°C	>>500 €/ton
Thermal treatment	Fusion and vetrification with gas or electric ovens	> 150 €/ton
Ceramization	Solid state reactions	80-150 €/ton
Chemical	Dissolution in strong acids or liquids under high pressure	not rated
Mechano-chemical methods	Fibers destruction by high-energy mills	80-150 €/ton

In the perspective of reducing the environmental issue and to explored recycling of the breakdown products, we experimented the use of highly exothermic and fast thermite reactions exploiting the **Self–propagating High temperature combustion Synthesis (SHS)** taking to the **chemical** and **physical** breakdown of fibers

What is a thermite reaction?

An highly exothermic reaction, involving reduction of a metallic oxide by aluminium or another reducing element:

$$\mathbf{AO + M \rightarrow MO + A + \Delta H^\circ}$$

once ignited by means of external heat sources for a few seconds, the reaction proceeds as a combustion wave through the reactant volume without any additional energy input.

The maximum attainable temperature in a reaction of this kind is defined as **adiabatic temperature** T_{ad} estimated from

$$\Delta H^0_{298} = \int_{298}^{T_{ad}} Cp_s(AB)\, dT$$

Because of heat dissipation, adiabatic conditions are seldom reached, as well as the theoretic T_{ad}

As a consequence, the T_{max} attained at the reaction front is the exothermic threshold during the synthesis.

Experimented *(alumino)* Mg-thermic reactions

$Fe_2O_3 + 3Mg \rightarrow 3MgO + 2Fe$ (ΔH_r = -979,22 kJ/mol)

$Fe_3O_4 + 4Mg \rightarrow 4MgO + 3Fe$ (ΔH_r = -1291,10 kJ /mol)

Chrysotile was mixed with Hem + Mg and Mgt + Mg in stoichiometric amounts, according to the following:

1. $Mg_3Si_2O_5(OH)_4 + Fe_2O_3 + 3\ Mg \rightarrow 2\ Mg_2SiO_4 + 2MgO + 2Fe + 2H_2$

(ΔH_r = - 846,43 kJ /mol)

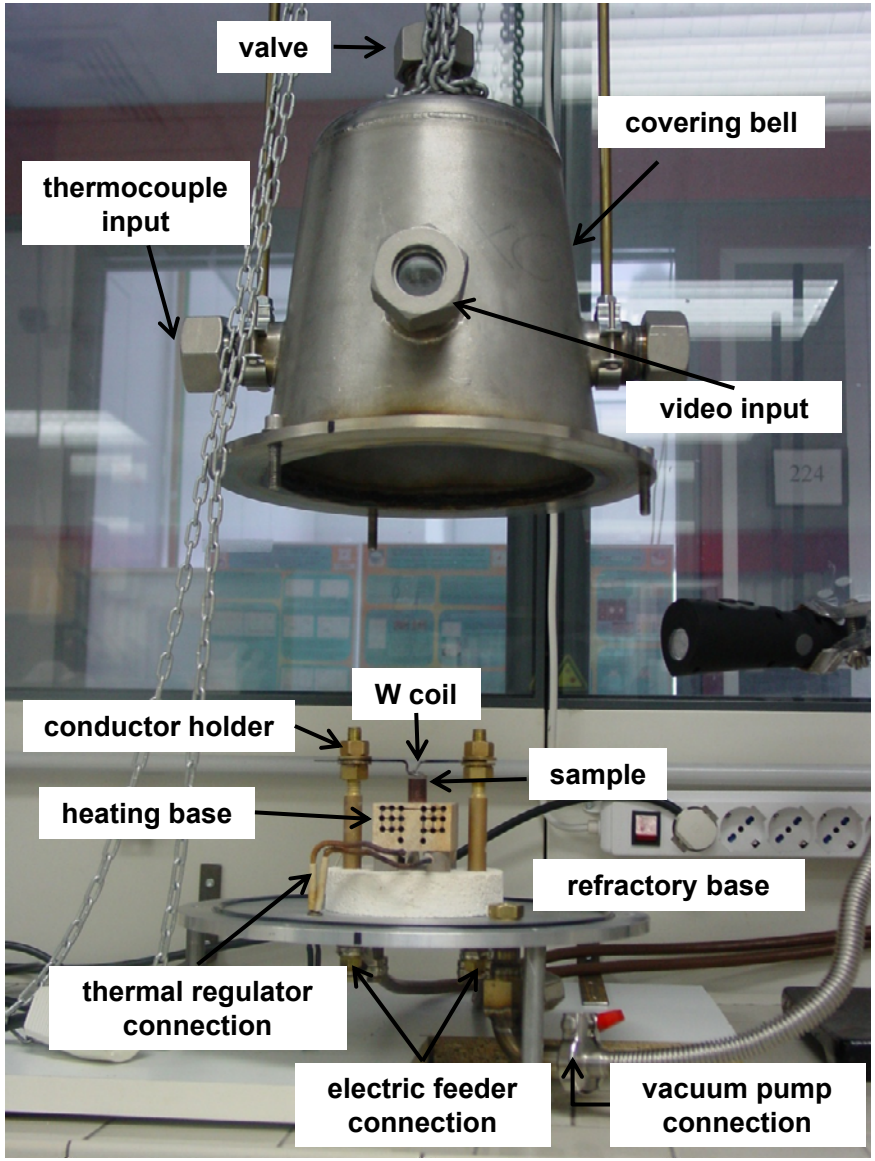
2. $Mg_3Si_2O_5(OH)_4 + 2Fe_3O_4 + 2Mg \rightarrow 2Mg_2SiO_4 + MgO + 6FeO + 2H_2O$

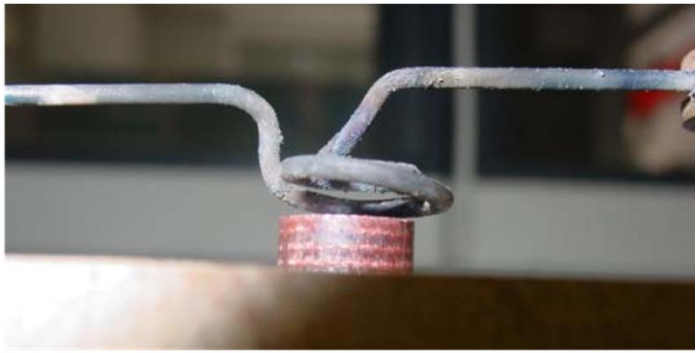
(ΔH_r = - 437,21 kJ /mol)

Chrysotile breakdown – Apparatus

Operating conditions

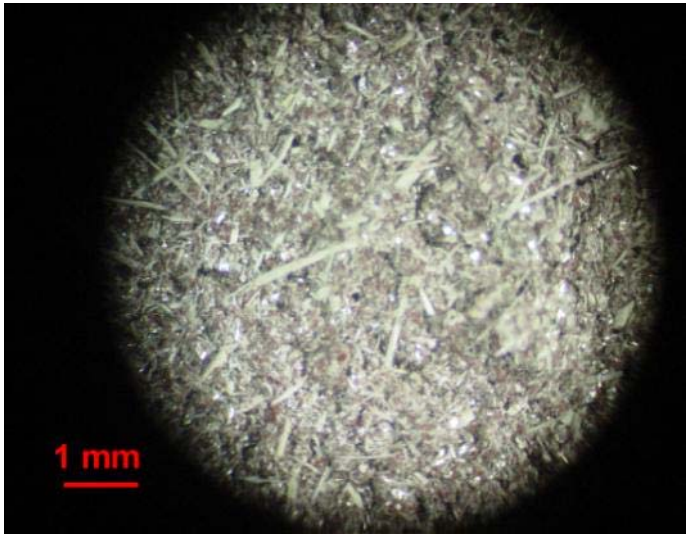
- Reaction triggered by Electric impulse (W ignition coil)
  - 20 V for 4-5 sec
- Oxygen-free atmosphere





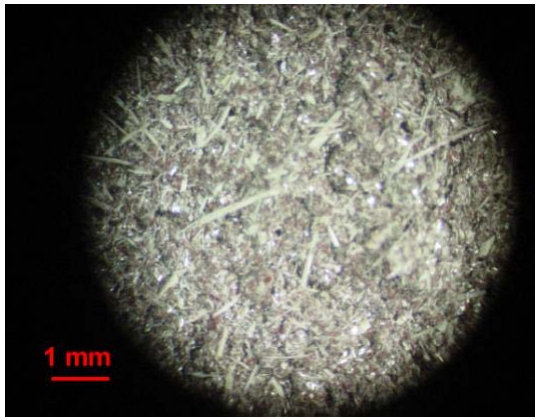
PARAMETERS IN SAMPLE MOULDING

- Mg-thermic reactants: Hem + Mg; Mgt + Mg;
- Chrysotile amount: Ctl 45 %, Ctl50%, Ctl54%, Ctl60%, Ctl65%;
- Pellet size: diameter (10 mm – 13 mm); height (h_{avg}= 7-8 mm; h_{max} = 13 mm);
- Pellet type (homogeneous or layered)

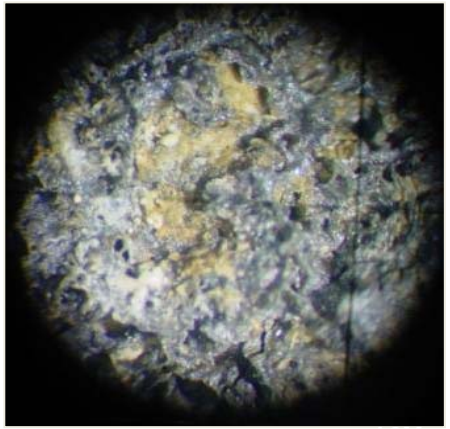


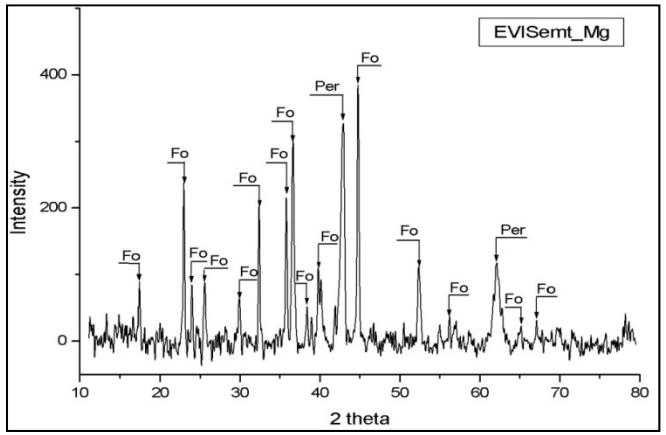
Chrysotile breakdown

Starting materials



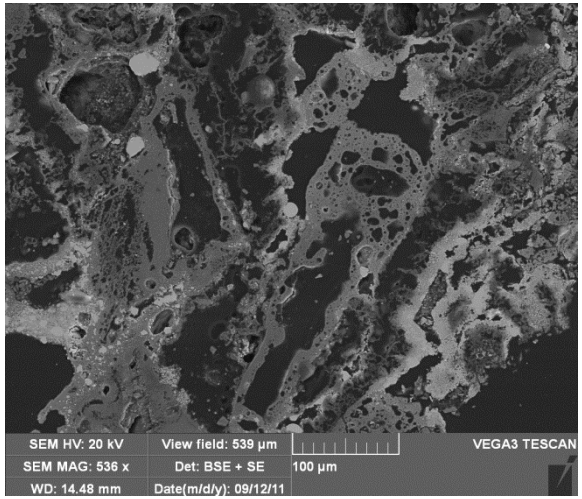
- New effective technique addressed to chrysotile breakdown
- New effective application of self-propagating high temperature synthesis (SHS) involving natural materials
- Fast and energy-saving method
- Reaction products are NOT industrial waste
- Reaction products are liable to become a second resource (refractory, abrasive etc)



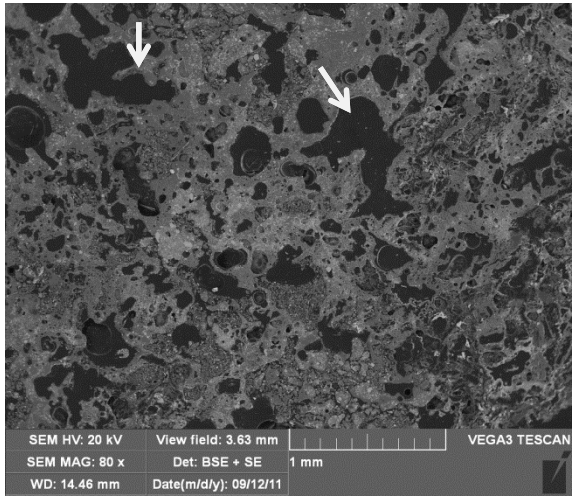


THE PRODUCTS

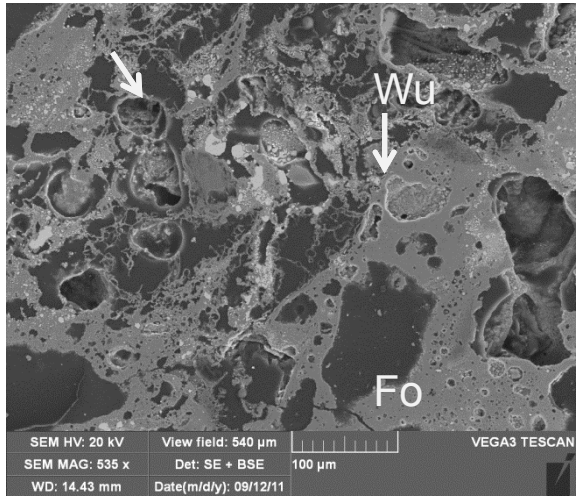
Chrysotile breakdown – Microtexture and composition



Voids originated in the volatile release from chrysotile, surrounded by blocky, homogeneous forsterite



Irregular, swirly, amygdalar texture of bubble distribution, ➔ volatile release occurred in visco-plastic host material



Spongy texture defined by wustite shells enclosed in forsterite

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FIBERS INNOVATIVE BURNING AND REUSE BY SHS

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FIBERS

telerobotlabs

VICO GRUPPO TECNOMETAL

www.fibers-life.eu

OBJECTIVES

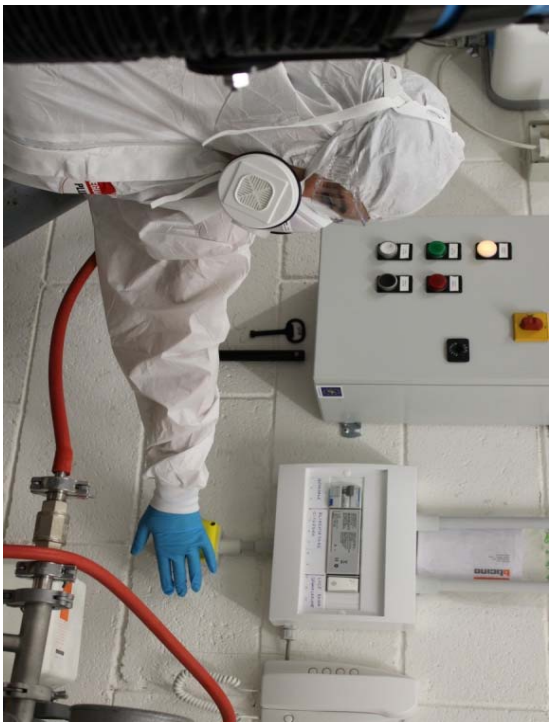
•Implementation of SHS technology for Asbestos-waste treatment

•Two scaled-up plants: (prototype 1, ≈ 1 Kg capacity, prototype 2 ≈ 100 Kg capacity)

•Reproducibility of SHS reaction on different asbestos waste (Eternit™ tiles, loose fibers, linoleum, fiberglass etc).

•Post-SHS characterization of by products for possible re-use.


VIETATO L'ACCESSO
ALLE PERSONE
NON AUTORIZZATE



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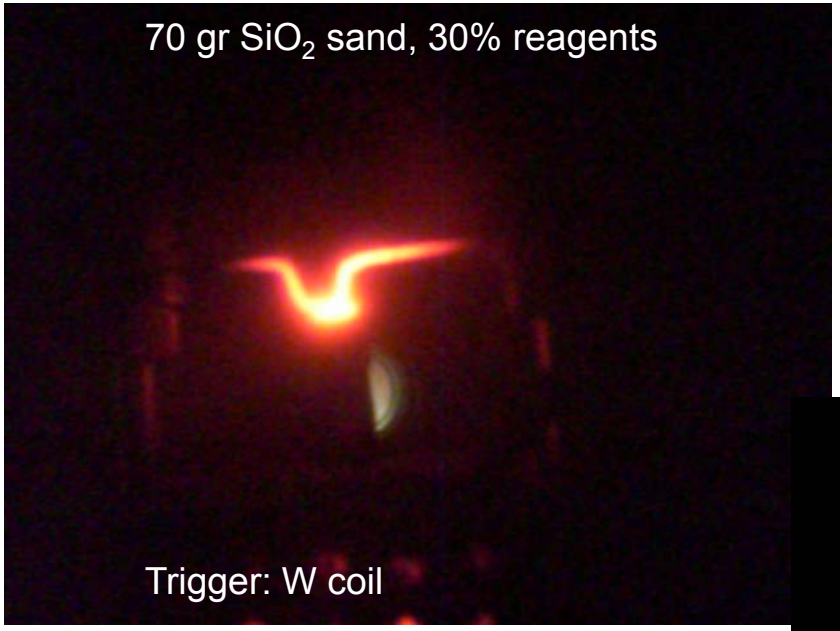
Prototype 1 discontinuous

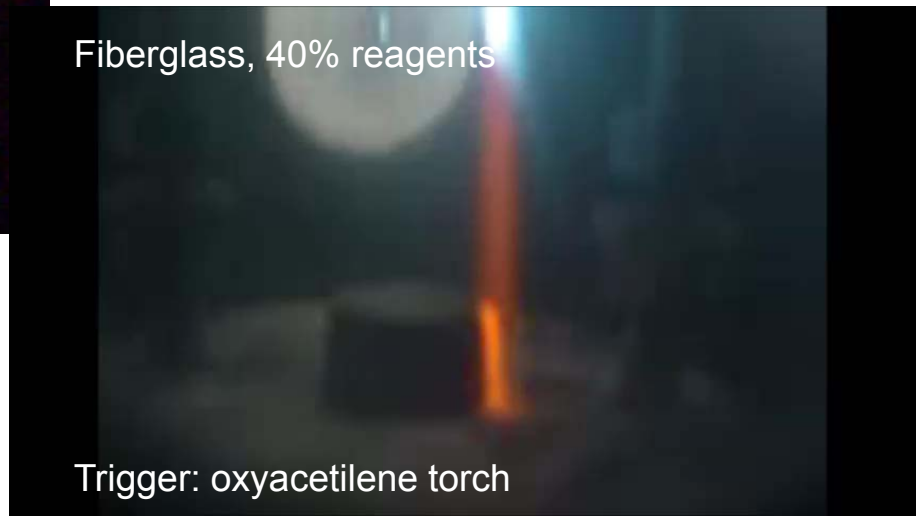
Prototype 1 continuous

- Different ACWs: fiber cement and friable asbestos
- ACW amount: from 50 to 70 weight %
- Pellet size: diameter 25 mm; height 20 - 80 mm
- Weight of samples: from 20 to 100 g
- The reaction is triggered by an oxyacetylene torch

PROGRESS STATE

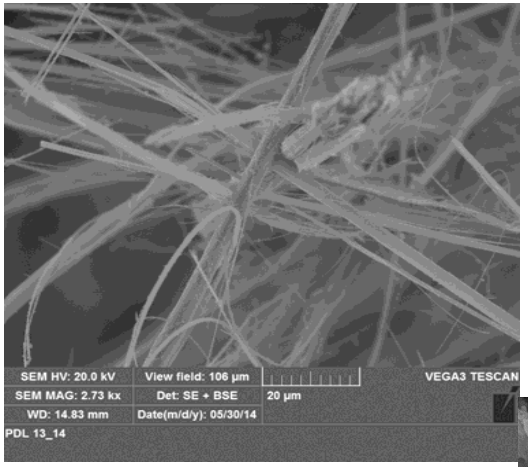
Successful steps towards prototype 2





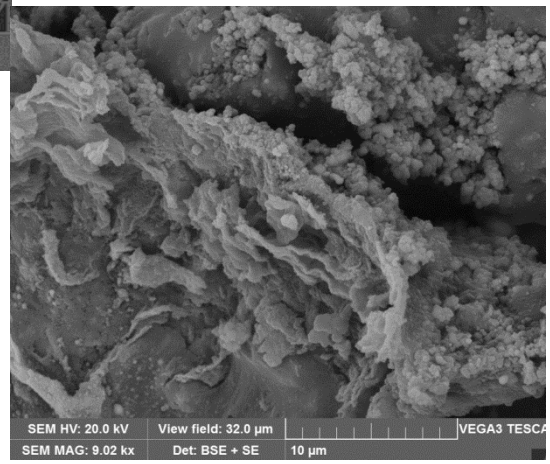
Scaling up from lab to plant

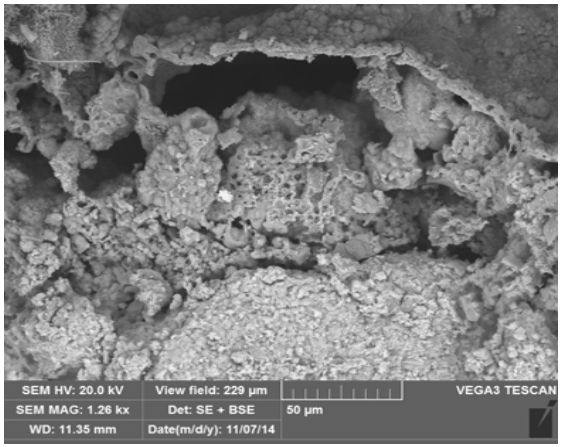
Friable asbestos



Sample	Asbestos waste	% of waste
FIBERS-1	friable asbestos	50
FIBERS-2	friable asbestos	60
FIBERS-3	friable asbestos	70
FIBERS-5	fiber cement	50
FIBERS-6	fiber cement	60

Results after SHS treatment





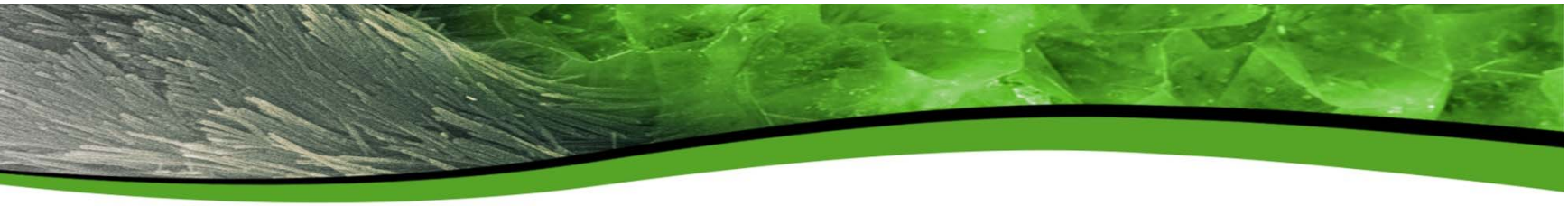
Cairo Montenotte (SV)

Prototype 2

lesign evolution and cross fertilization
ce feed back on iCub

rel. 3.0

telerobotlabs



Final results

- Both prototypes achieved the goal. We optimized the parameters to achieve **complete conversion** of the asbestos to mineral grains in all the cases.

- The SHS process in comparison with conventional thermal treatments, due to **fast reaction time, low activation energy,** particularly advantages the asbestos inertization and positively reflects into time and costs of the process.

- Finally, the product of this transformation is liable to be re-used, e.g. as abrasive, or refractory material; this represents the end of waste status and a **second life** as secondary raw material.

FALLOUT:

- Treatment of hazardous waste in confined environment
- Development of advanced technologies

JOB CREATION

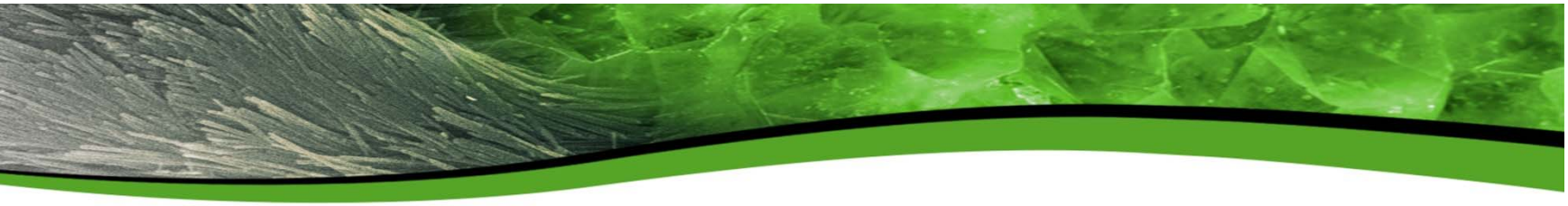
WASTE MANAGEMENT

ENVIRONMENTAL POLICIES EU

- Considerable decrease of waste to landfill
- Decreased need of landfills
- Better use of the territory

SUSTAINABILITY

CIRCULAR ECONOMY
saving resources, creating jobs
Green Week, Brussels > 3-5 June 2014



Thank you for your attention

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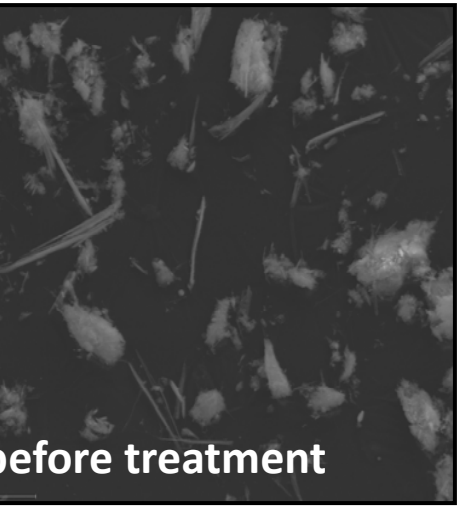
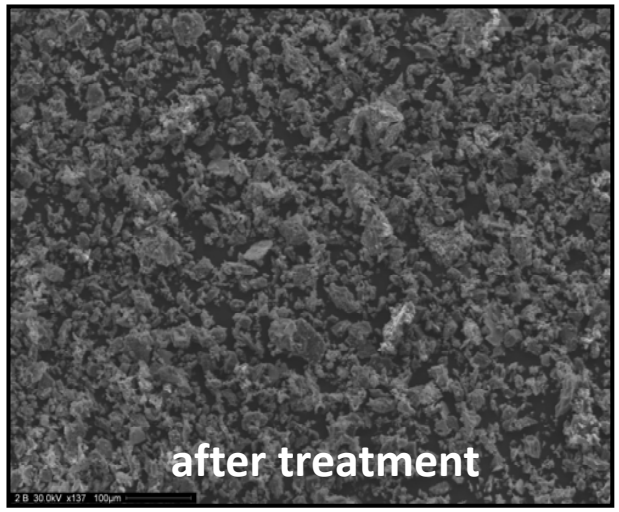
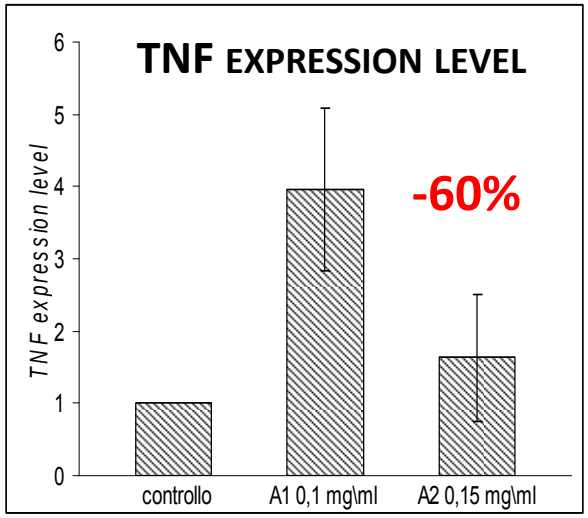
POWDER RESIDUAL TOXICITY AFTER SHS TREATMENT

In vitro test with macrophages







- ✓ Wet grinding→ l>4µm, d<0,25 µm (Stanton et al., 1981)
- ✓ Cells suspension (5 mg) and cells culture(19 mg)
- ✓ Incubation: 37 °C per 2 h