The ReCoVeR Project

Regenerating the Performance and Value of Glass Fibres Thermally Recycled from End-of-Life and Waste GRP

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AMRL
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EPSRC
Engineering and Physical Sciences Research Council

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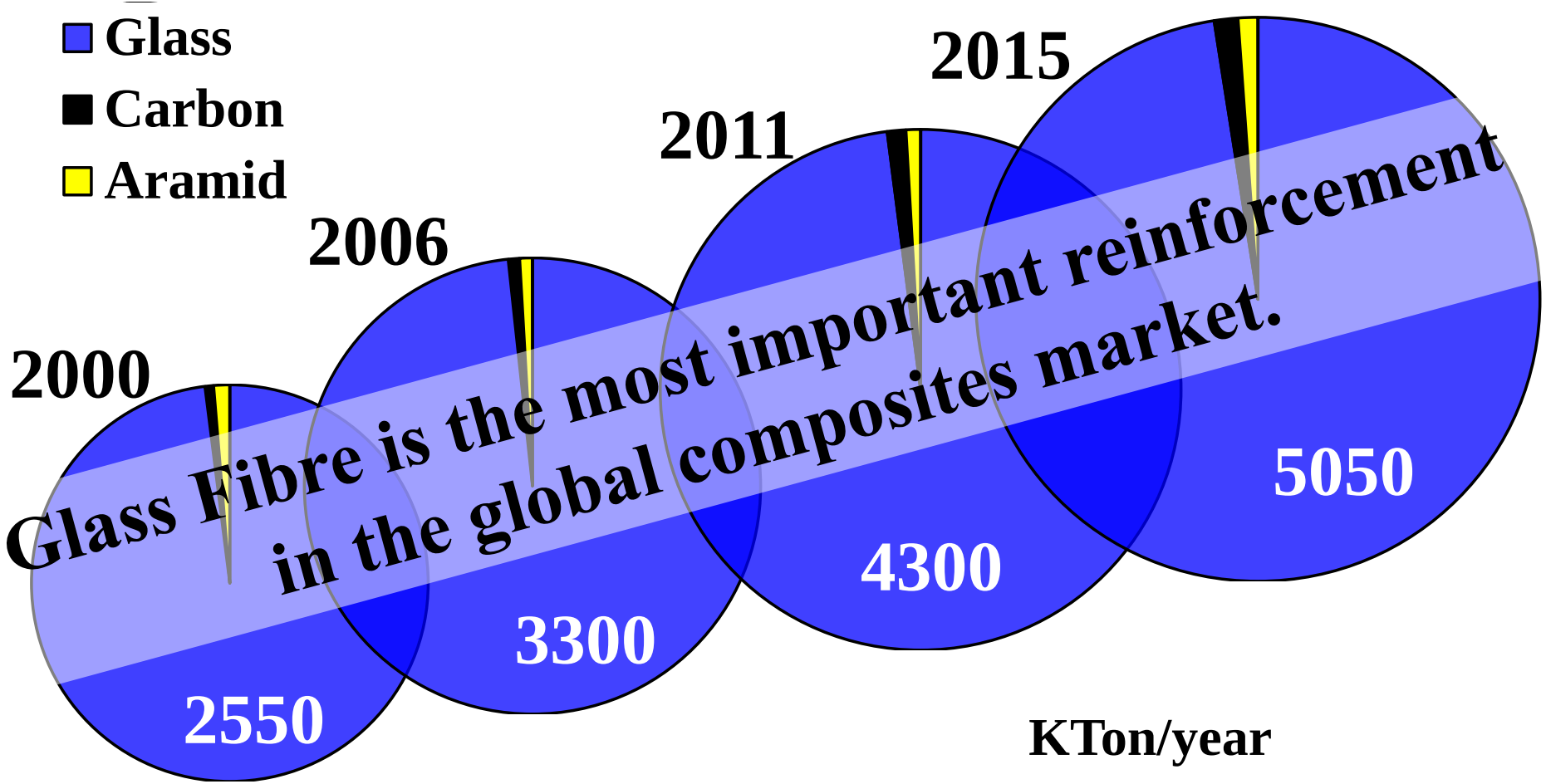
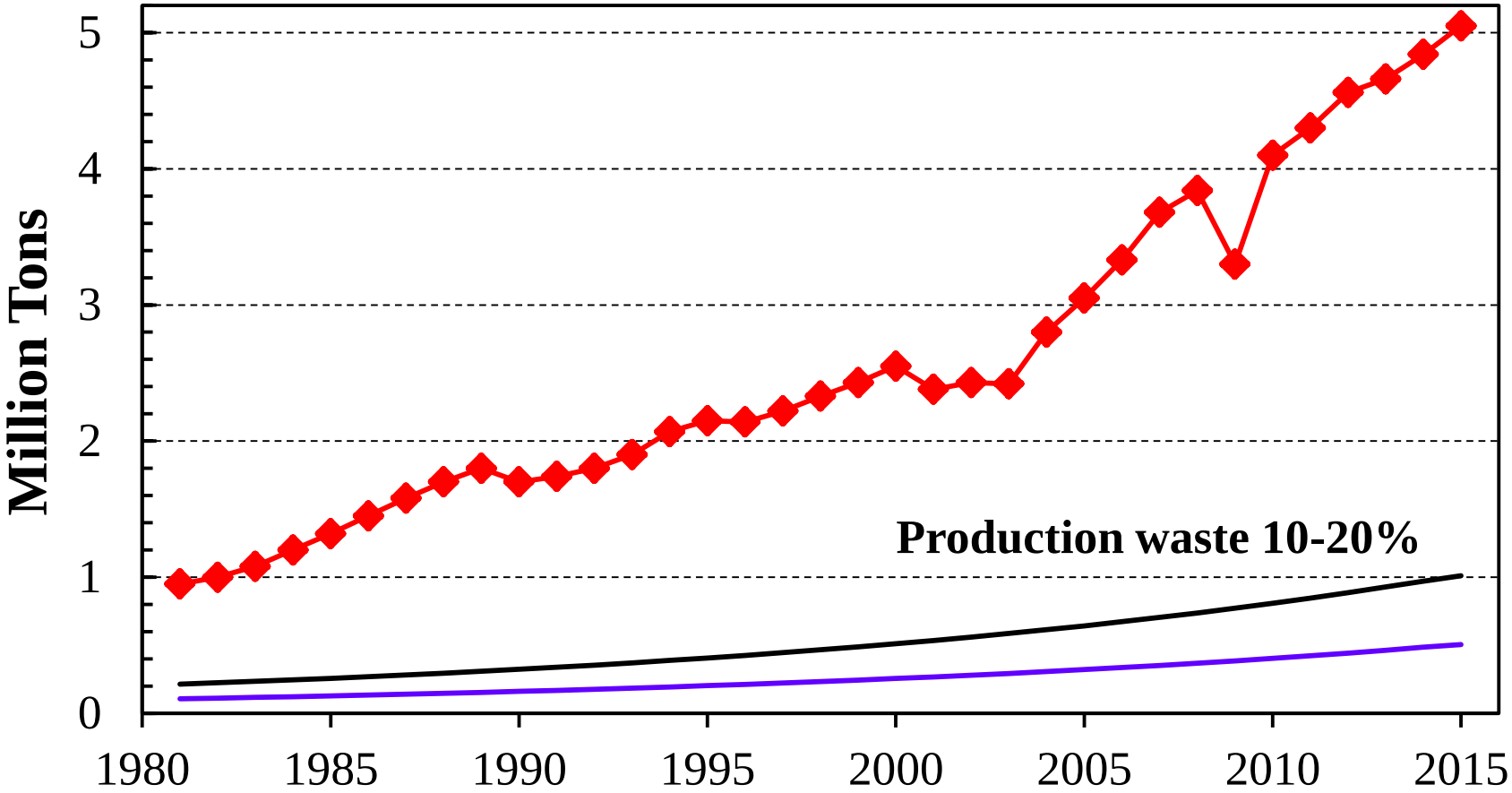
ReCoVeR

- Introduction
- ReCoVeR GF Performance Regeneration
  - ReCoVeR-0, Proof of Concept, HF
  - ReCoVeR-2&3, NaOH
- Some Conclusions
- Future Developments?

Global Reinforcement Fibre Usage

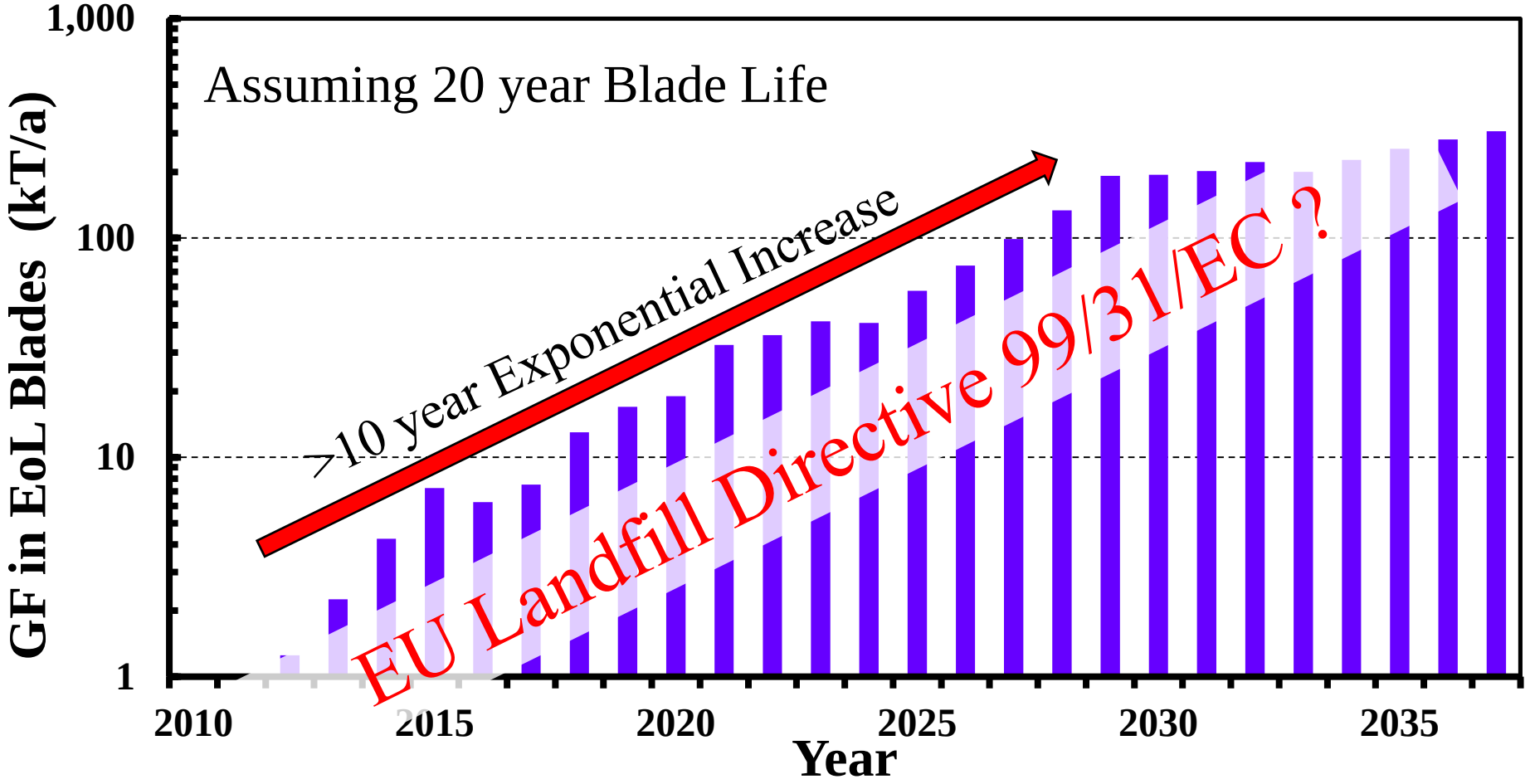


Global Glass Fibre Demand

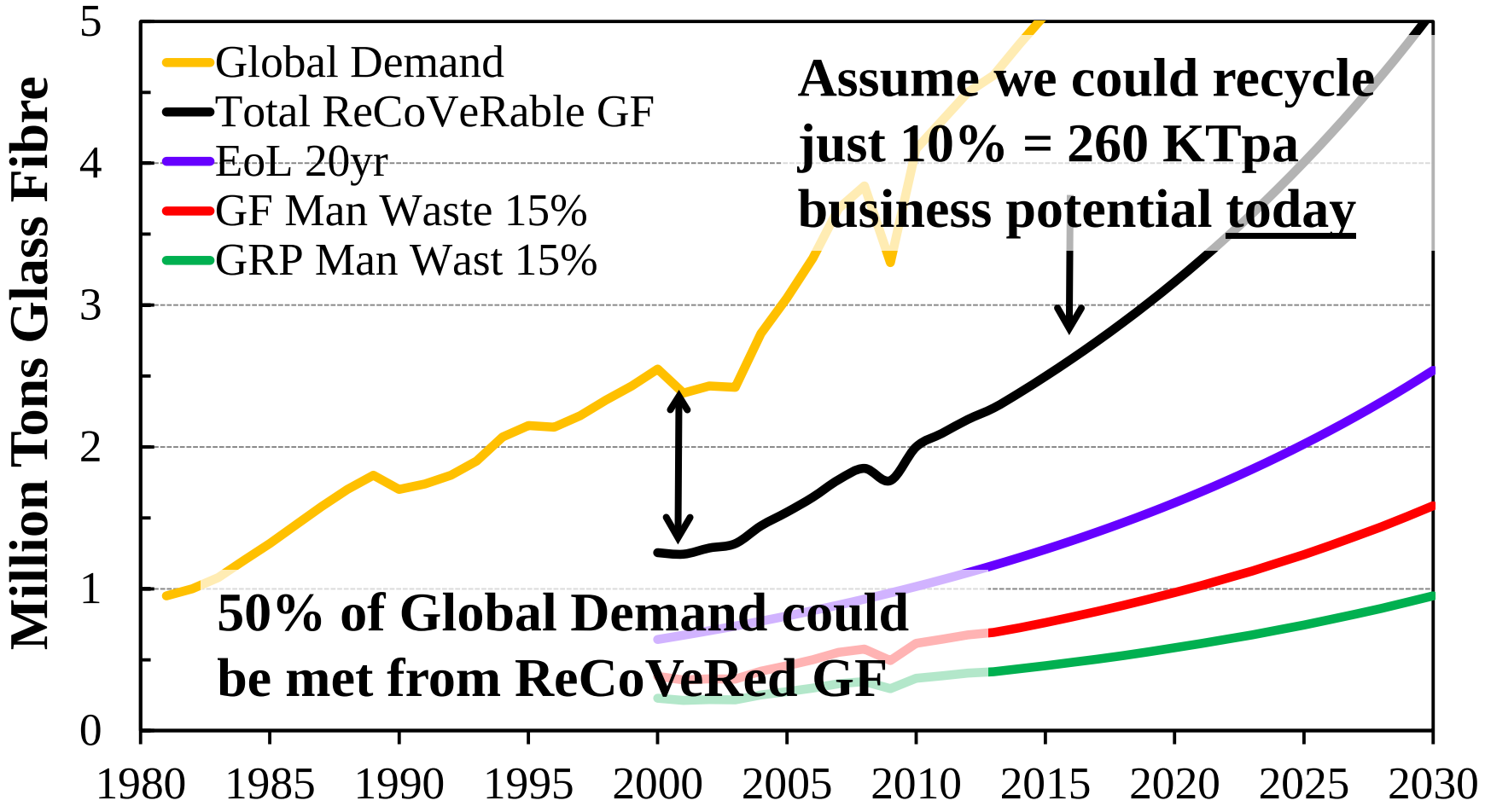


Source Owens Corning

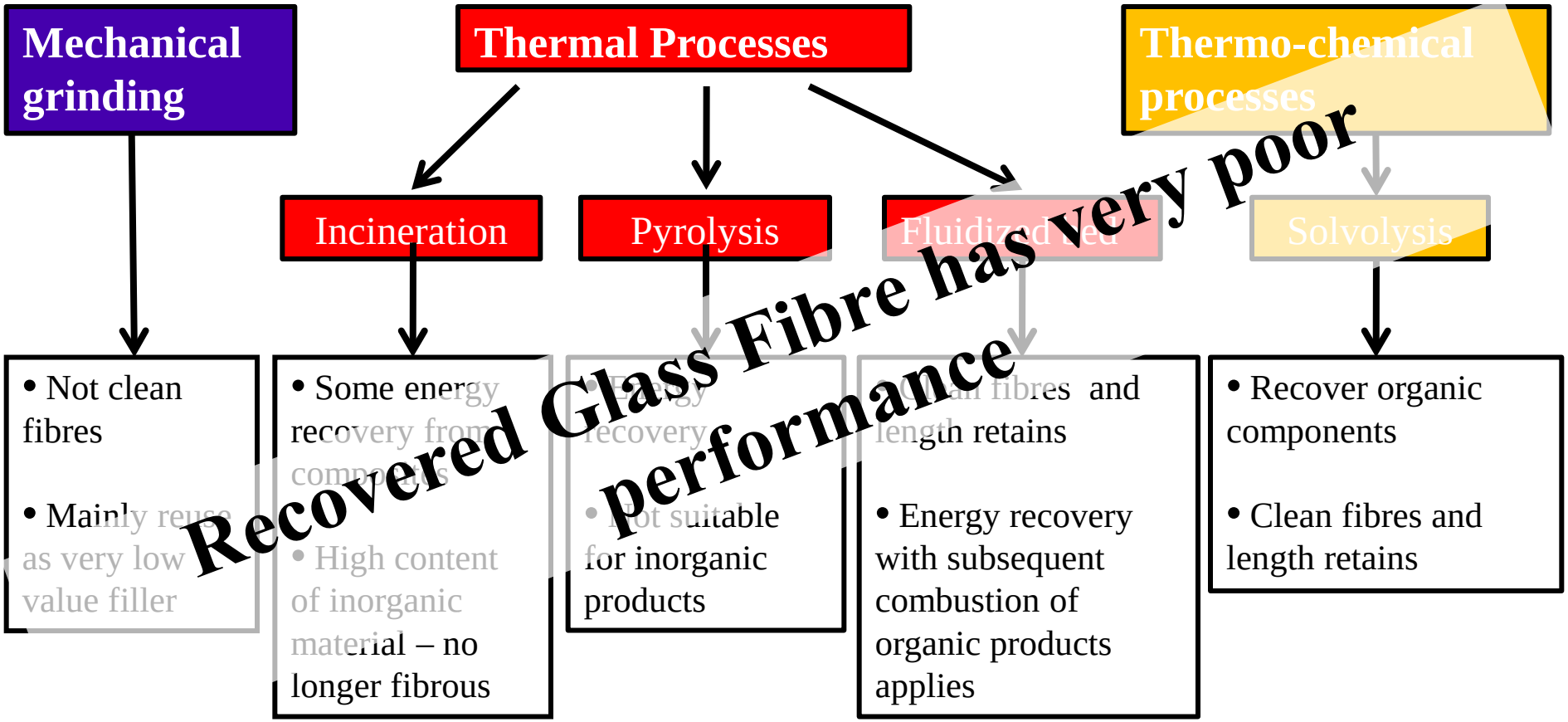
Global End-of-Life Blade Material



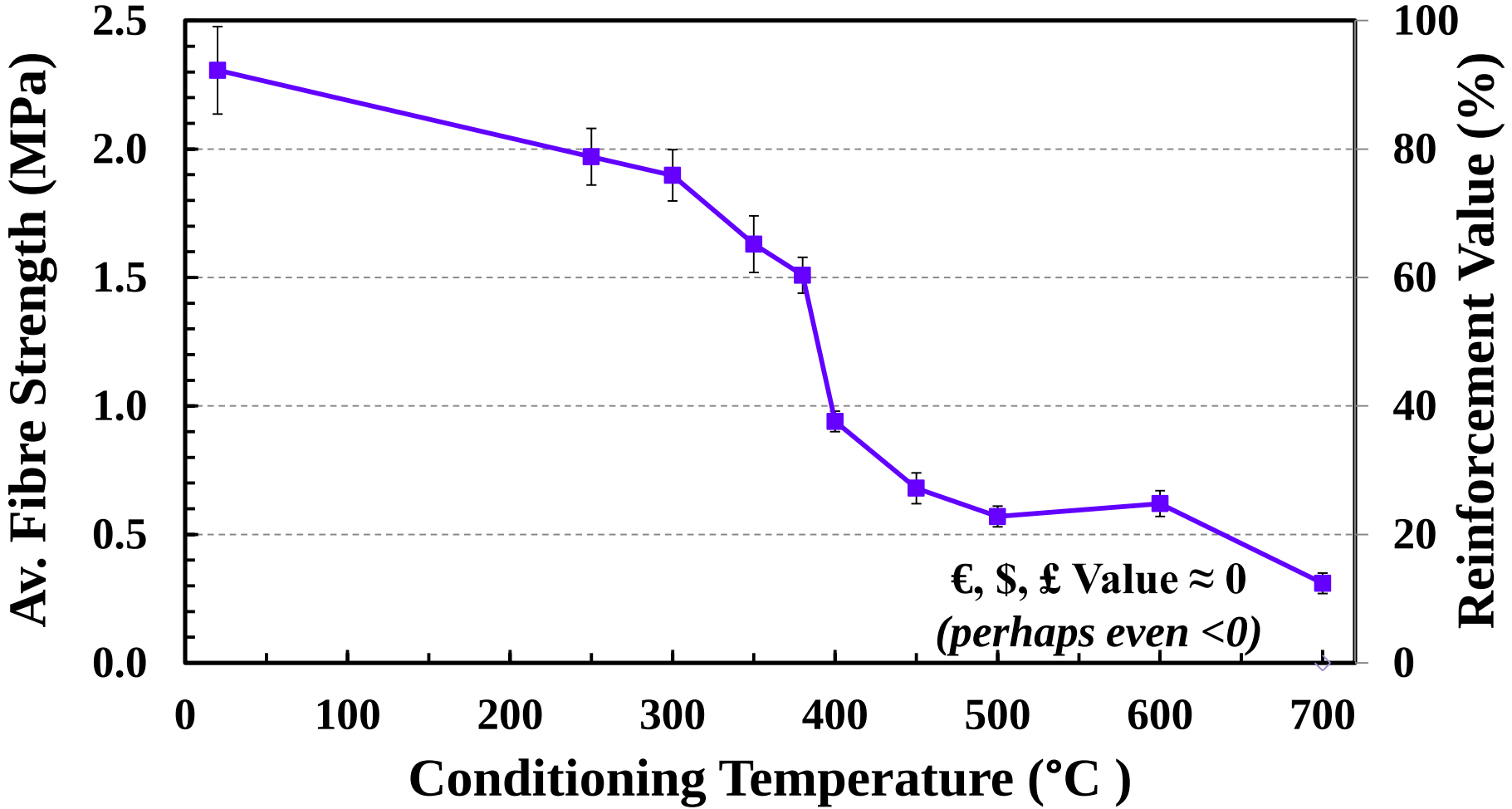
ReCoVeRable GF in EoL GRP and Manufacturing Waste



GRP Recycling Techniques

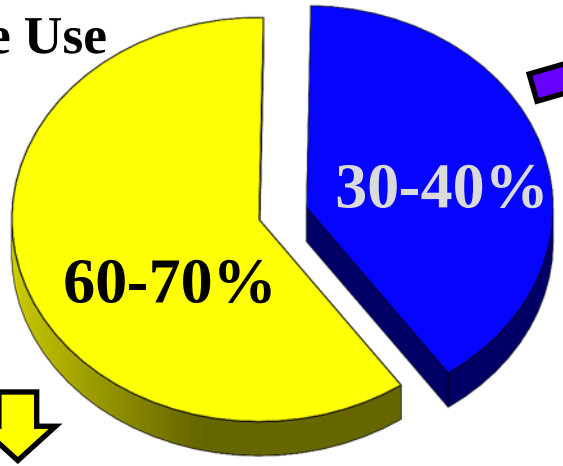


Single Fibre Tensile Strength of RGF



The ReCoVeR Vision

Global Glass Fibre Use



Mainly to chopped fibre* thermoplastic *composites. Intrinsically recyclable

ReCoVeR and replace new chopped fibre

Landfill no longer acceptable – but difficult to recover continuous fibre

Mainly to continuous fibre* thermoset *composites

At end-of-life -challenging to recycle - so = landfill ? (or zero value filler)

The ReCoVeR Project

EPSRC
Engineering and Physical Sciences Research Council

Regenerated Composite Value Reinforcement

The ReCoVeR Mission

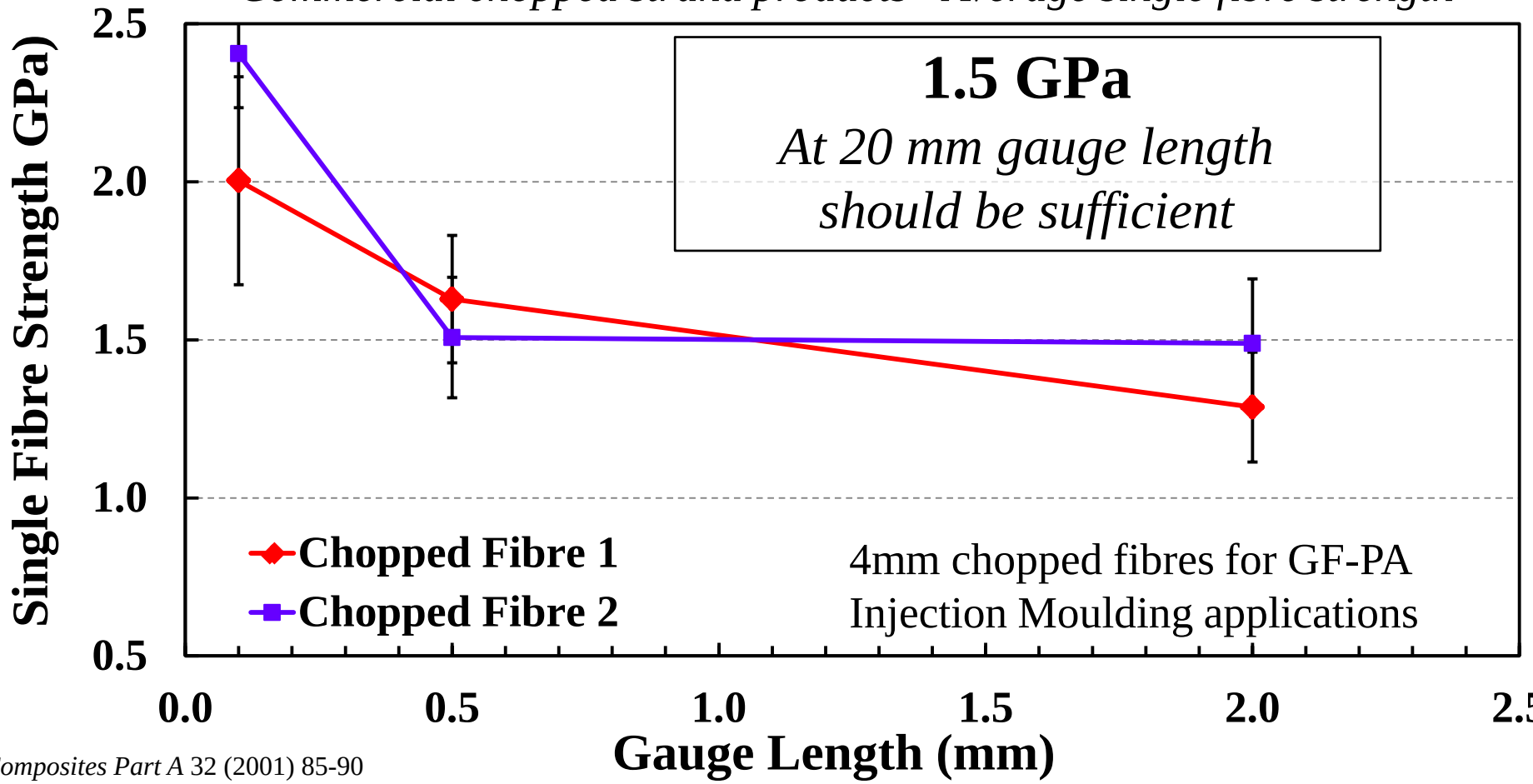
Enable the development of cost-effective, *drop-in*, glass fibre and composite products based on recycled glass fibres with regenerated mechanical performance

The Research Goals

- ***Research fundamentals of (300-600°C)RGF property changes***
- ***Cost effective treatments to regenerate RGF performance ?***
- ***Produce examples of GF or composite products using RRGF***

Target Strength for ReCoVeRed Fibre ?

Commercial chopped strand products - Average single fibre strength



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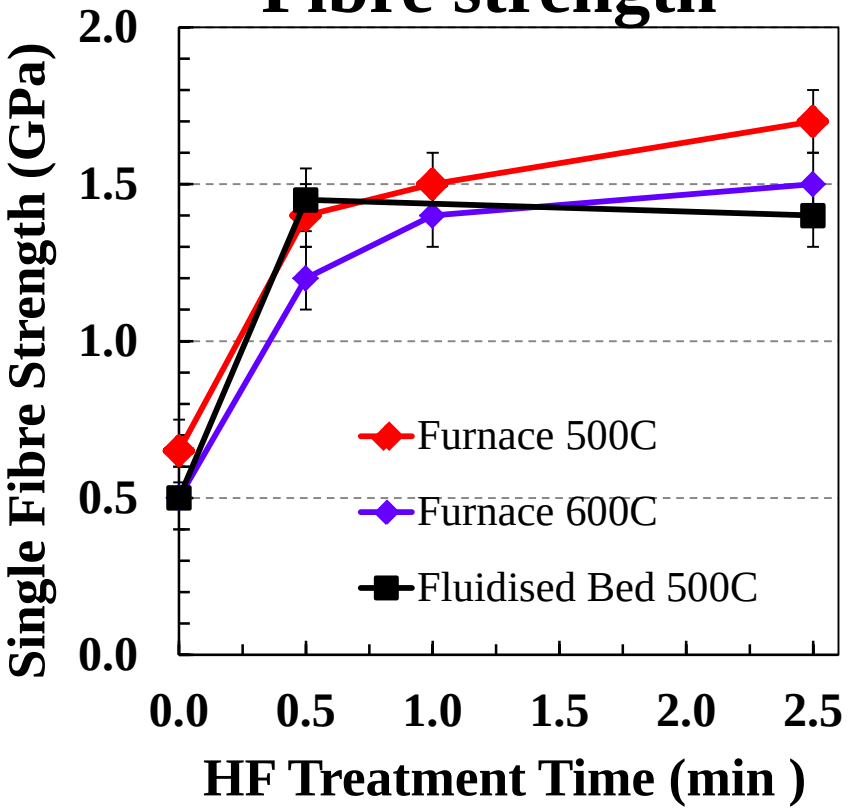
Strength Loss Mechanism and Regeneration

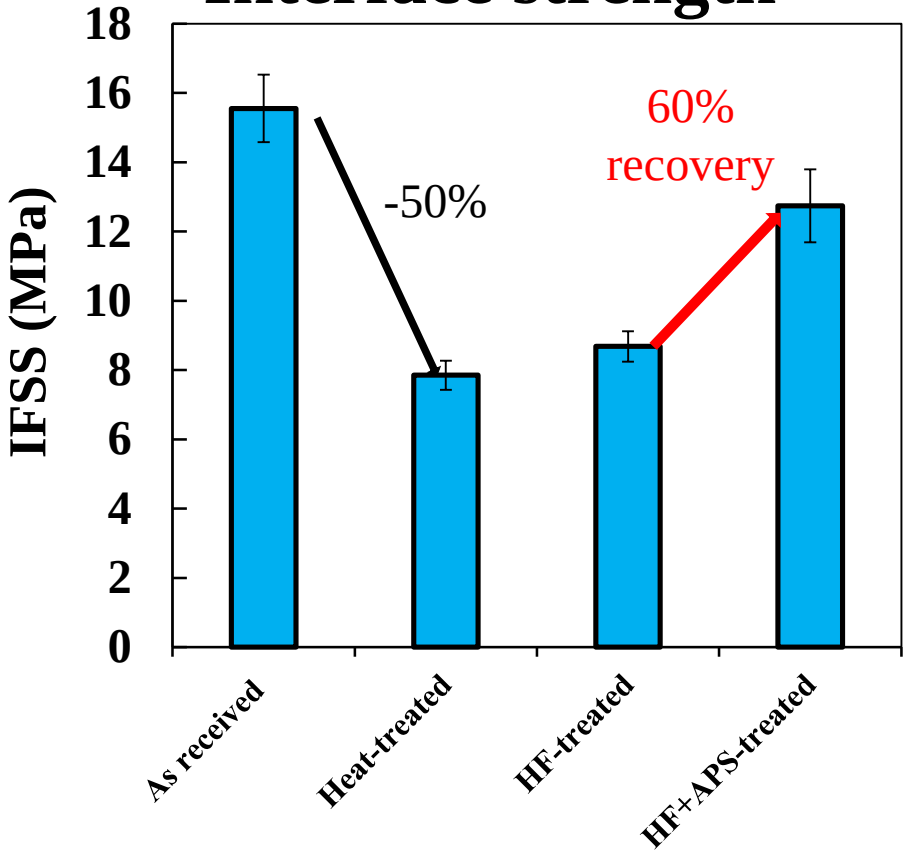
- **Griffiths theory tell us that the strength of brittle fibres (glass, carbon) is dominated by the effect of surface flaws**
- ***If fibre strength after heating is related to increasing number or severity of flaws can we regenerate strength by etching the fibre surface?***
- **ReCoVeR-0 proof of concept – HF etching**

ReCoVeR-0, HF Surface Etching

Fibre strength



Interface strength



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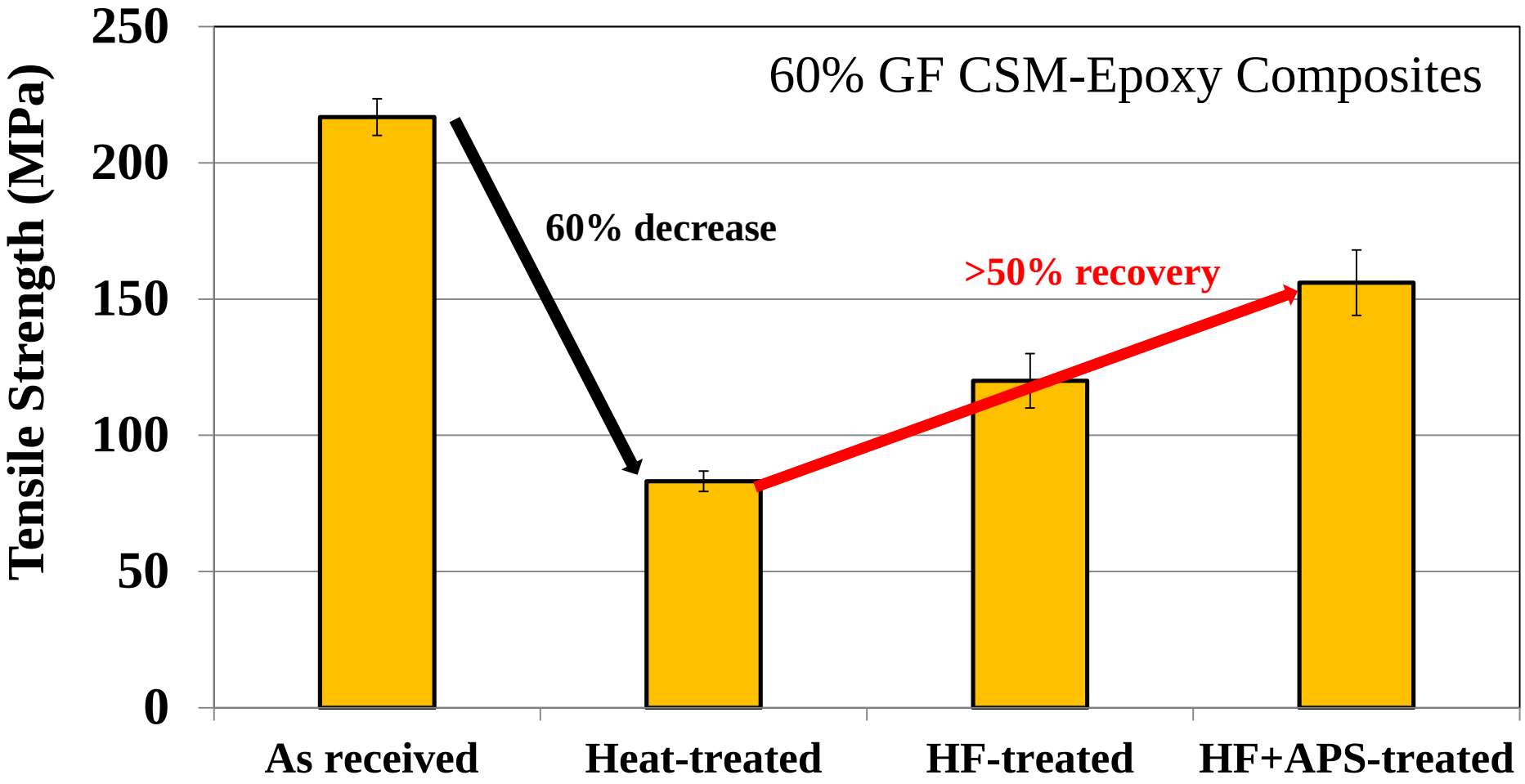
ReCoVeR-0 Composite Performance



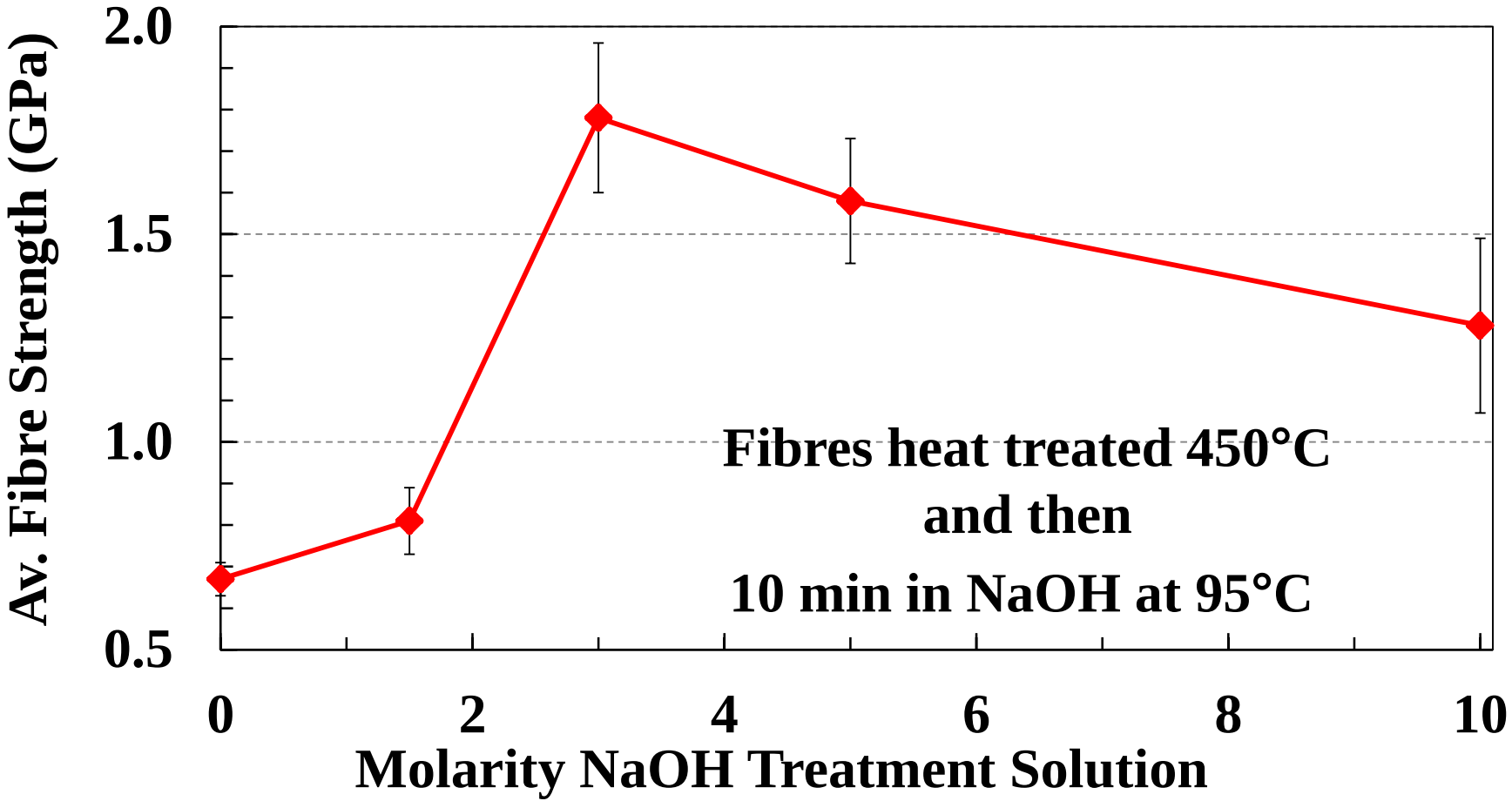
Conclusions ReCoVeR-0

- **Tensile strength of thermally conditioned/recycled glass fibre regenerated by HF etching process (+200%)**
- **Surface of HF etched RGF can be reactivated by silane treatment (>60% recovery in IFSS)**
- **Proof of Concept demonstrated**
  - **regenerating both fibre strength and surface functionality results in significant recovery of composite performance**
- **But HF cannot lead to cost-effective ReCoVeR technology**

ReCoVeR-2 (NaOH treatment)

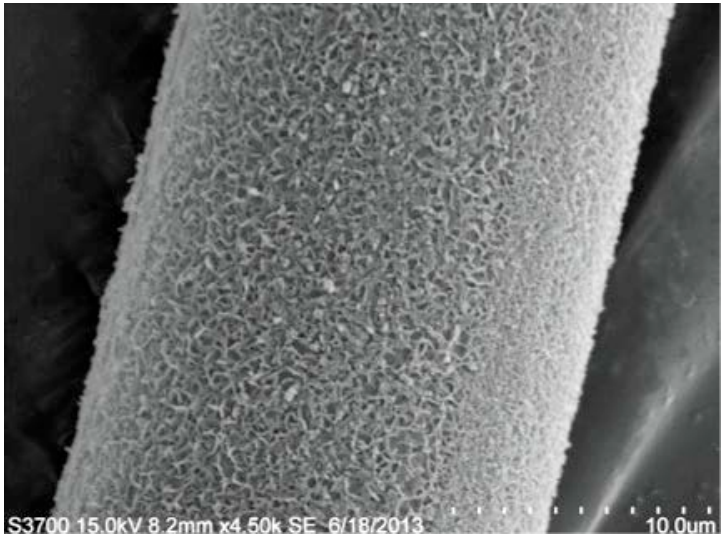
- HF work demonstrated proof of regeneration concept
- Any less aggressive chemicals giving a similar effect?
- Hot alkalis known to attack silica
- Literature is almost universally negative about alkali effects on E-glass fibres
- But until now everyone was concerned about maintaining the performance of strong fibres
- **Can NaOH regenerate the strength of weak fibres??**

ReCoVeR-2, NaOH Treatment

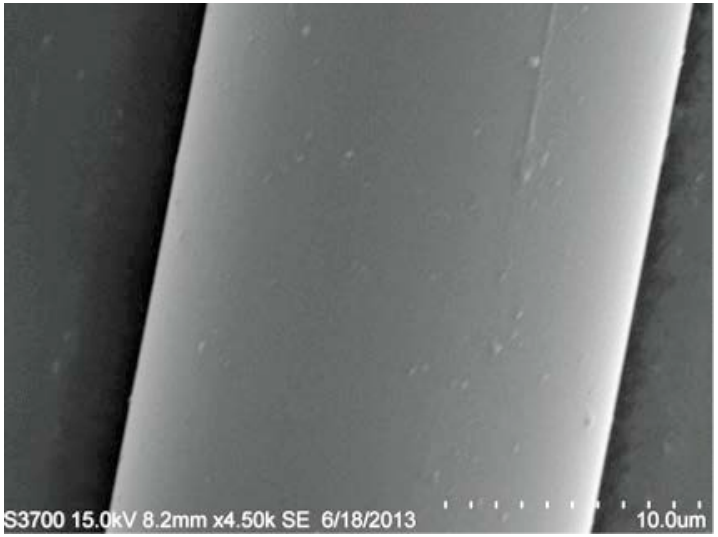


ReCoVeR-2, NaOH Treatment

Fibres heat treated 500°C



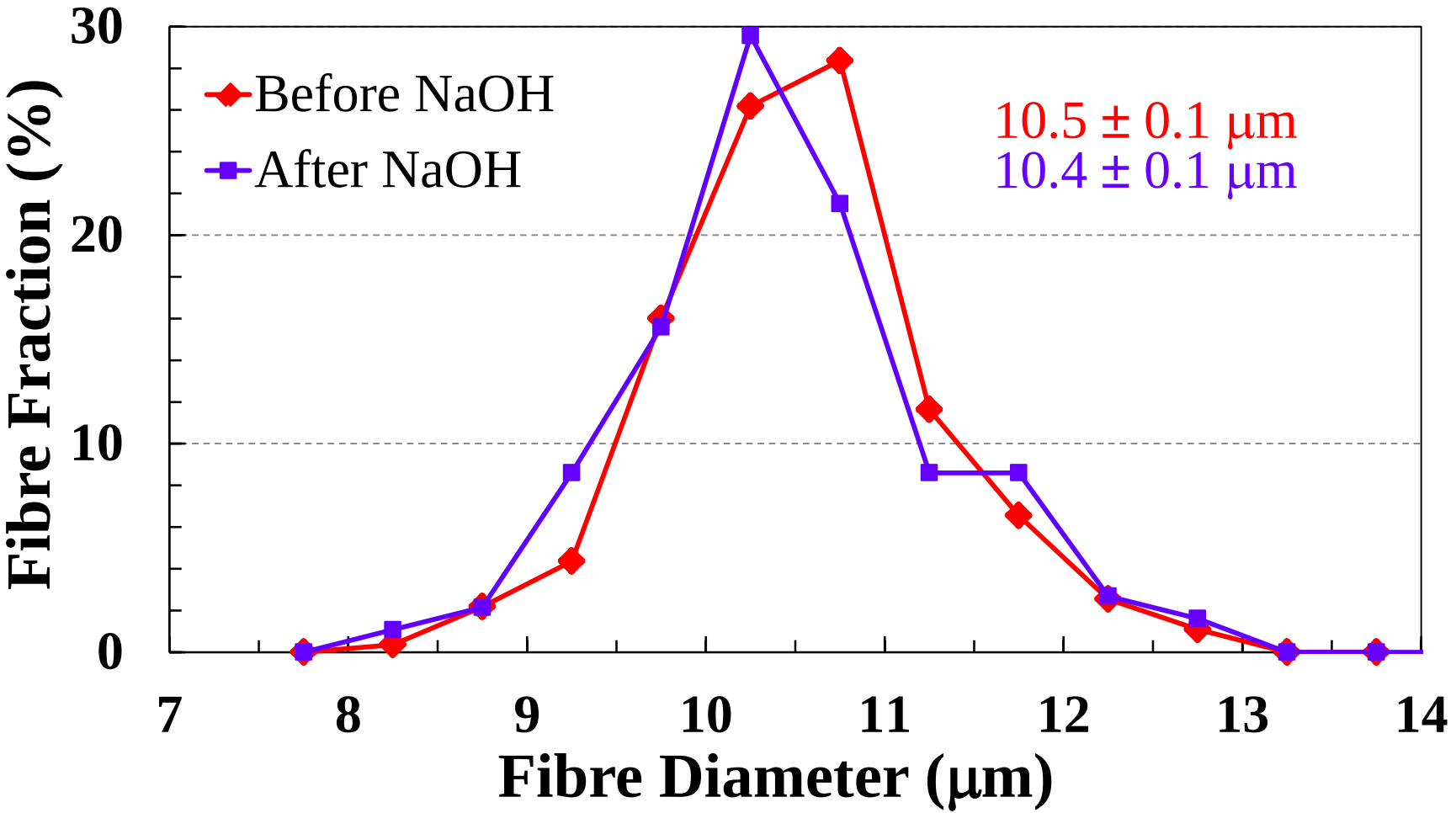
10 min in 3M NaOH at 95°C



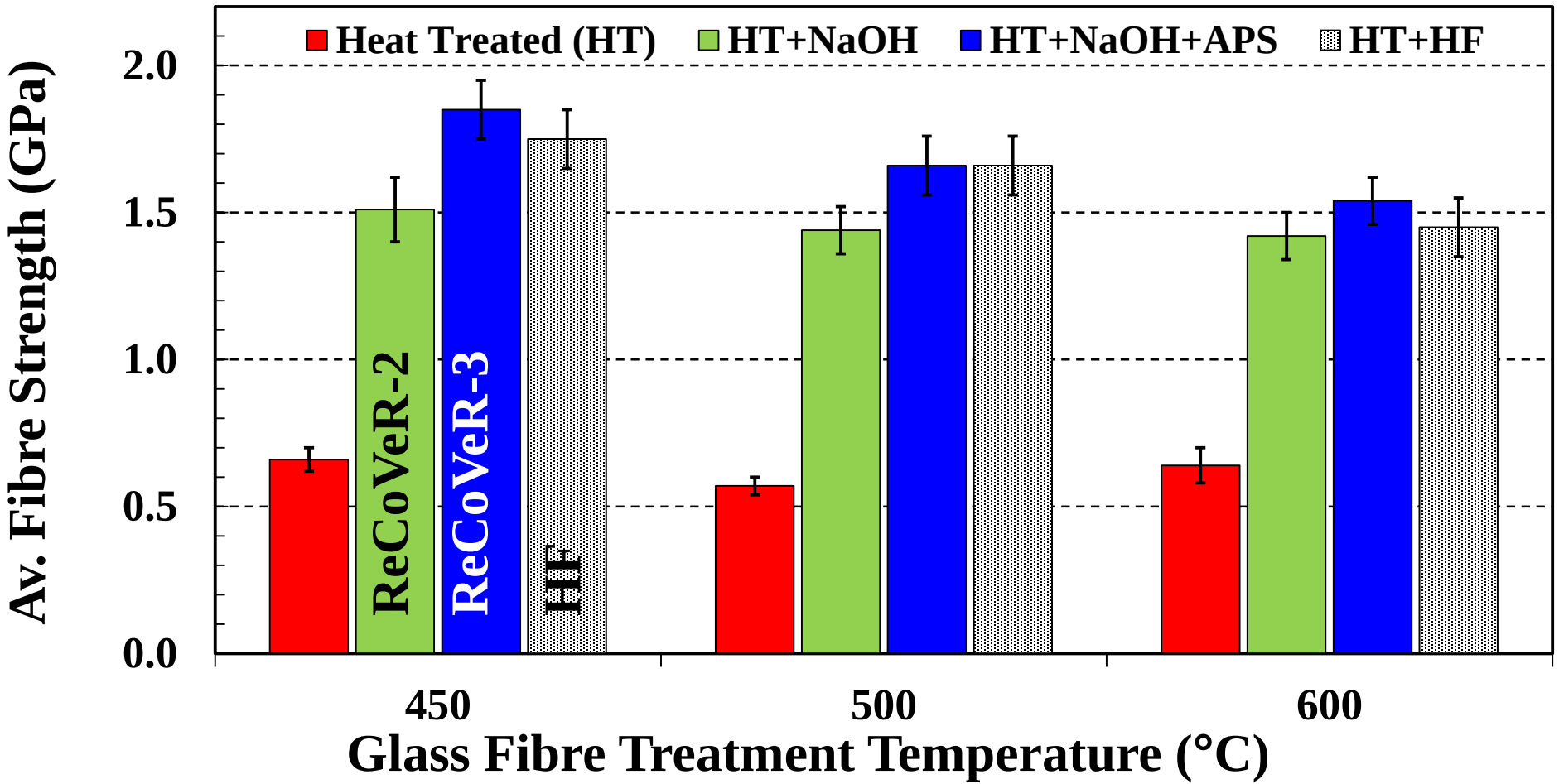
+ rinse in HCl and water

Can also post-treat with a silane coupling agent (ReCoVeR-3)

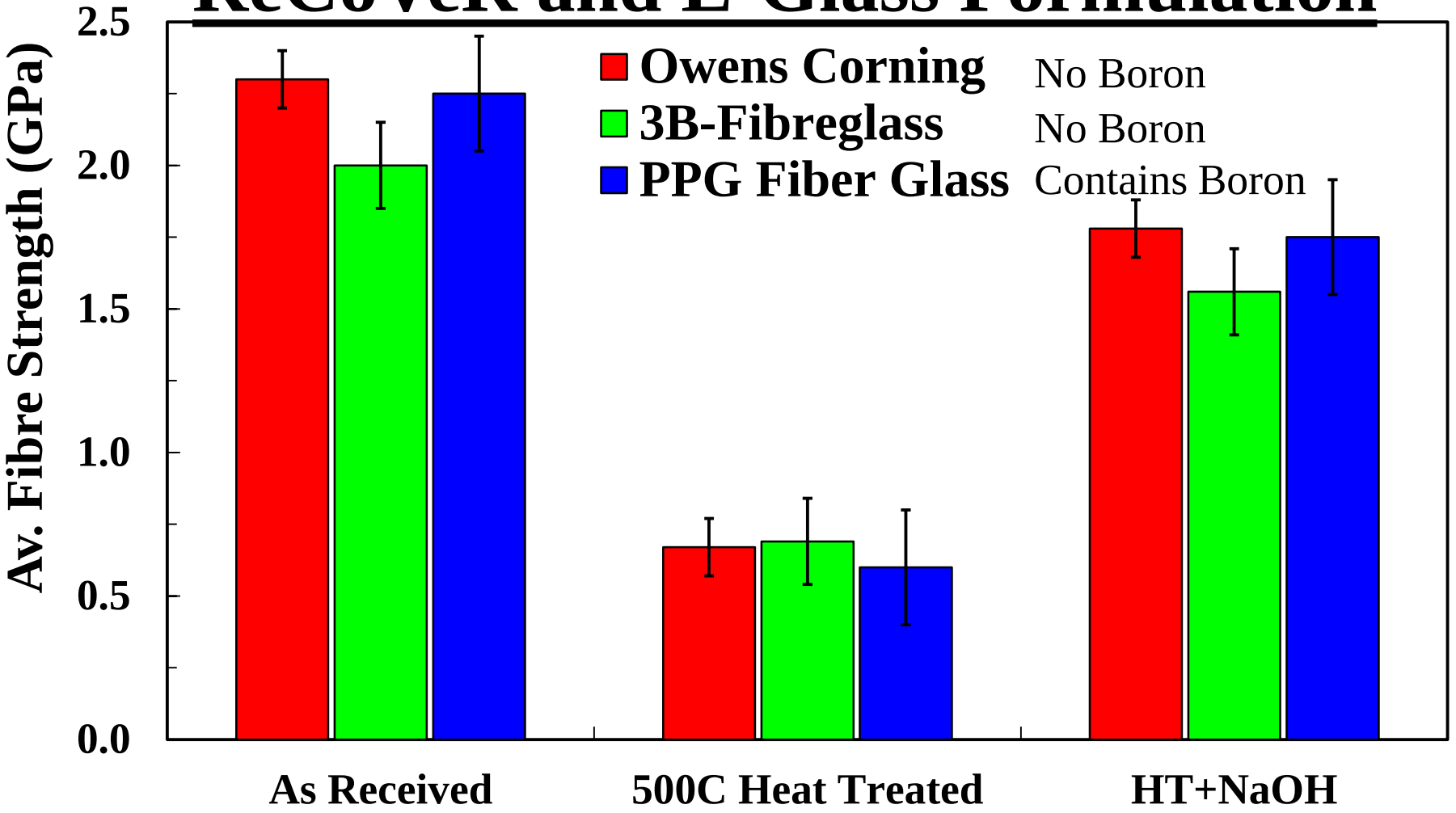
Fibre Diameter Change?



Glass Fibre Strength ReCoVeRy

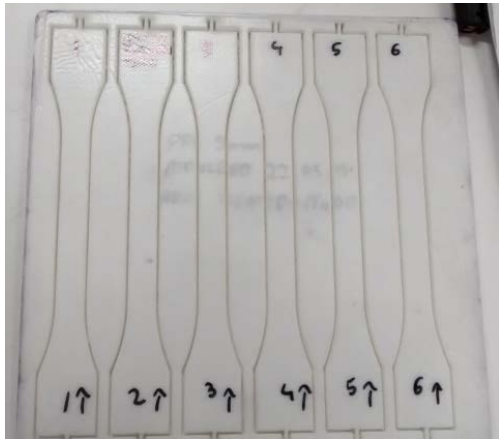


ReCoVeR and E-Glass Formulation



ReCoVeR and Composite Performance

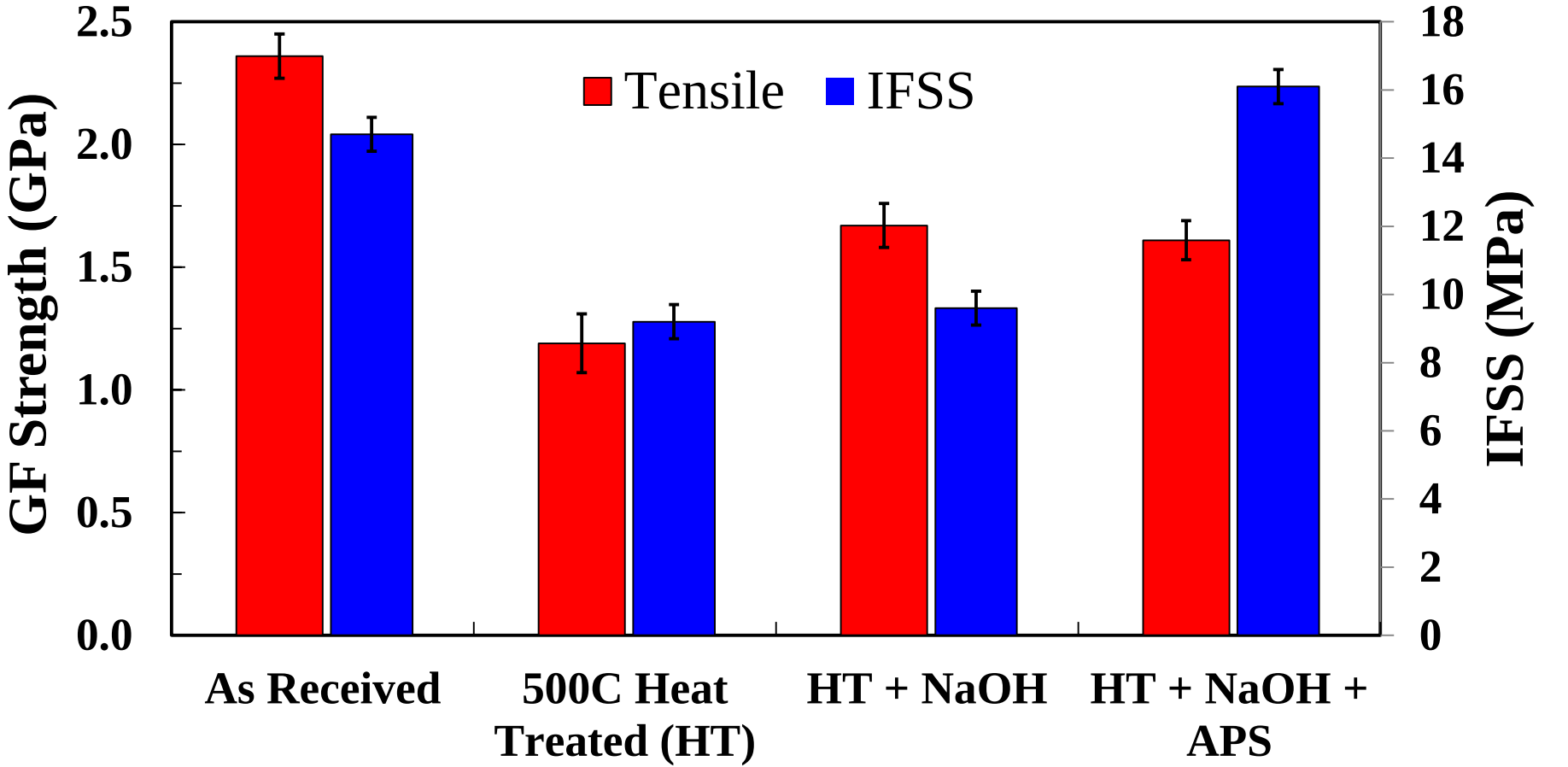
- **GF-PP glass mat thermoplastic composites produced by wet deposition (paper-making) and compression moulding. Random-in-plane 30% wt. fibre content.**
- ***PPG 8069 GF 9 mm long, 10.5 μm diameter, with Goonvean DA3/60 chopped PP homopol fibres (no MaPP coupling agent)***



ReCoVeR on PPG 8069 Fibres

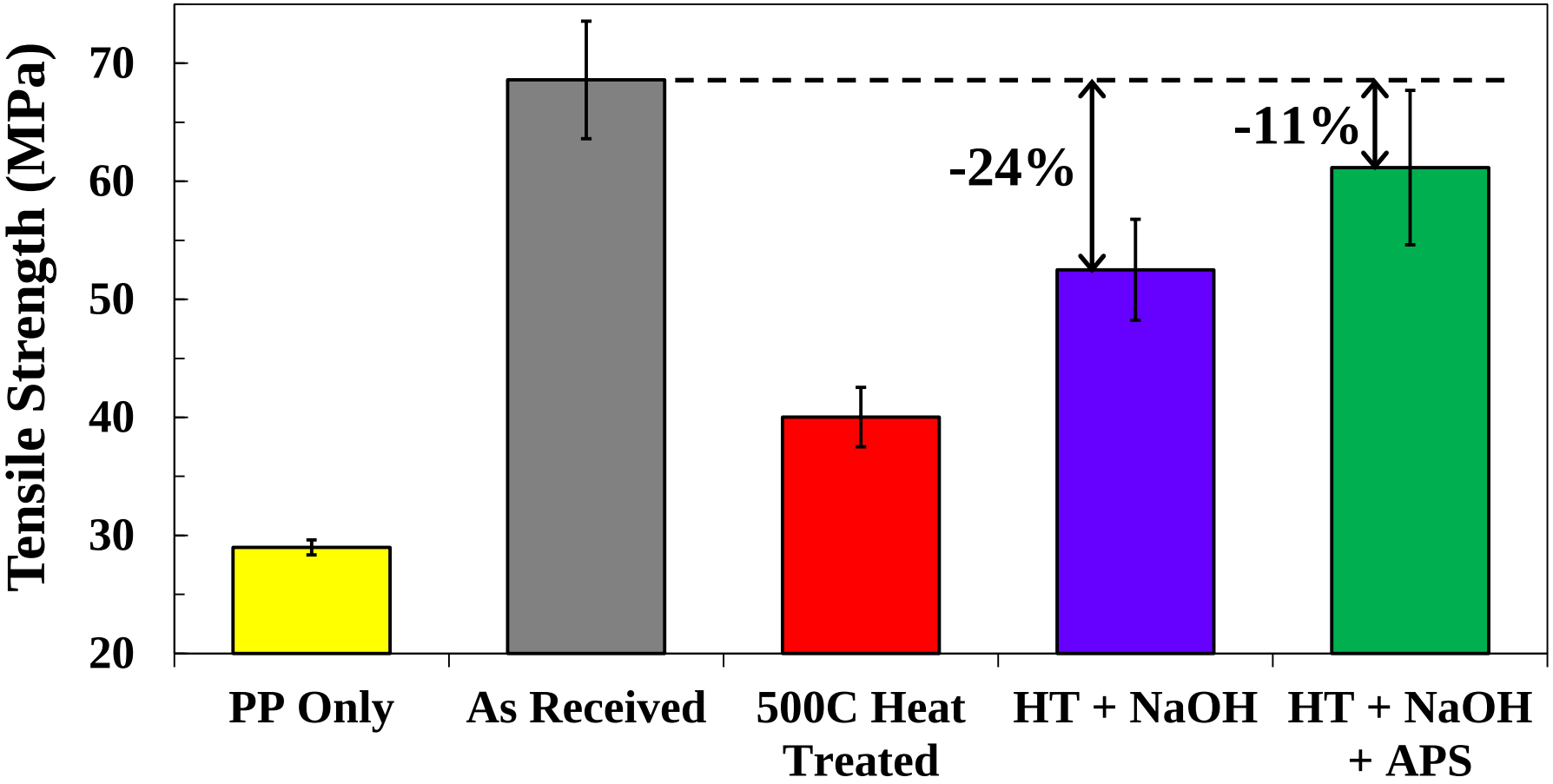
Fibre strength at 5 mm gauge

IFSS = microbond test



ReCoVeR Composite Performance

Wet Laid 30%GF-PP GMT (9mm fibres, no MaPP)



Conclusions

- **The world needs an environmentally and economically acceptable solution for dealing with GF and GRP waste and end-of-life GRP**
- **Glass fibres lose their strength after heat treatment above 400°C**
- **Thermal conditioning of fibres during recycling also drastically reduces end-use composite performance**
- **Development of a cost-effective technology to regenerate the properties of thermally recycled GF could have major environmental benefits**
- **The ACG is developing treatments to ReCoVeR the strength (*and value*) of thermally recycled glass fibres**

Future Development ?

- **Continue fundamental research of GF strength loss and regeneration**
- **Integration of ReCoVeR technology into full recycling/regeneration/reuse process - requires**
  - **Formation and funding of consortium of vested interests**
  - **Defined input material stream, end-of-life GRP, production waste (GRP or GF)?**
  - **Defined recycling process for fibre input to ReCoVeR**
  - **Defined target end-use application (*GF-PP in Automotive?*)**