Glassflake Ltd: 
Product & Company Overview 
Nora Hartwig
TURKCOAT, 14th September 2013
Key facts

• Established in 1987
• Global leader in glass flake products
• Proprietary production technology
• Innovation in borosilicate effect pigments
• Continuous innovation
• Key partnerships in industry served
Company history

- 1980 - Concept of novel glass flake rotary production
- 1983 - First glass flakes produced on new process
- 1987 - Formation of Glassflake Ltd in the UK
- 1993 - Development of 3 micron thick flake for the Industrial Coatings Market
- 1998 - Development of ground breaking 1 micron flake
- 1999 - Introduction as pigment substrate
- 2001 - Development of metal coated flakes for decorative and functional applications
- 2003 - First sub 1 micron product produced
- 2005 - Complete sub 1 micron range released
- 2006 - Development of LA type glass specifically for the Pigment market
- 2007 - Formation of Glassflake Australia Pty Ltd
- 2009 - Joint venture Glassflake China Production Facility: Langfang, Beijing
- 2009 - Development of Effect Series pigments
- 2010 - Development of glass with inherent colour in thicknesses below 5 microns
- 2012 - Addition of colour travel series to our Moonshine® pigment range
- 2013 - Launch of sub 1 micron flake glass flakes as the ‘next generation’ of effect pigment substrate
- Development of ultra-thin glass flakes for cosmetic fillers
Original glass flake technology
Original glass flake technology
Improvements in Glassflake technology have allowed thinner, more consistently uniform glassflake to be produced.
Borosilicate platelets: glass flakes

400nm Glassflake

400nm

420nm

09-Feb-05

WD28.5mm 5.00kV x8.0k 5um
Borosilicate platelets: glass flakes

Functional and decorative purposes:

- Corrosion protection, in-situ barrier within coatings
- Effect pigments
- Polymer reinforcement

The type of glass flake used (thickness and diameter, composition) will depend on the application.
Borosilicate platelets: glass flakes

- Thicknesses from 75nm to 9 microns
- Varying particle size diameters dependent on application
- Several different compositions predominately ‘C’ or ‘E’ type glasses
- Functional or decorative use
- May be coated or used uncoated: coatings may be functional or decorative or both
Composition Range

- ECR Type Glass flake
- C Type Glass flake
- E Type Glass flake
- LA Type Glass flake
- Moonshine® Effect Series pigment
Composition usage per sector

Coatings: ECR/C Type

Pigments: ECR/LA Type

Thermopolymers: ECR/E Type
### Product overview: Glass flakes by flake thickness

| ECR type glass | • GF750 series 5.5 - 9.0μm |
| • GF500 series 3.5 - 5.5μm |
| • GF300 series 2.3 - 3.5μm |
| • GF200 series 1.3 - 2.3μm |
| • GF100 series 1.01 - 1.3μm |
| • GF750nm series 750 - 900nm* |
| • GF500nm series 450 - 650nm* |
| • GF350nm series 300 - 400nm* |
| • GF250nm series 200 - 300nm* |
| • GF100nm series 50 - 150nm** |

| C type glass | GF750 series 5.5 - 9.0μm |

| E type glass | GF500 series 3.5 - 5.5μm |
| GF100 series 1.01 - 1.3μm |

| LA type glass | GF100 series 1.0 - 1.3μm |

In a range of nominal planar distributions

* Available on special order
** Available through special arrangement

Other compositions by agreement (Ceramics, Basalt)
Standard particle size diameters

Unmilled D50 ca. 160 microns
Milled D50 ca. 120 microns
Micronised D50 ca. 30 microns
Core markets

- Coatings
- Effect pigments
- Polymers
Market activities

Historical markets by vol.

- Coatings: 80%
- Polymers: 15%
- Pigments: 5%

Current markets by vol.

- Coatings: 60%
- Pigments: 36%
- Polymers: 4%
Glass flake in anti-corrosion coatings

• Our largest market is the coatings industry

• The benefits of using glass flake are:
  – Reduced moisture vapour transmission rates
  – Thermal expansion coefficient similar to steel
  – Increased weathering stability
  – Chemical resistance
Properties of heavy duty glass flake linings

- Excellent temperature resistance
- Excellent chemical resistance
- Excellent dry and immersed adhesion
- Low permeation rate
- Applicable over a wide range of substrates
- High abrasion resistance
- Dimensional stability
- Repairability
- Impact resistance
- High tensile strength
- High resistance to cathodic disbondment
- Durability, very long service lives
- Very low VOC
- Cost effective
Micrograph of glass fibre in resin with the fibre orientation parallel.
Schematic of permeation path length through glass fibre resin material
Path length to substrate is dramatically increased, thus, MVT potential is substantially reduced dependant upon particle size and distribution/ flake thickness.
Effect of flake thickness on MVT

Test Method: ASTM D1653
Test Temperature: 25°C
Film Thickness: +/- 1mm
1 ng/(s.m^2.Pa) = 1.459 perm/inch
**Evaluation of flake diameter**

<table>
<thead>
<tr>
<th>TEST</th>
<th>TEST METHOD/STD</th>
<th>RESULT 1</th>
<th>RESULT 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMPRESSIVE STRENGTH</td>
<td>BS 6319 : Part 2 : 1983</td>
<td>631.8 kg/cm² 8984 lbs/sq inch</td>
<td>359 kg/cm² 5051 lbs/sq inch</td>
</tr>
<tr>
<td>FLEXURAL PROPERTIES (three point method)</td>
<td>BS 2782 : Part 10 : Method 1005 : 1977</td>
<td>164.6° @ 0.85 kg</td>
<td>171.4°@ 1.1 kg</td>
</tr>
<tr>
<td>% ELONGATION TO BREAK</td>
<td>BS 6319 : Part 7 : 1985</td>
<td>0.6%</td>
<td>0.05%</td>
</tr>
<tr>
<td>ADHESIVE STRENGTH (Vertical Pull-Off)</td>
<td>BS 3900 : Part E10</td>
<td>132.3 kg/cm² 0.84 ton/sq inch</td>
<td>79.38 kg/cm² 0.5 ton/sq inch</td>
</tr>
<tr>
<td>SHEAR STRENGTH (Dog Bone)</td>
<td>BS 6319 : Part 4 : 1984</td>
<td>198.4 kg/cm² 2821.3 lbs/sq inch</td>
<td>207.7 kg/cm² 2953 lbs/sq inch</td>
</tr>
<tr>
<td>HARDNESS (Barcol)</td>
<td>ASTM D-2583</td>
<td>40.0 Rockwell H 38.2 Barber Colman</td>
<td>52.0 Rockwell H 43.2 Barber Colman</td>
</tr>
<tr>
<td>IMPACT STRENGTH</td>
<td>BS 3900 : Part E3 : 1973</td>
<td>9.5 Joules Forward 2.0 (N/M) Reverse</td>
<td>8.2 J Forward 2.0 N/M Reverse</td>
</tr>
<tr>
<td>ABRASION RESISTANCE</td>
<td>Taber H-18 1000gm 1000 cycle</td>
<td>435 mgm</td>
<td>415 mgm</td>
</tr>
<tr>
<td>HEAT DISTORTION TEMPERATURE</td>
<td>Differential Scanning Calorimetry (DSC) and DMTA</td>
<td>92°C</td>
<td>96°C</td>
</tr>
<tr>
<td>SHRINKAGE RATIO</td>
<td>COR102</td>
<td>8.5%</td>
<td>3.9%</td>
</tr>
</tbody>
</table>

Test data obtained at 20 Deg C on standard cure.
a D50 of 200um (1) and a D50 of 575um (2). The loading was 15% by weight in each case.
## Evaluation of varying flake concentration

### Change in Moisture Vapour Transmission Rates

<table>
<thead>
<tr>
<th>Glass flake concentration</th>
<th>Average result of 5 samples (perm. inches (10^{-5}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>14%</td>
<td>10.61</td>
</tr>
<tr>
<td>15%</td>
<td>3.46</td>
</tr>
<tr>
<td>16%</td>
<td>3.64</td>
</tr>
</tbody>
</table>

### Cathodic Disbondment Testing

<table>
<thead>
<tr>
<th>Glass flake concentration</th>
<th>Average disbondment over 3 tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>14%</td>
<td>5.0 nm</td>
</tr>
<tr>
<td>15%</td>
<td>3.4 nm</td>
</tr>
<tr>
<td>16%</td>
<td>4.9 nm</td>
</tr>
</tbody>
</table>
Evaluation of silane coupling agent addition levels, in a vinyl ester glass flake coating

Polyglass VEF (Glassflake 15%)

<table>
<thead>
<tr>
<th>R&amp;D Batch 943</th>
<th>A 0.19%Silane</th>
<th>B 0.38%Silane</th>
<th>C 0.57%Silane</th>
<th>D 0.76%Silane</th>
<th>E 0.95%Silane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Permeability (perm/inch)</td>
<td>1.86 x 10^{-4}</td>
<td>0.41 x 10^{-4}</td>
<td>0.34 x 10^{-4}</td>
<td>1.06 x 10^{-4}</td>
<td>1.63 x 10^{-4}</td>
</tr>
<tr>
<td>Water Absorption (% wt. gain)</td>
<td>0.148(24hrs)</td>
<td>0.120(24hrs)</td>
<td>0.0345 24hrs</td>
<td>0.100 (24hrs)</td>
<td>0.147 (24hrs)</td>
</tr>
<tr>
<td></td>
<td>0.358(7day)</td>
<td>0.312 (7day)</td>
<td>0.198 (7day)</td>
<td>0.317 (7day)</td>
<td>0.350 (7day)</td>
</tr>
<tr>
<td></td>
<td>0.512(14day)</td>
<td>0.447 (14day)</td>
<td>0.435 (14day)</td>
<td>0.444 (14day)</td>
<td>0.486 (14day)</td>
</tr>
<tr>
<td>Adhesive Strength (Kg/cm²)</td>
<td>500</td>
<td>587</td>
<td>625</td>
<td>585</td>
<td>557</td>
</tr>
<tr>
<td>7 Day Barcol Hardness</td>
<td>49</td>
<td>50.2</td>
<td>51</td>
<td>49.7</td>
<td>49</td>
</tr>
<tr>
<td>Bend Test - angle coating cracked</td>
<td>11°</td>
<td>16°</td>
<td>20°</td>
<td>14°</td>
<td>10°</td>
</tr>
</tbody>
</table>
Pump coatings

After 4 years’ sea-water service

After refurbishment with a Glassflake filled polyester/acrylic

After 7 years’ service
Pump coatings

After 4 years sea-water service

After refurbishment with a coating containing glass flakes, note the wear ring areas using specialist casting techniques

After 7 years service
Externals of buried pipe-work
Coatings for concrete

Lining containing glass flake have also been used extensively for concrete tanks, floors and secondary containment areas.
Oil separators

Vinylester Acrylic Glassflake, inspected August 2006, after 14 years service, Sour Crude 71 °C
Oil storage tanks

45m diameter sour crude surge tank coated Vinylester Acrylic Glassflake in 1989. Tank had previously been lined with a coal tar epoxy (which failed within 5 years, the tank had suffered from SRB attack). Inspected in 2005 and put back into service until 2012.

The sister tank to this was coated in 1991, both tanks are still in excellent condition.
Pipeline coating
Cooling water pipework

Pipe Coating using Polyester Glassflake

Pipes between 1m to 30m

Total Surface Area: >175,000m²
New carbon steel manifolds
Industrial coatings - powder coatings and other

- May be used in solvent and waterborne coating systems
- In powder coatings micronised and milled product may be used to improve reinforcement and also UV resistance (Architectural)
- Thin film systems (20 microns) to high build systems (+800 microns)
- Properties imparted depend on a number of factors including but not limited to: choice of glass flake, loadings and good dispersion
Potential markets

Any coating system that requires a reduction in permeation rates
Effect pigments
Glass flake morphology

Cross section view of mica in comparison to glass flake based pigments

Substrate coating

Interference colour achieved with varying metal oxide coating

Metal oxide coating thickness and interference colour achieved.
Moonshine® effect pigments: product overview

Current range:

- **Effect series - Metal oxide range**
  White, Blue, Violet, Gold, Red, Green, Bronze, Copper, Russet and Metallic Gold

- **Ultra effect series - Metal oxide / organic colour**

- **Meta effect series - Metal coated range**
  Silver, Silver/Gold

NEW:

- **Colour travel series – multi layer metal oxide range**
Moonshine® standard particle size diameter ranges

Sparkle  PSD 50-250 microns
Shimmer PSD 20-100 microns
Moonshine® application areas

**Industrial**
- Plastics
  - Extruded
  - Blow molded
  - Injection molded
- Coatings
  - Liquid coatings
  - Powder coatings

**Cosmetic**
- Colour cosmetics
  - Lip colours
  - Eye makeup
  - Nail polishes
  - Face and body make up
- Personal Care
  - Hair care products
  - Bath soaps and gels
  - Skin lotions and creams
Moonshine® applications

- Polymers
- Coatings & Varnishes
- Cosmetics
- Inks
- Automotive exteriors
- Credit and gift cards
- Decorative papers
- Residential paints
- Tiles & Home furnishings
New products: Moonshine®

- Extend the oxides coated on GF
  - Iron oxide coated glass
  - OVP coated glass
- Automotive grade

Future products: Moonshine®

- Ultra thin pigments <750nm
- Pigment with inherent color
- Functional pigments
Polymers
Usage in polymers

- Reinforcement
  - Dimensional stability
  - Modulus
- Barrier properties
  - Moisture/ vapour
  - Gas permeation
  - Improved weather/ UV stability
- Thermal properties
  - Heat distortion temperature (HDT)
  - Fire retardancy

May be used in all types of polymer systems: high performance, engineering and commodity thermo-polymers

Certain amorphous polymers may only use E type glass due to the presence of Sodium in other compositions (E glass <0.5%wt)

Glass flake pre-treated with silane coupling agents recommended for most applications
Applications and polymer types

Engineering thermoplastics
- PC/ABS blends – dimensional stability
- PBT
- LCP
- PA

Commodity Plastics
- Polyolefins
- Barrier films
- Injection moulded

Automotive
- Vehicle tyres
- Under the bonnet
Silane coupling agents

Glass flakes are offered with four different functional silanes as standard

<table>
<thead>
<tr>
<th>Surface treatment</th>
<th>Resin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amino Silane</td>
<td>Polyamides, Phenolics, PET</td>
</tr>
<tr>
<td>Vinyl Silane</td>
<td>Polyester, Polyethers, Polyolefins</td>
</tr>
<tr>
<td>Epoxy Silane</td>
<td>Epoxy, PU, ABS</td>
</tr>
<tr>
<td>Acryl Silane</td>
<td>PP, Polyolefins</td>
</tr>
</tbody>
</table>

Promote adhesion of the glass to the polymer matrix
  • good bonding ensures better mechanical properties, good chemical & heat resistance

Improve ‘wet-out’ of flakes in a resin

Prevent surface moisture absorption
  • assists storage, reduces clumping, aids flow
Potential markets

Engineering polymers
- Small components
- Dimensional stability

Automotive
- Interior
- Under the bonnet

Rubber compounds
- Tyres
- Barrier

Commodity polymers
- Barrier films
- Dimensional stability
Potential Markets: General

- **Plastic**
  - Stabilisation and reinforcement

- **Electronics**
  - Printed circuit boards

- **Agriculture**
  - Fertilizer

- **Medical, Work surfaces, Sanitary**
  - Antimicrobial fillers

- **Sunscreen, Paints, Military**
  - UV absorption and reflection

- **Chemical industry**
  - Catalysts

- **Electrical, Anti-static**
  - Electrically conductive

- **Telecommunications**
  - EMF shielding

- **Coatings, Cables, Flooring, Construction**
  - Fire retardancy

- **Ceramics**
  - Thermal insulation, high temperature pigments, metal reinforcement, frits
Glassflake is a market leader in product & process innovation.