EPMT Show
Wednesday, 18 June 2014

Smart Fiber Lasers for Micro Machining Applications

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Product Manager
Product Ranges include:

- Laser sources
- Scanning and beam delivery products
- Medical visualization and informatics solutions
- Precision motion control products

GSI Group

- Leading provider of precision laser, medical and motion control technology
- Canadian Company founded in 1968, with U.S. Headquarters in Massachusetts
- ~$365M in annual revenue and ~$60M in annual Adjusted EBITDA*
- Approximately 1,400 employees for continuing operations
- Trade on NASDAQ (GSIG)
**Laser Products Group**

**Laser Products Overview**

**Sales Trend ($M)**
- 2012: $159
- 2013: $167

**Brands**

**Range**

**Location**

**Primary Applications**

**Scanners**
- Cambridge Technology
- Galvanometers
- Scan Heads
- Bedford, MA
- Material Processing
- Marking
- Ophthalmology
- PCB Drilling

**Sealed CO$_2$**
- SYNRAD
- 10W to 400W
- Mukilteo, WA
- Marking, Engraving, Date Coding of non-metals

**Fiber Lasers**
- JK Lasers
- 50W to 2kW
- Rugby, UK
- Metal cutting, welding, drilling
JK Lasers: Key Facts

• Founded in 1972
• Previously best known as ‘Lumonics’
• Based in Rugby, UK and Suzhou, China
• Global installed base of 1000’s of industrial lasers.

- Industrial Fiber Lasers complement lamp pumped Nd:YAG based lasers for Welding, Cutting and Drilling.
  - JK Lasers is able to offer the right laser for each Application.
Tradition as leader in Industrial Lasers

1970
- Launch of the NJ Series—the first Nd:YAG laser system with breakthrough powers for industrial use. Medical device manufacturers are among the first users.

1980
- Launch of JK706, the first industrial 1W pulsed Nd:YAG laser. Launch of JK88, a high peak power laser system capable of fine focus and ideally suited to drilling.

1990
- Launch of the JCT0418 - Twin Rod 30kW Peak Power 60 J pulse drilling system for the aerospace industry.

2000
- Laser generation JCM²MCL family of pulsed Nd:YAG lasers become available.
- Launch of JK Scanning Head System with integrated controller and software interface.
- JK 100P introduced, a high peak power, short pulse fibre delivered Nd:YAG laser.

2010
- Launch of JK0404 high beam quality aerospace drilling laser.
- JSM09PL becomes available, complementary to the JK Fiber Laser range.
- The high powered 2kW fiber laser (JK2000FL) is introduced.
JK Fiber Lasers use their own patented technologies and know-how to give unique user advantages.

**Fiber Architecture**
- US7649914 – US granted
- 200680037877.1 – CN granted
- EP06794985.9 – EU pending
- US 2009/0251770 – US pending
- EP7824915.8 – EU pending

**Combiners**
- EP2033277 – EU granted
- US7720340 – Granted
- 200780029869.7 – CN pending
- 2009-517441 – JP pending

**Applications/Process**
- US2009/0296748 – US pending
- EP09718580.5 – Application in progress
- PCT/GB2011/051359 – Application.

**Beam Delivery/HP Combiner**
- US2010/0124393 – US pending (near granted)
- EP8750781 – EU pending
- 2010-511726 – JP pending
- WO2011/048398 – Application in progress
JK Lasers have over 40 years experience of designing, manufacturing and processing with our own industrial lasers.

- This experience has already been ‘designed in’ to our range of Fiber Lasers.

JK Lasers now present the ‘Smart Laser™’ Concept

- Of course beam quality, reliability etc. are highly important
  - But these are now ‘givens’ for industrial fiber lasers.

- Next generation lasers will have features that ensure higher throughput, better process control and save money by eliminating the need for additional external controls and equipment.

- Now that is a ‘Smart Laser™’.
‘Smart Laser™’ features

• JK Lasers is showcasing a number of our key differentiators and ‘Smart Laser™’ features.

• This presentation covers:
  - Back Reflection Protection
  - Focus Position optimisation
  - In Process Monitoring
What is Back-Reflection?
- Laser light reflected back from the work-piece
  - Can occur when processing reflective materials like Al, Cu, Au, Ag
  - Can occur when ‘coupling in’ to less reflective materials or being out of focus

Why is avoiding back-reflection important?
- At best it will affect the effectiveness of the laser process
- At worst it can damage an unprotected laser source or delivery fibre

Generally how is it protected against?
- By not processing reflective materials!
- By using non-optimal process head alignments
- By using additional components to protect the laser source

Many new laser users don’t appreciate the problems that back reflections can pose - until they hit the problem!
A fibre damaged by BR
**Back-Reflection**

- Delivery Fiber
- Process Tool
- Reflective Material e.g. Al, Ag, Au, Cu
- Core
- Cladding
- To Laser
- Back-Reflected Light

Unprotected Laser Source
Protecting Against Back-Reflection

- Faraday isolator
  - Degrades beam quality & power
  - Adds significant extra cost.
  - Bulky, especially for higher powers

- Process at an angle
  - Elliptical spot
  - Material cut becomes thicker
  - Uneven kerf width & cut profile

- JK Lasers’ Smart solution
  - Luminator™ fiber
JK Luminator™ Fiber

- Patented (US5179610, GB2255199)
- It comes as standard
- Simple, Plug-in – Pre-aligned
- Automatic interlocking with laser
Features of Luminator™ Fibres

Back Reflected light is rejected out of the side of the connector.
Additional FL Protection

- Protection against Back-Reflected light is also designed into laser control system
- Back-reflection levels constantly monitored
- Laser protects itself if excessive levels detected
- Very fast embedded control system response time (ns)
- Back-reflection levels may be viewed in FiberView™ GUI
- Short and long response times monitored.
Harnessing Back Reflection

- Back-reflection can actually be a useful thing if we can harness the signal.

- The measured back-reflection levels are available for:
  - Automatic focus finding
    - No additional external control system components needed
    - Saves system cost, improves repeatability and throughput
  - Automatic material pierce detection
    - No additional external components needed
    - Saves system cost, improves throughput
  - Process status monitoring
Signal Access Points

Having Fiber Laser and Beam Delivery system from a single supplier allows for an integrated approach using multiple access points to Back Reflected signal.
Focus optimisation using BR signal

- A null is formed around the focus point
  - around the size of the depth of field of the beam
- Different spot sizes have been tried, all give similar curves
- Finding the vertex of the parabola gives greater accuracy,
- 100µm displacement measured
- Possibility of use on welding and galvanometer based scanning systems
Focus Optimisation

Copper (purple curve) & SS (pink curve) Compared

FIG. 5

- Pulse laser with 50W, 100usecs
- Fiber laser software captures and integrates photodiode signal off CMS
- Values recorded, z and Int photodiode
- Move workpiece
- Move z
- Plot Int photodiode against z

(10) International Publication Number
WO 2012/022951 A1
In Process Monitoring

Process monitoring
Coupling in detection
What information does the BR signal carry?

- Here, half programmed Pierce dwell time was wasted
  - Over complete nested sheet of thick metal, this is appreciable productivity reduction.
<table>
<thead>
<tr>
<th>Patent number</th>
<th>Title</th>
<th>International Publication date</th>
<th>Priority date</th>
<th>Expiry date</th>
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<tbody>
<tr>
<td>US5319195</td>
<td>Laser system method and apparatus for performing a material processing operation and for indicating the state of the operation</td>
<td>NA</td>
<td>2/4/1992</td>
<td>2/4/2012</td>
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<tr>
<td>US5850068</td>
<td>Focus Control of Lasers in Material Processing operations</td>
<td>NA</td>
<td>3/6/1997</td>
<td>3/6/2017</td>
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<tr>
<td>US6347178</td>
<td>Optical Fibre apparatus</td>
<td>NA</td>
<td>1/11/1999</td>
<td>1/11/2019</td>
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<tr>
<td>US8213753</td>
<td>System for delivering the output from an optical fibre</td>
<td>20th May 2010</td>
<td>29/5/2008</td>
<td>8/12/2029</td>
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<tr>
<td>(WO2009/112815)</td>
<td></td>
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<tr>
<td>WO2012/022951</td>
<td>Method of optimising the focus of a fibre laser</td>
<td>23/2/2012</td>
<td>10th August 2010</td>
<td>NA</td>
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Conclusions

• Fiber lasers are generally very similar in terms of being a source of light for materials processing.

• What can differentiate these laser sources is their level of sophistication in terms of “Smart Laser” features
  - Ease of integration
  - User friendliness
  - Remote diagnostics
  - Process improvements

• Back-reflection can be a big problem
  - Protecting against it can be expensive and uses bulky components
  - JK Lasers Luminator™ fibers and smart laser control system are a low cost in-built solution that completely protects against back-reflection.

• Back-reflection can be useful
  - It can be used to monitor the laser process, detect breakthrough and find laser focus.