Regeneration of the Performance of Glass Fibre Recycled From End-of-life Composites or Glass Fibre Waste

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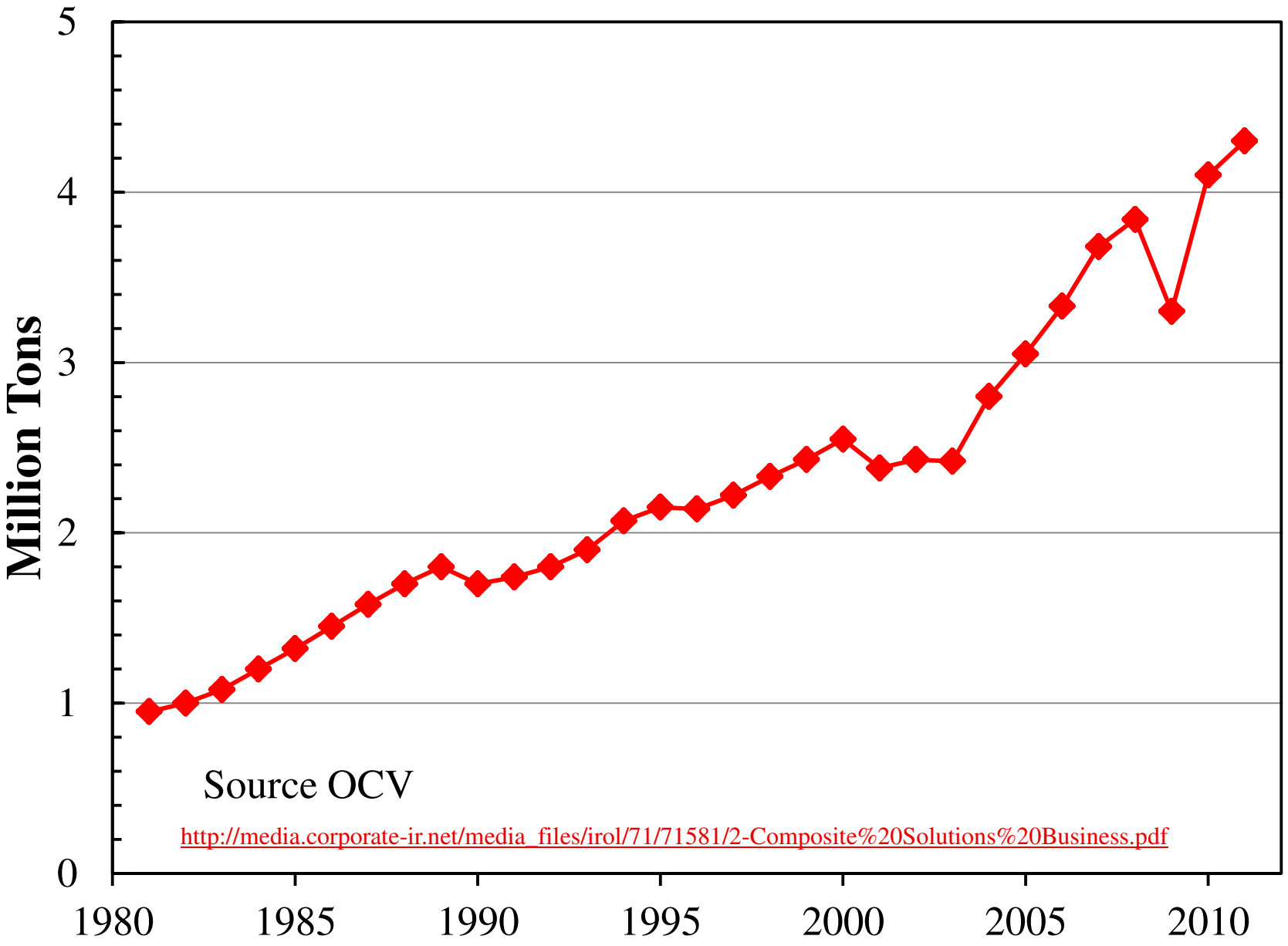
EPSRC
Engineering and Physical Sciences Research Council

AMRL
Advanced Materials Research Laboratory

University of Strathclyde Engineering

- Introduction
- ACG Recycling Projects Overview
  - TARF-LCV
  - ReCoVeR
- Some Initial Results
- Conclusions

Global Glass Fibre Demand

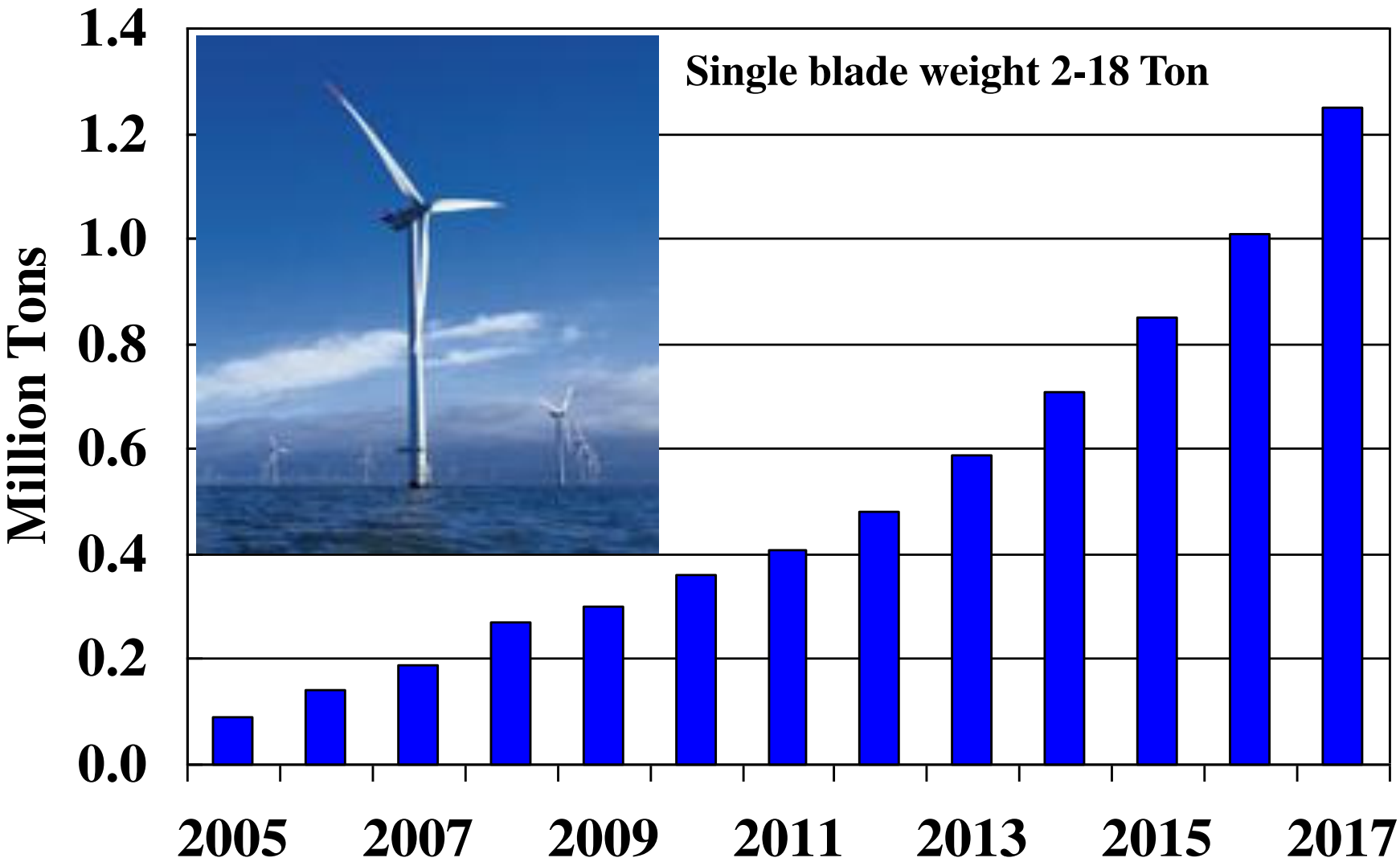


Composites in Automotive

BMW photo as shown in Modern Plastics Magazine

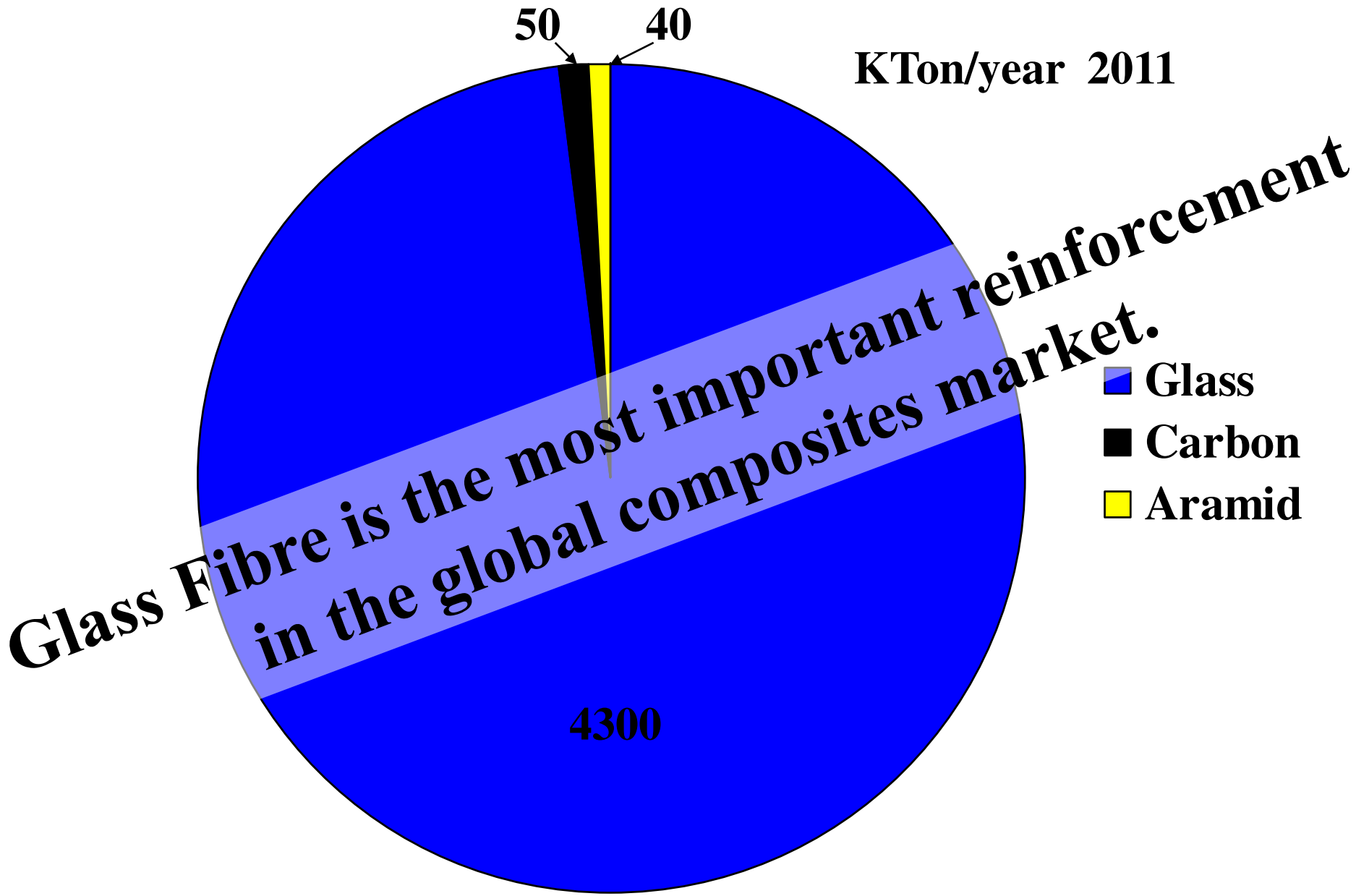
Composite Wind Turbine Blades

Forecasted Global Composite Rotor Blade Shipments, 2008-2017

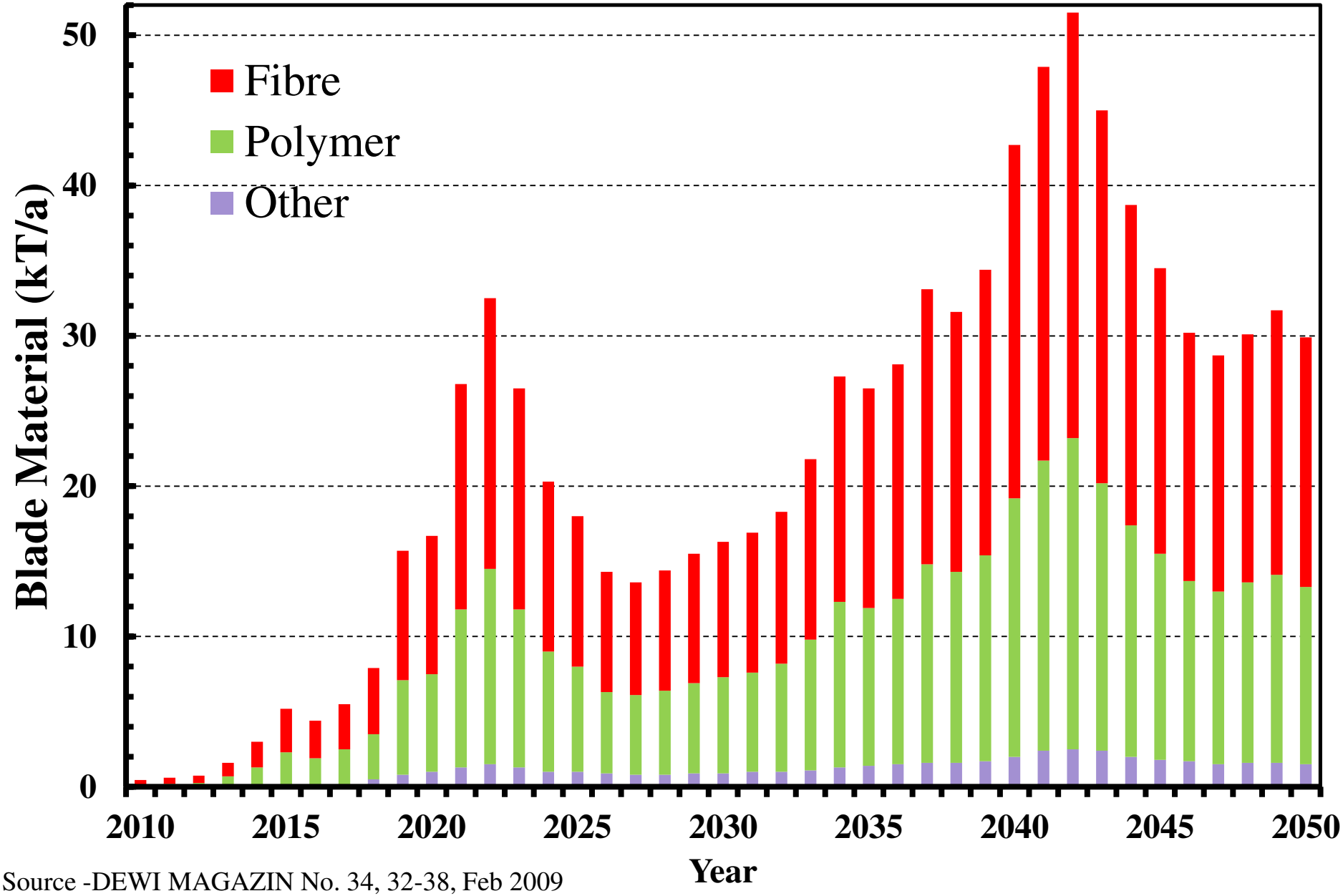


Source - Composites Technology, June 2008

Global Reinforcement Fibre Usage

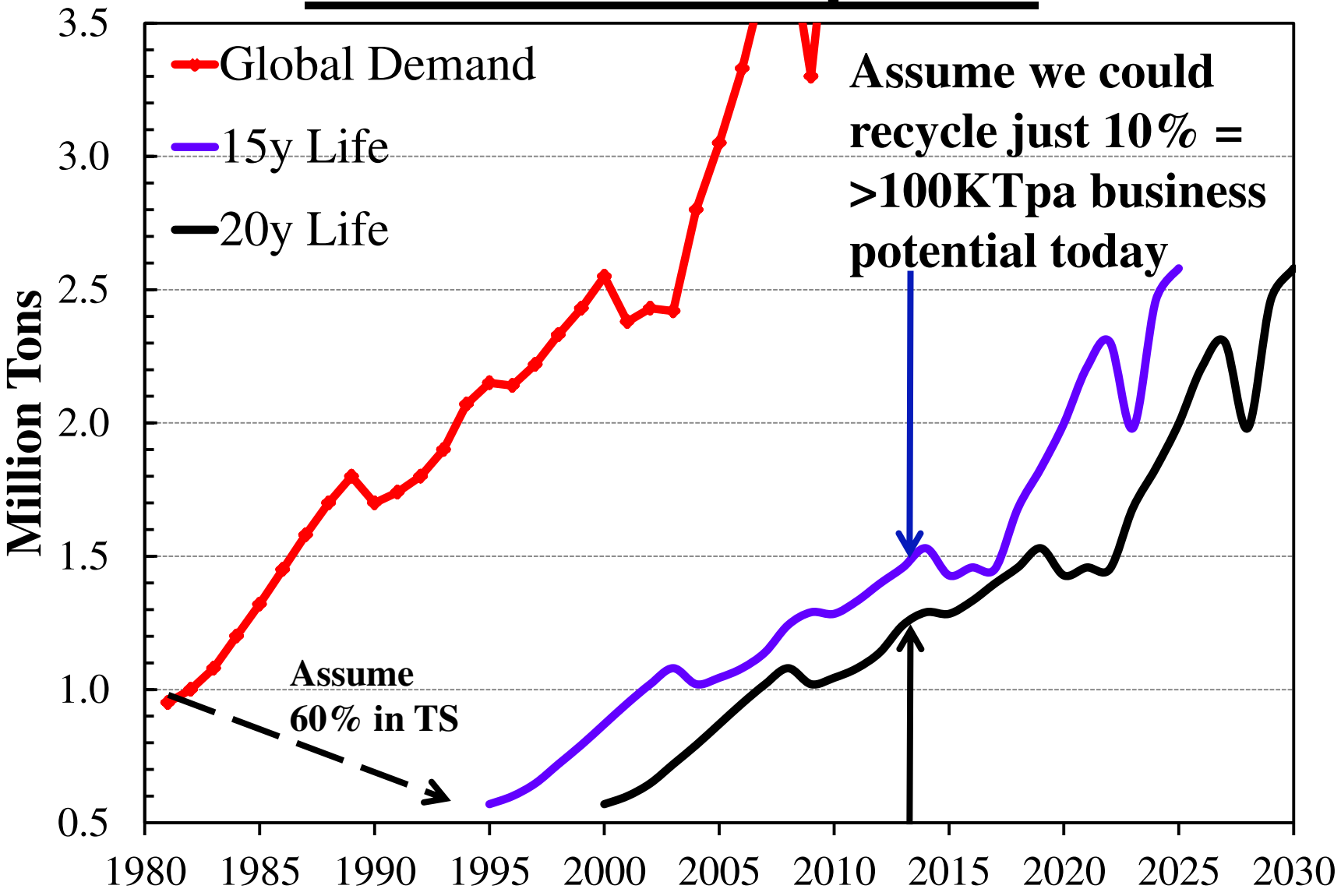


End-of-Life Blade Material in Germany



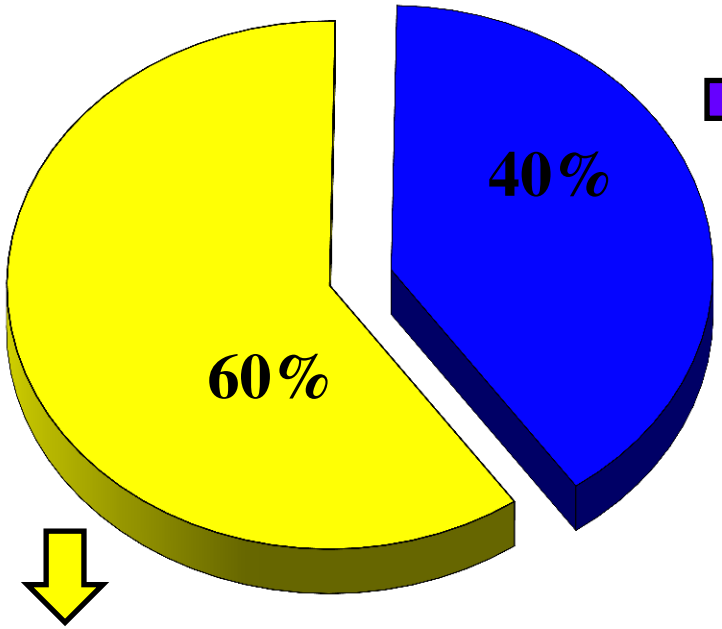
Source -DEWI MAGAZIN No. 34, 32-38, Feb 2009

Available End-of-Life Glass Fibre in Thermoset Composites



Glass Fibres: End-of-Life Scenario

4.3 MegaTons Glass Fibre



Mainly into chopped fibre thermoplastic composites. Intrinsically recyclable

ReCoVeR and reuse as valuable chopped fibre ?

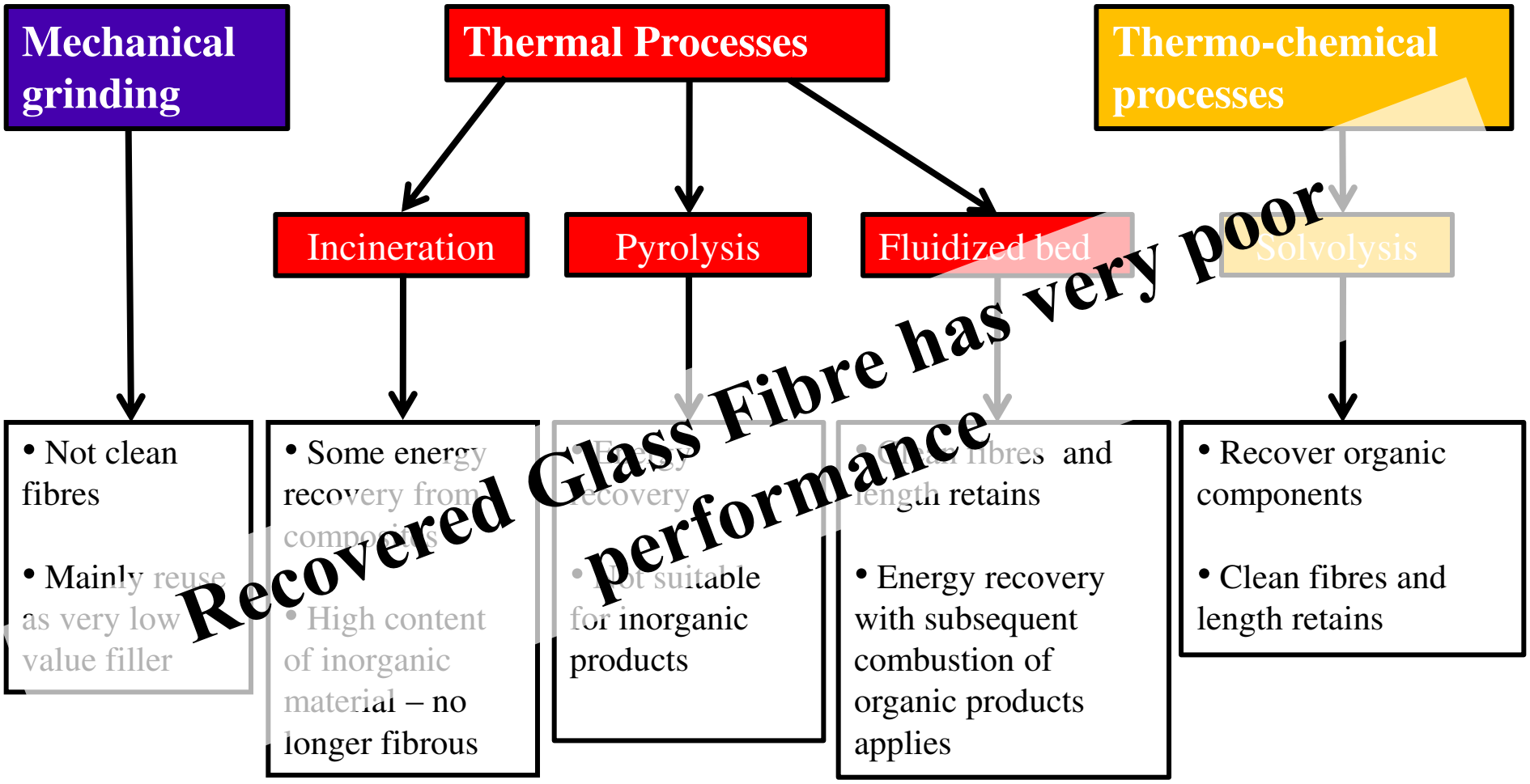
Mainly into continuous fibre thermoset composites

Challenging to recycle - so end-of-life = landfill ?

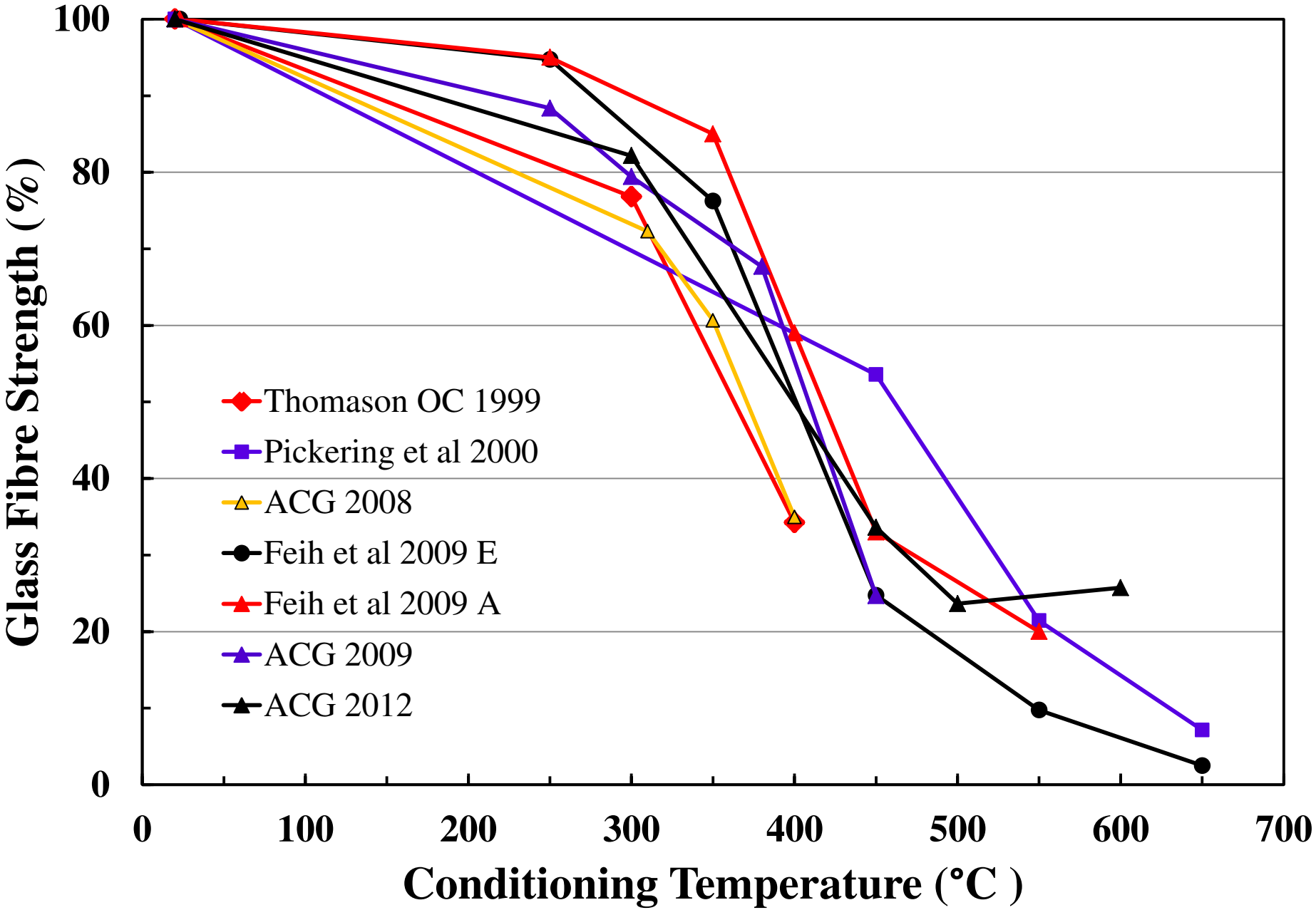
Landfill no longer acceptable – but very difficult to recover continuous fibre

(or +- zero value filler)

GRP Recycling Techniques



Strength after Thermo-Mechanical Treatment



Key Research Questions

- **Mechanism(s) of strength loss during thermal recycling of glass fibre?**
- **How to regenerate the fibre strength?**
- **How to process recycled glass fibre?**

- **How to improve temperature resistance of pristine glass fibre products?**

ACG projects on GRP Recycling

Towards Affordable, Closed-Loop Recyclable Future Low Carbon Vehicles (TARF-LCV)

- 8 University team (45 researchers) addressing the grand challenges facing the development of recyclable lightweight materials for future Low Carbon Vehicles
- £4.9M EPSRC funding, £550K to ACG
- ACG will focus on glass fibre science and composites technology (1Post-doc, 3 PhDs over 4 years)

Regenerated Composite Value Reinforcement (ReCoVeR)

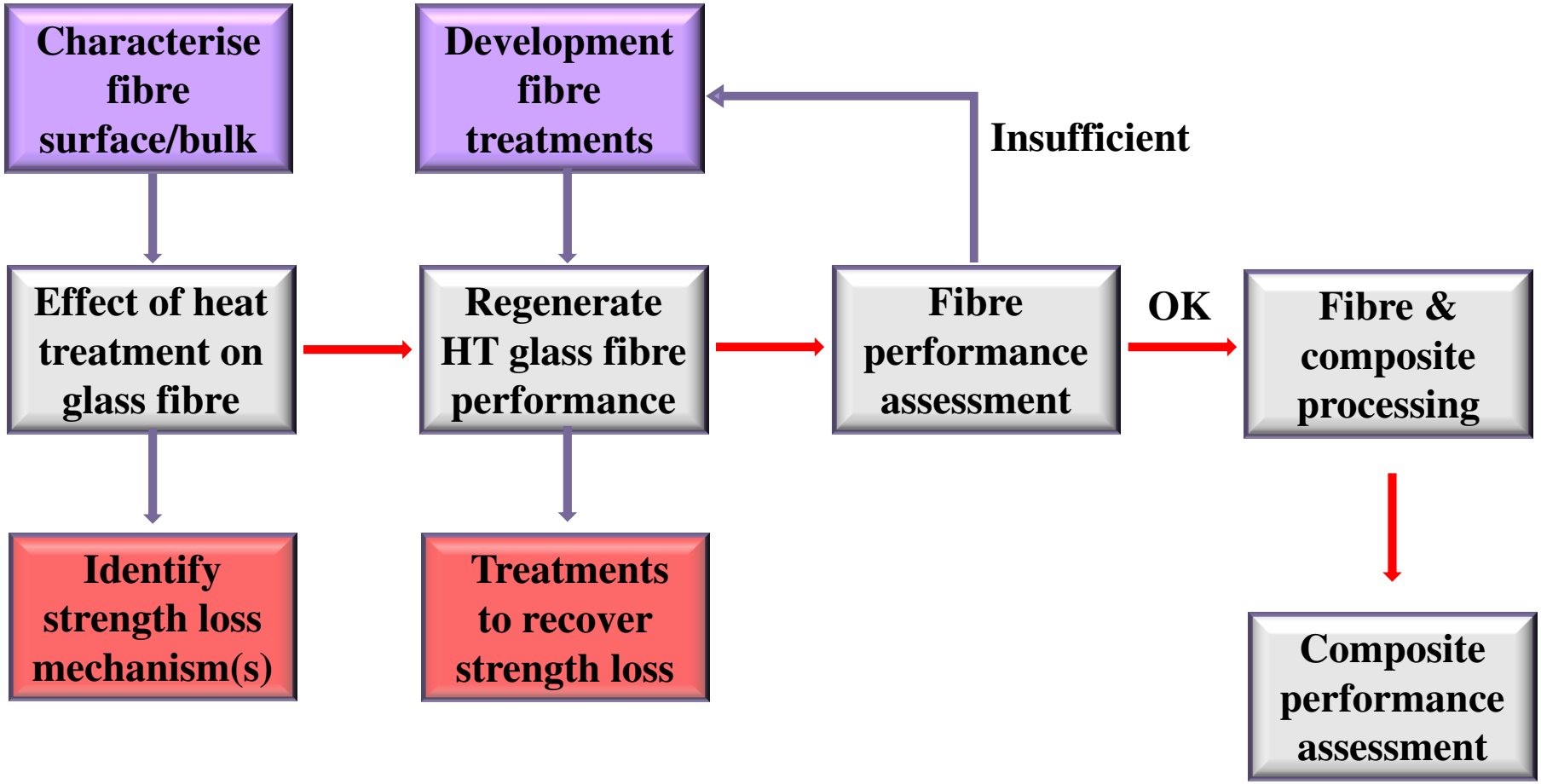
- Cost effective regeneration of glass fibres recovered from recycled GRP composites (wind turbine blades)
- 1Post-doc, 1+ PhD over 3 years
- £564K EPSRC funding.
- Support from Vestas, Owens Corning, DSM, SABIC

ACG GRP Recycling Projects Goals

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

- Generate a fundamental understanding of the degradation of glass fibre strength during thermo-mechanical conditioning (300-600°C)
- Develop cost effective treatments (sizings) to regenerate the performance of thermo-mechanically treated glass fibres
- Produce examples of glass fibre and composite products using regenerated glass fibres
- Develop sizings that will enable high performance glass fibres to be recovered from thermally recycled GRP

Projects Overview



Some Initial Results

Materials

- Boron Free E-glass (Advantex) OCV
- 1200 Tex continuous, single end roving (pilot bushing)
- Nominal 17 μm fibre diameter
- Sizing
  - US - Water sized = Unsized
  - APS - 1% wt.% γ-aminopropyltriethoxysilane sized
- Thermal Conditioning for 15 minutes in air

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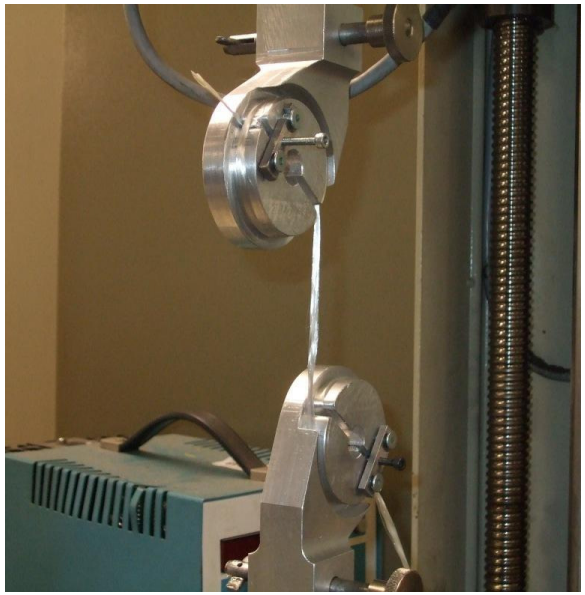
Fibre Testing

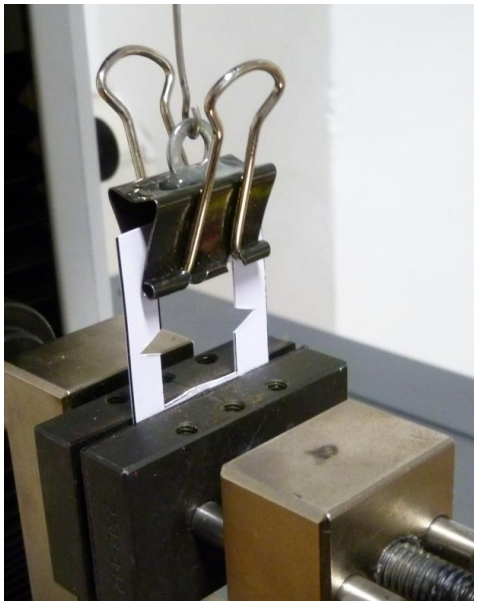
Bundle Testing

- ASTM 578 and ASTM 2256
- Gauge length: 250 mm
- Strain rate: 1.5 %/min
- 10 tests per condition
- Only breaks > 3mm from grips recorded



Single Fibre Testing

- ASTM C1557-03
- Gauge length: 20 mm
- Strain rate: 1.5 %/min.
- 70 – 100 fibres per condition
- Diameter average of 4 transverse measurements



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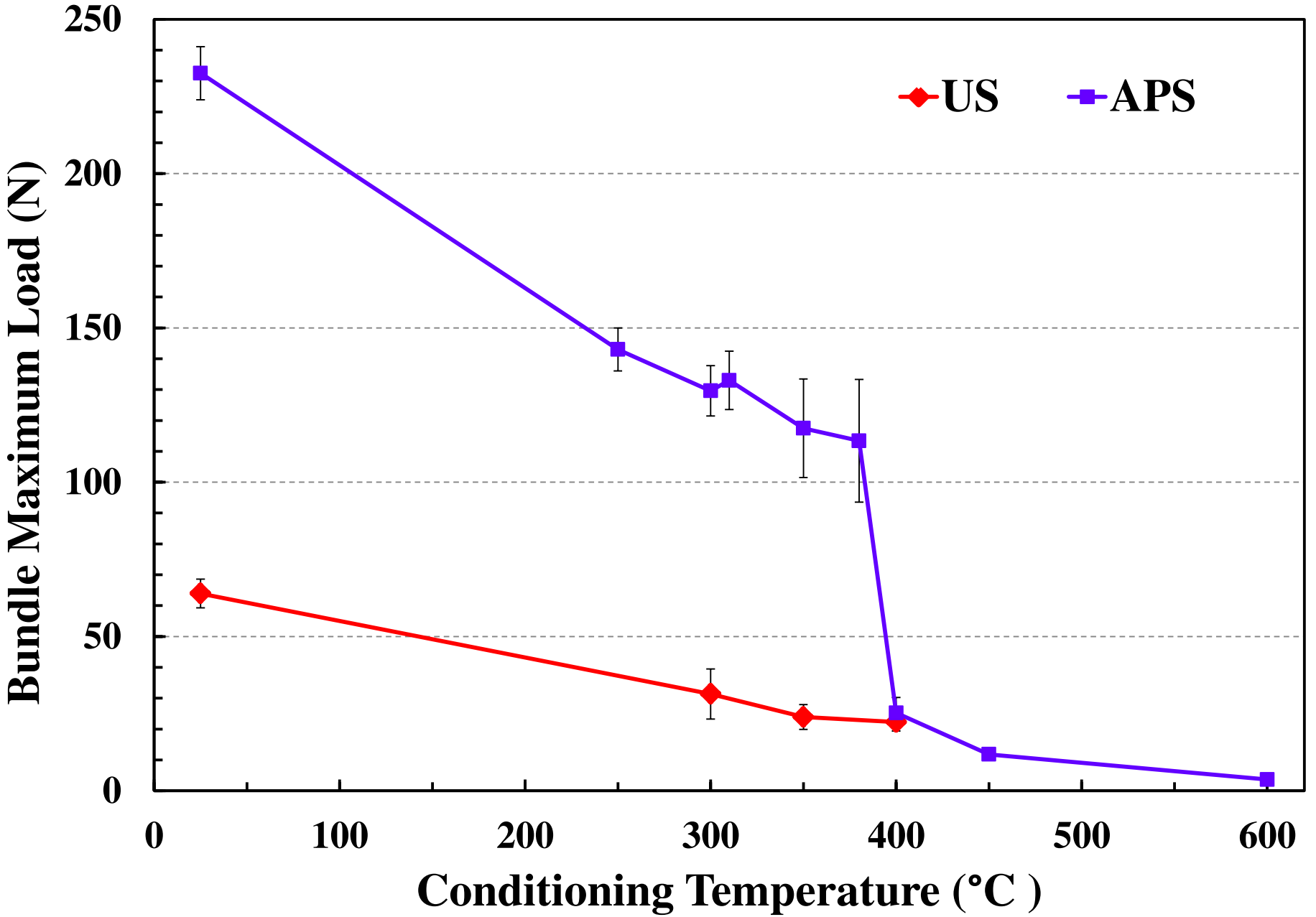
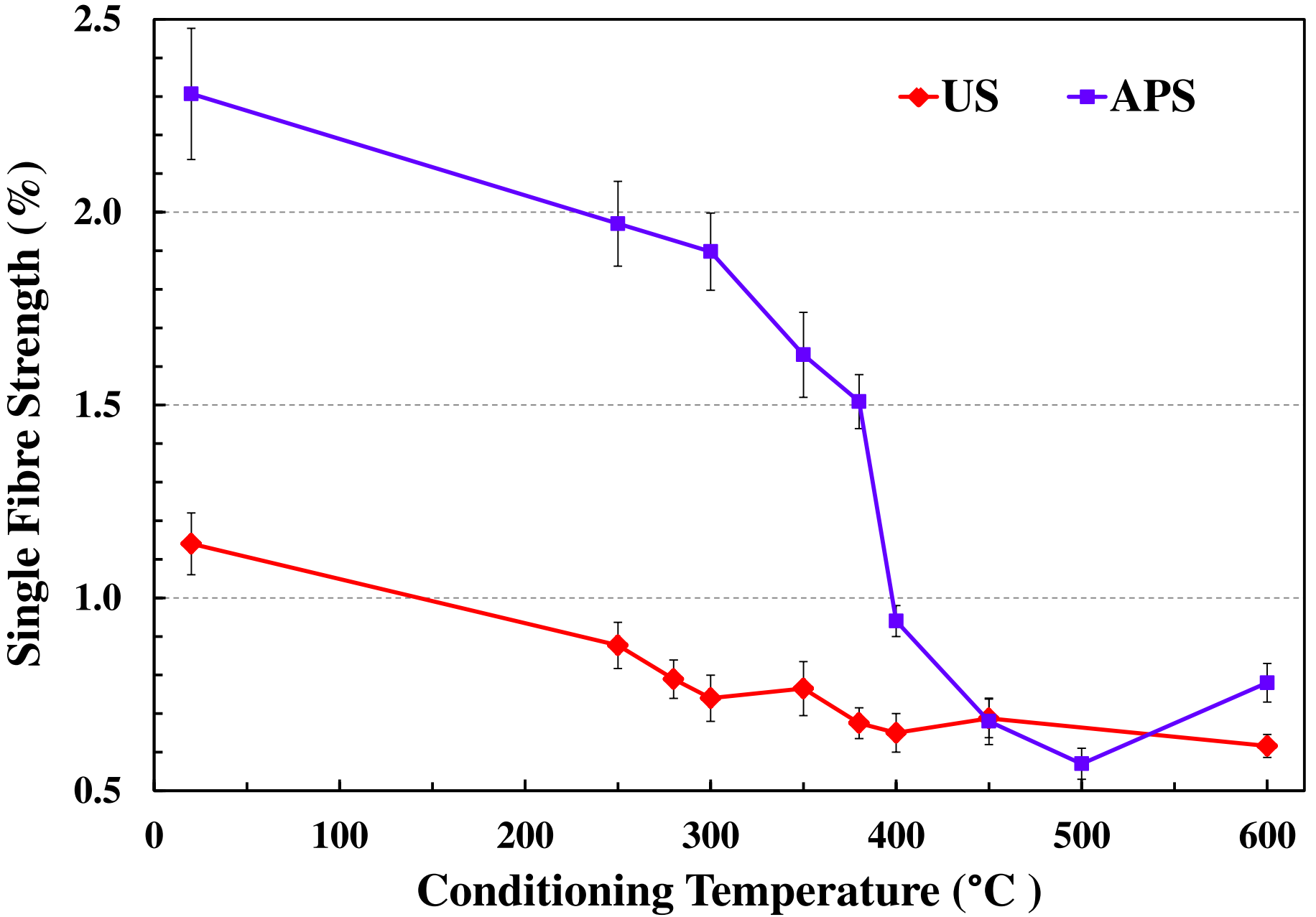
Fibre Bundle Test



Single Fibre Tensile Test



Results Thermal Conditioning on Fibre Strength

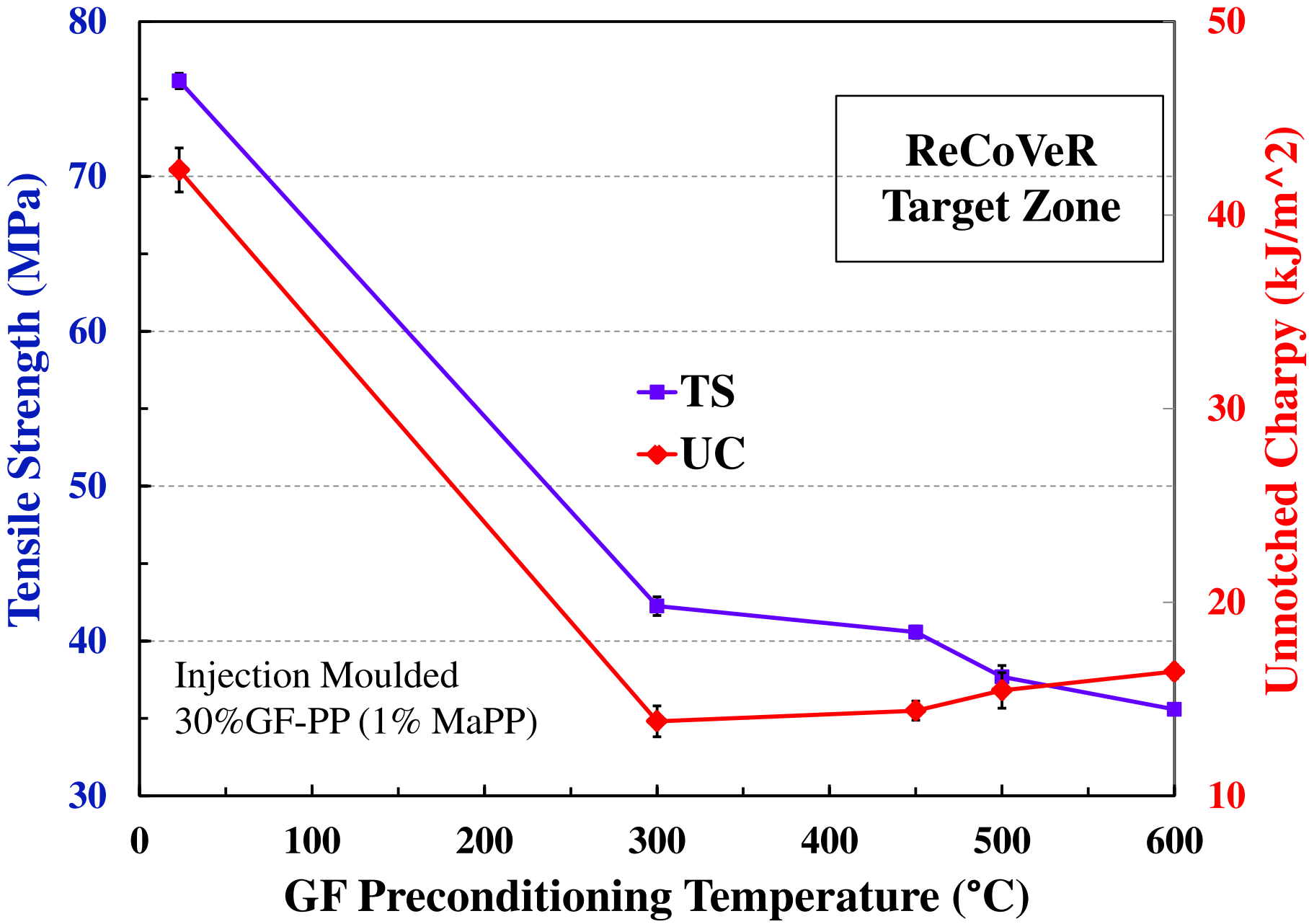
APS Sized Fibres

- Moderate strength loss in 23-300°C range
- Severe strength loss in 350-400°C
- No practical strength if conditioned above 450°C

Unsized Fibres

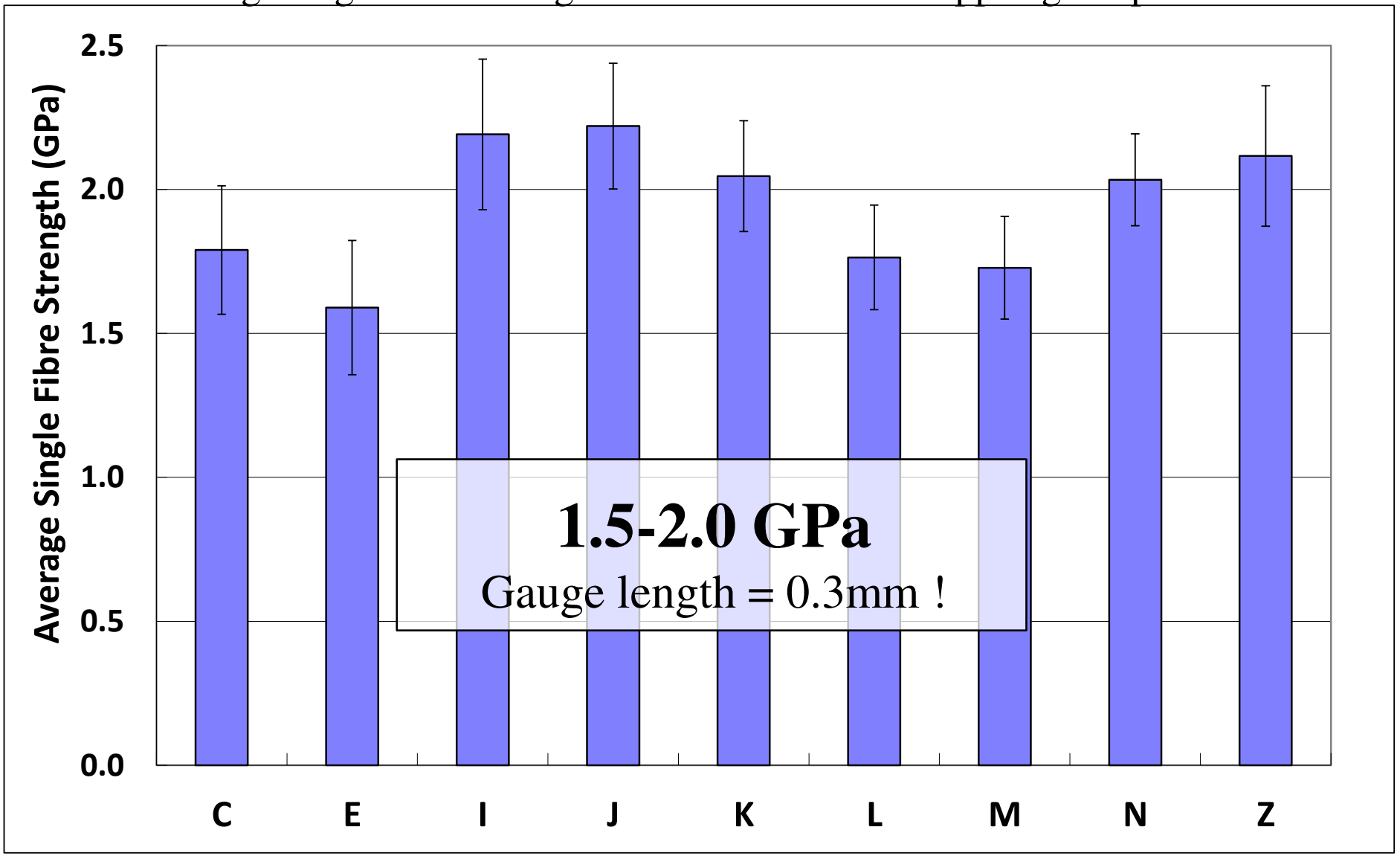
- Low initial strength due to lack of surface protection
- Continually decreasing fibre strength with increasing conditioning temperature

GF Heat Treatment & Composite Performance



Target Strength for ReCoVeRed Fibre ?

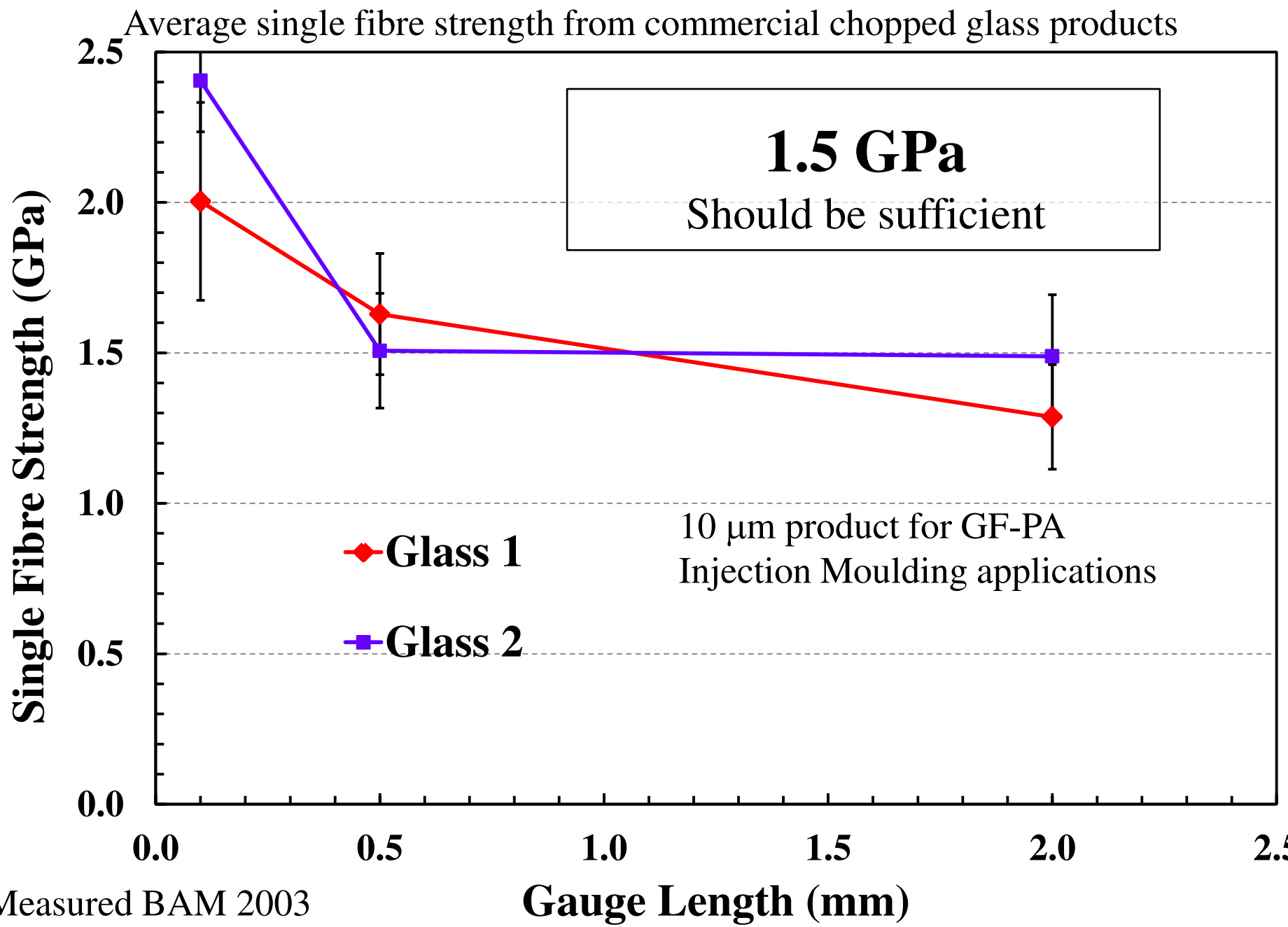
Average single fibre strength from commercial chopped glass products



Measured BAM 1999

Composites Part A 32 (2001) pp 85-90

Target Strength for ReCoVeRed Fibre ?



Conclusions

- **The development of a cost-effective technology to regenerate the properties of thermally recycled glass fibres would have major environmental benefits**
- **Sizing is essential to the retention of glass fibre strength**
- **Both sized and unsized glass fibres lose most of their strength after a short heat treatment above 400°C**
- **300-600°C conditioning of pristine chopped E-glass drastically reduces composite performance**
- **The ACG is developing treatments to ReCoVeR the strength of thermally recycled glass fibres**

Announcement

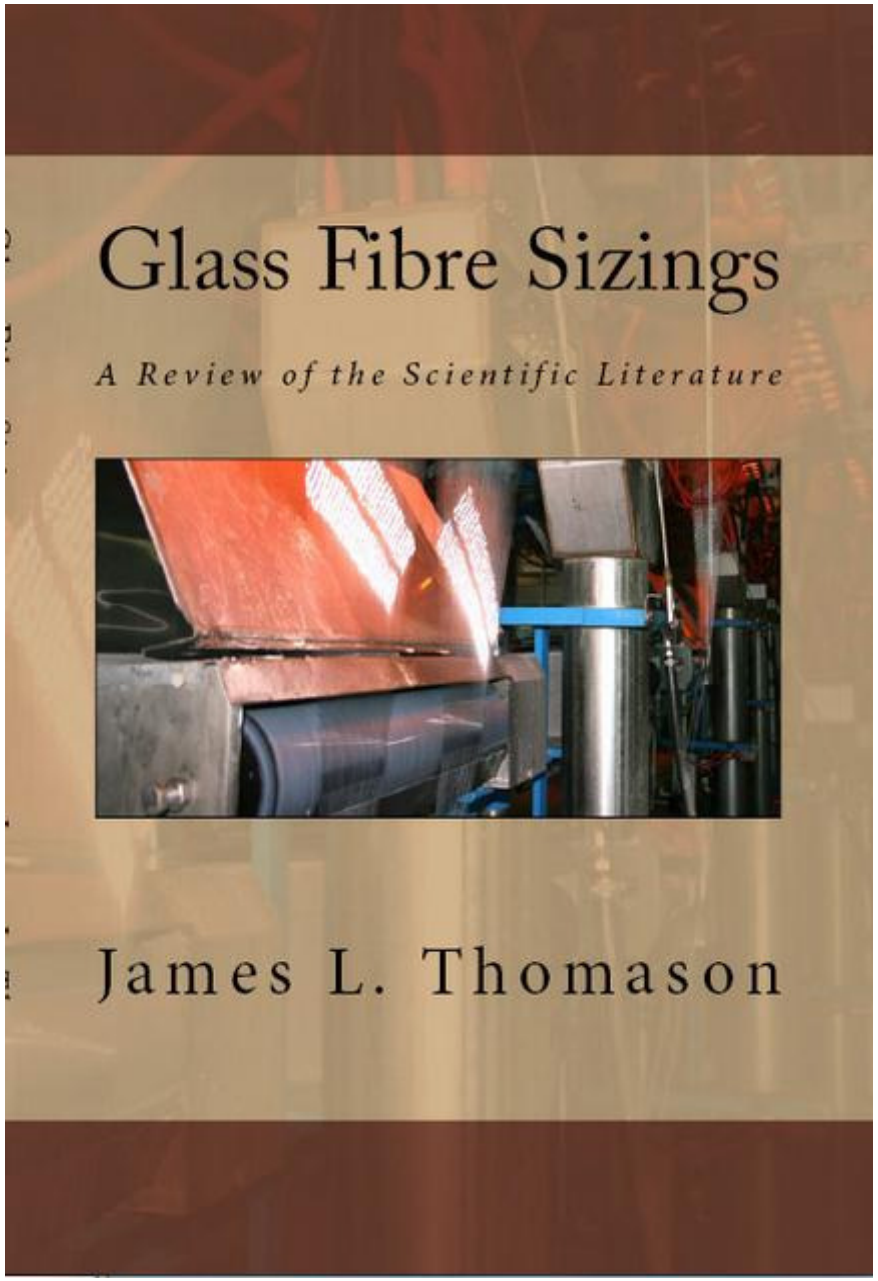
University of Strathclyde Engineering

In August 2013 the Advanced Composites Group at the University of Strathclyde filed its first patent application in the area of

Glass Fibre Recovery

covering cost effective, industrially applicable, treatments to regenerate the strength of thermally recycled glass fibres.

Glass Fibre Sizing Review



"Never in the field of material* science has so much of the success of so many applications depended *on the knowledge of so few"

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